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An Exploratory Study of Users' Preference for Different Planting Combinations along Rural Greenways

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Abstract: The literature highlights the importance of vegetation to enhance the ecological and visual qualities of streets and paths; however, when studies specifically focus on rural greenways they do not consider users' assessments of the planting design. This exploratory study aims to contribute to this issue. It is hypothesized that planting combinations characterized by greater variety and aesthetic flow may be more preferred and restorative. To this end, four virtual scenarios simulating bikers moving along a greenway at 25 km/h were created to find out the following: first, what kind of planting combination is the most preferred, and second, which planting combination is perceived as the most restorative by bicycle riders. To assess the experience, subjects were administered a questionnaire made up of: (i) the Perceived Restorativeness Scale-11 with additional items to assess compatibility, familiarity, and preference; (ii) a list of physical and aesthetic attributes; and (iii) information on bicycle use. The results show that participants' preferences were affected by the perception of the scenario's restorative value, which was not given exclusively by the degree of naturalness, but by the opportunity the greenway offered to engage in social/physical activities. This study shows that preference and restorativeness are not a "simple" matter of quantity of vegetation, but of quality instead, i.e., planting variety. Designers have to consider that the restorative value of greenways is related to the opportunities they offer to engage in physical/social activities.

Keywords: virtual landscape; greenways; users' preferences; perceived restorativeness

1. Introduction

According to the European Greenways Association, greenways are "communication routes reserved exclusively for non-motorized journeys, developed in an integrated manner, which enhances both the environment and quality of life of the surrounding area. These routes should meet satisfactory standards of width, gradient, and surface condition to ensure that they are both user-friendly and low-risk for users of all abilities. In this respect, canal towpaths and disused railway lines are a highly suitable resource for the development of greenways" [1]. Greenways are not simple connecting elements but "places" in their own right [2] that allow people to access and enjoy different landscapes [3]. Greenways can be planned at different scales and are used to achieve multiple objectives in human and ecological dimensions [4–6]. As multifunctional green spaces, greenways can connect fragmented habitat patches in the city and preserve biodiversity, and, since they provide people with the opportunity to stay close to nature, they are receiving more attention as a way to foster environmental education and preservation of natural resources [7]. Greenways create new recreational spaces in both urban and rural areas [8], providing safe and quiet routes through parks, green areas and streets. Greenways generally develop along paths already present in the landscape, in natural corridors such as rivers, valleys and ridges, disused railways, canals and embankments, panoramic roads and minor rural roads [9], offering sustainable mobility alternatives to motorized travel. They offer the advantage of being easily established even in areas that are critical in terms of competition for space [10].

There is a significant body of literature on greenway planning [8,11–13] and design [8,14–16]; a few studies only analyze the role of vegetation in different greenway functions [17,18] and the role of greenways in maintaining and restoring rural landscapes [19]. In general, the literature shows that plantings invite more walking [20,21] and cycling in urban streetscapes [22,23]. These studies highlight the importance of vegetation to enhance the ecological value of streets and paths, but when they specifically focus on rural greenways, they do not consider users' assessments of the planting design. In fact, to the best of our knowledge, there are few studies tackling the user's point of view on planting design. The present study aims to contribute to this issue and give landscape designers criteria for planting along greenways.

To accomplish the study aim, a driving simulator (a technique used to assess car drivers' behaviour, usually combined with qualitative and/or qualitative measures [24,25]) was used to encompass cyclists' experience of virtual greenways. To this end, four virtual runs simulating bikers moving along a rural greenway at 25 km/h were created to find out first, what kind of planting combination along a rural greenway is the most preferred, and second, which planting combination is perceived as the most restorative by bicycle riders. To investigate preference and perceived restoration, virtual cyclists were administered questionnaires to assess qualitative measures. It is hypothesized that planting solutions characterized by greater variety and aesthetic flow would be more preferred and restorative.

2. Literature Review

To accomplish these aims, landscape design, the discipline that provides greenway design criteria, planting solutions and choices for materials construction, borrows the theoretical framework and methodology to assess the effect of different planting solutions on individual preferences and perceived restoration from environmental psychology, a discipline whose purpose is to understand the complex relationships between people and the environments around them.

2.1. Environmental Preference and Restorative Experiences

Environmental perception is not a passive process of registration but an active process of interaction between the individual and the environment. Humans' eyes and brains have evolved in order to extract from the natural world a sensible order that is crucial for survival [26], and to recognize certain patterns of stimuli in the environment that satisfy the biological need for comprehension and exploration and offer the opportunity for relief from stress and mental fatigue [27]. For this reason, human beings prefer natural environments or environments with natural attributes, namely those environments that give positive emotions and moods. In this regard, the Environmental Preference Model [28] identifies the predictors of environmental preference in four physical characteristics: coherence, complexity, legibility and mystery, which are the result of an evolutionary process in terms of humans' adaptation to the environment. The more the environment displays the right combination of predictors, the more it is preferred, because it meets the requirements of understanding and exploration [27].

Natural environments are highly preferred because they are perceived as more coherent, less complex, more legible and having the right level of mystery compared to built/artificial environments. Natural environments are preferred because they are also perceived as more restorative than built/artificial environments. Natural settings which allow positive changes in physiological activity levels and in behaviour and cognitive functioning, and more positively-tone emotional states are called "restorative" [28].

In attention restoration theory (ART) [29], voluntary attention is contrasted with involuntary attention. The former is effortful and can be tiring, whereas the latter is effortless and allows the attentional system to rest and recover. Unfortunately, everyday situations call for voluntary directed attention and the price paid is mental fatigue. It is important to find ways to restore the directed attention capacity; one way is exposure to natural environments. Attention can be categorized into two distinct functions: "bottom-up" attention, also known as stimulus-driven or exogenous, and "top-down" attention, also known as goal-driven or endogenous. In natural environments, mostly bottom-up involuntary attention is captured and people do not spend energy suppressing distracting stimuli [30,31]. In ART, this type of involuntary effortless attention has been referred to as fascination. Fascination is the most important characteristic of a restorative environment; thanks to fascination, directed attention can rest from mental/attentional fatigue and be restored. In addition, there are three other components that are likely to contribute to make an environment restorative: being-away (implies a setting that is distant either physically or conceptually from one's everyday routine/environment), extent (the environment's extension in time and space, whether the setting has sufficient coherence and scope to engage the mind and promote exploration), and compatibility (to what degree a setting fits and support one's inclination or purpose). Natural settings not only are liberally endowed with all of them and hence assessed as more restorative than urban environments, but also are more preferred [32,33]. Usually natural settings are distinct from everyday environments of modern urban dwellers (being-away), are rich and coherent (ecosystems to observe, trails, paths for exploration), contain many sources of fascination (water, animals, foliage) and provide a wide range of compatible connection to the setting (hiking, observation, walking, peaceful meditation, cycling, etc.) [34,35].

The restoration process is a mixture of fascination and pleasure (i.e., preference); not only do settings that encourage fascination involve an important aesthetic component, but environmental preference and psychological restoration are also strongly related [28,33,36].

The perception of restoration does not rely on naturalness only; on the contrary, it depends on a series of "sensorial semiotic aesthetic attributes" such as openness, mystery, complexity, order, vegetation, maintenance, style and perceived use [37,38]. Actually, fascination with nature derives from the quantity and quality of items displayed in Nature that people find appealing and pleasing [34]. The presence of trees is highly valuable for the urban environment [39], and streetscapes where there are trees and spaces beneath them, i.e., flowering herbs in combination with trees, have the greatest effect on street preference [40]. Studies of street-planting models [41] showed preferences for combined types of vegetation, e.g., tall trees in combination with ground cover, or tall trees in combination with low trees. Street plantings create a safer and more comfortable environment for pedestrians and help to separate them from traffic, increasing the use of pedestrian strips [42]. This effect was found more frequently for street plantings of a combined type, consisting of trees, shrubs and ground cover, than single formations consisting of only trees or shrubs. In brief, exposure to nature gives people an opportunity to recover cognitive resources and restore the optimal level of physiological activity and plays an important role in regulating emotions, as well as improving perceived well-being and promoting faster recovery from disease.

Vegetation offers natural fascinating distractions that have positive effects on one's sense of control and privacy (which are displayed through "temporary being-away" or "temporary escape"), and encourages personal relationships and physical exercise (estrangement from routines means to move away from stress sources) [43]. Greenways are more likely to promote activity than other green spaces because they serve a double purpose: they are transit corridors to reach school/work/recreational settings, etc., and destinations for leisure activity on their own [44]. In both cases, well-planted greenways may not only increase the number of users but have a regenerative effect too. All types of vegetation contribute to the visual improvement of streets and paths and provide delineation of spaces, but this aspect lacks investigation as far as greenways are concerned. In this study we wanted to evaluate users' preferences and perceived restorativeness of greenways: if greenways are appreciated and preference goes along with the perception of restorativeness, it means that they can help people in the process of restoration and recovery from stress.

2.2. Greenways: Experiencing a Landscape through Motion

Experiencing an environment by riding a bicycle is similar to the perception of a succession of images where both the subject and the items of the scene move within the visual field. In addition to what is done when driving, the cyclist needs to focus on the path, therefore the visual experience is not "complete" and the traveller fills knowledge gaps by imagining parts of the landscape he/she has missed seeing [45]. The traveller clearly sees the foreground and might imagine the background. However, the outlined silhouette between sky and landscape is particularly important because it is the most dominant edge in a typical landscape image, and it has been found to attract a lot of the viewer's attention. Along an unpaved rural greenway, pedestrian speed ranges from 3 km/h (families walking with children) to 10 km/h (runners), and bicycle speed ranges from 10 km/h (families with small children) to 35 km/h (adults in general) [13]. When people travel on foot along a greenway, their landscape perception is similar to what they may have when walking in a green area [46,47], whereas when people travel by bicycle, their perception is more similar to the what they have when they drive. Pedestrians and cyclists cover greenways at different speeds and they a perceive the surrounding landscape in different ways.

Unfortunately, there are few studies showing the effect on users of greenway planting design [25], while many studies show that roadside configurations have an effect on driver behaviour [48]. Comparing the physiological responses of subjects who watched a video of driving through nature with those who watched a video of driving through more built-up environments, Parsons et al. [49] found that the nature group had lower levels of stress and recovered more quickly from the stress they experienced.

Views of dense vegetation (vs. sparse and mixed) in fact enhanced drivers' ability to tolerate frustration [50]. In a survey assessing the scenic beauty of roadside vegetation in Northern England, the most preferred roadside vegetation type was a combination of grass and flowering herbs [51].

According to Blumentrath and Tveit's review [52], three aspects need to be considered when addressing the design of a road to make it visually attractive: the road has to be seen (1) as an independent structure, (2) in relation to its surroundings and (3) in relation to the traveller's movement. The following characteristics need to be considered:

Variety. This refers to landscape features. A variety of features and views from the road enhances the attractiveness and at the same time avoids monotony, reduces mental fatigue and enhances concentration [53]. A variety of landscape over time is equally appreciated, e.g., vegetation colour and shape change with the seasons, day and night landscapes differ in shades and sounds, etc. A "good" landscape has a balance between unity and variety [54].

Legibility. This is the degree to which a path is understandable for users [55]. This quality is connected more to safety than attractiveness; uncertainty about the direction to follow and/or the distance to cover generates stress in users.

Aesthetics of flow, rhythm and balance. This refers to travel experience as a result of motion and space. Travel speed is a basic aspect of the aesthetics of flow. "The speed of human visual perception is estimated at around 25 frames per second" [56]; considering a cycling speed of 25 km/h, this means cyclists perceive about 25 cm per frame. At this speed they are not able to perceive any planting elements that have a dimension smaller than 25 cm. Rhythm and balance maintain the continuity of the travel experience, easing mental fatigue. The aesthetics of flow includes "mystery" and "surprise," which enhance road attractiveness [52].

Orientation. This refers to the capacity of users to locate themselves in the landscape and understand progress in their movement. Disorientation causes anxiety, which in turn negatively affects the subjective perception of safety and attractiveness of the path experience in general. On the contrary, "orientation" enhances appreciation for the journey.

Greenways are public facilities and need to be designed addressing both safety and attractiveness for users, at the same time maintaining the integrity of the landscape environment [14]. Toccolini et al. [57] proposed a useful protocol to plan greenways at the regional level, made up of four phases: (1)

analysis of the landscape resources, existing green trails and historical route networks; (2) assessment of each element; (3) composite assessment and (4) definition of the greenways plan. To start, a greenways intervention plan includes identifying the missing sections and lacking connections along the route and the elements of greatest interest. Interventions may be classified in relation to their type and may include improvements to both the constructive characteristics and the junctions. During the planning phase, it is necessary to select the greenway users; the selection of the target will help in the next phase when the design elements will be singled out. Once the route is planned and the users are identified, in phase two, the designer needs to more specifically define the characteristics of the greenway, such as sections and other geometric characteristics, surface materials, road crossings, signs, support facilities (e.g., parking areas, rest rooms, drinking fountains, benches, etc.) and planting materials [14,58,59]. In particular, plant materials fill a number of roles in greenway design: they create a good microclimate for users [14], enhance the ecological [18] and visual [26] value, and offer structures around which to organize functions [60]. Plantings must not reduce visibility: users should have at least of 30 m of forward visibility. This is particularly important at approaches to intersections. When plant material is properly chosen, it has no impact on the pre-existing environment and can be inserted in tiny spaces. For these reasons and because they are inexpensive, trees and shrubs are usually planted along greenways because they fit perfectly in this kind of project. With respect to Blumentrath and Tveit's criteria [52], planting material is useful to enhance greenway variety: the number of species is vast, plants are different from one another and change every day and in every season, etc.; greenway legibility: trees and plants along the way support way-finding and can be used to separate different users, e.g., walkers from cyclists, cyclists from road traffic, etc.; greenway aesthetics of flow: plants with different characteristics, e.g., height, colour, etc., can be alternated to give rhythm; and greenway orientation: rows of trees, monumental trees in particular, are excellent landmarks.

3. Materials and Methods

Plantings enhance the ecological and visual qualities of rural greenways. To define design criteria for plantings along greenways, we considered users' assessments of planting design. It was hypothesized that planting combinations characterized by greater variety and aesthetic flow would be more preferred and restorative. To accomplish the study aim, it was decided to apply simulation techniques to create virtual scenarios to be assessed by users. It was decided to consider only cyclists, because the literature shows that rural greenways are mainly used by cyclists [53,61], for the exploratory approach of this study. Virtual scenarios were inspired by the flat rural landscape of Northern Italy. We defined scenario characteristics, video construction, instruments used for evaluation (referencing ART to measure restorativeness) and the procedure applied.

3.1. Participants

A total of 297 subjects (43.1% men and 56.9% women), whose ages ranged between 19 and 78 years (M = 39.3, SD = 14.7), were accepted to participate to the research study. The participants' levels of education were as follows: primary school, 2%; lower secondary school, 12.4%; upper secondary school, 43.1%; degree, 42.5%. Participants said they used a bicycle less than once a week (45.5%) and for leisure purposes (56%). Participants were recruited using a university mailing list, social media and personal networks.

3.2. Stimulus Material: Greenway Scenarios

To compare different planting solutions, we designed a plausible landscape, similar to that of the Po Valley, and we completed it with 4 possible planting layouts. Four greenway scenarios were devised; they were inspired by the typical rural greenway in the North Italy Plain, a very simple agricultural landscape, with no woods, few hedgerows, rows of trees and rural buildings scattered along the way. Videos reproduced a greenway at the beginning of the summer, when corn fields are green, wheat fields are already harvested and there are big round bales of hay mixed with alfalfa fields.

This kind of landscape is typical of intensive productive agricultural activity and is widespread in the Po Valley region [62].

We started drawing 2-dimensional scenarios using AutoCAD 2019 (Autodesk Inc., San Rafael, CA, USA). Two-dimensional files were imported in SketchUp 2018 (Trimble Inc., Sunnyvale, CA, USA) to create 3D scenarios. Render settings applied to the 3D model included good weather conditions, sun position at 10:30 (UTC +01.00) on 25 June in Voghera municipality (coordinates: 44.9833 north, 9.0166 east). The renderings simulated the scene observed by a cyclist at 1.85 m height moving in a north-to-south direction at 25 km/h. The video quality was enhanced by working with Thea Render (Altair Engineering Inc., Troy, MI, USA) for SketchUp software (Trimble Inc., Sunnyvale, CA, USA), and video creation was completed using VirtualDub software (free and open-source utility written by Avery Lee), which transforms sequences of images into a film. Finally, videos were uploaded on YouTube.

3.2.1. Geometric Characteristics of Greenways

Each virtual greenway was designed as a linear bicycle path with no curves, intersections, tunnels or bridges; when riding on a linear flat bicycle path, it is more likely that the cyclist will observe the planting configurations arranged along the sides. In Italy, no standard construction for greenways exists. According to the Italian laws on bike paths [63], the width of a 2-way path should be at least 2.5 m, therefore we planned a path of 3 m width plus 2.5 m shoulders (for drainage and planting, with trees planted 1.5 m inside the border line), for a section of 8 m [14]. The greenway surface material was asphaltic concrete, which supports most types of user functions, e.g., walking, running, skating, cycling, motorized mobility for handicapped individuals, etc.; it is accessible in all weather conditions and needs little maintenance.

3.2.2. Planting Combinations: Four Scenarios

The 4 scenarios were devised as follows. To start, it was necessary to identify the most widely used planting combinations in the North Italian Plain, and to this end surveys along 10 existing rural greenways had previously been conducted. In all, 18 surveys (some greenways showed different planting combinations for different stretches) were carried out along 45 km of trails. A greenway without any designed planting materials is the most common option (5 stretches for 16.2 km). Among greenways with designed planting materials, the most common options were a double row of trees (4 stretches for 10.6 km), shrubs combined with perennials (3 cases) and trees plus shrubs (2 cases). Other options were found only once; for more details see Table 1.

Consulting the international greenway handbooks [14,64] confirmed these arrangements as the ones used most often. Accordingly, 4 experimental scenarios were designed choosing planting layouts sustainable from both the agronomic and ecological point of view, i.e., using native species. Figure 1 shows the rendering and describes the 4 scenarios, and Table 2 summarizes the planting arrangements of the 4 scenarios.

Table 1. Planting arrangements found in the 18 surveys along greenways in the North Italian Plain.

Survey Number	Greenway Characteristics		
	Planting Arrangements		
	Length	Left Side	Right Side
1	3.2 km	*	*
2	4.5 km	Trees	Trees
3	2.4 km	Perennials	Shrubs
4	0.9 km	Shrubs	*
5	4.4 km	Shrubs	Trees
6	1.2 km	*	*
7	3.3 km	Trees	Trees
8	1.7 km	Perennials	Perennials
9	0.6 km	None	Trees
10	5.7 km	*	*
11	0.5 km	Perennials + trees	Perennials + trees
12	3.1 km	Perennials	Shrubs
13	2.0 km	Trees	Shrubs
14	1.5 km	Trees	Trees
15	2.7 km	Shrubs	Perennials
16	3.9 km	*	*
17	2.2 km	*	*
18	1.3 km	Trees	Trees

* No designed planting materials.

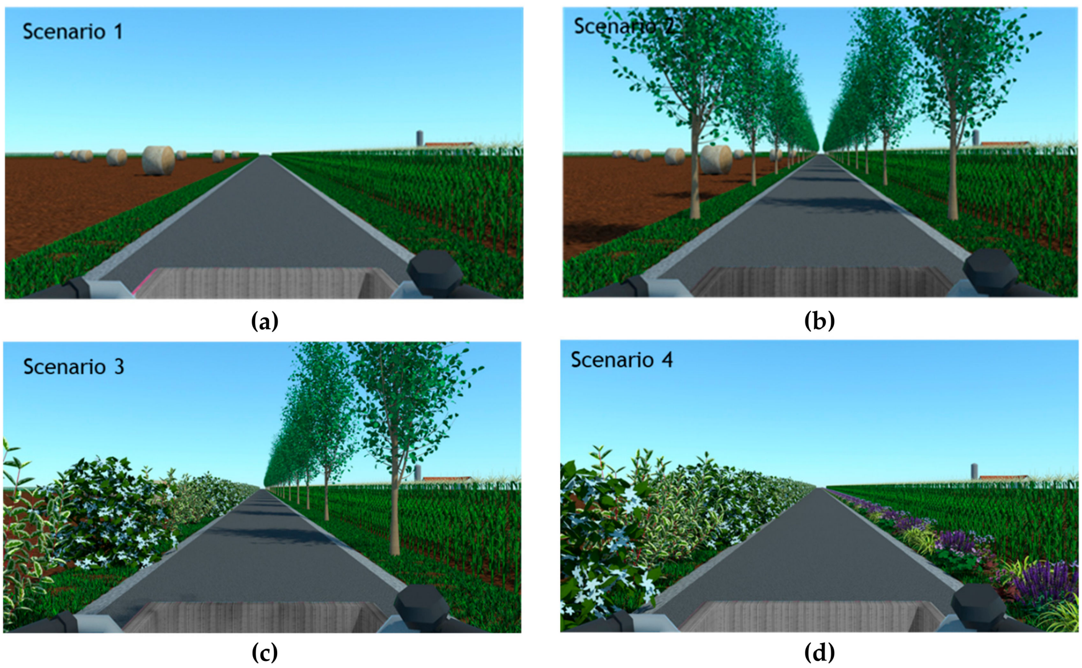

Figure 1. (**a**) Scenario 1 shows no designed planting materials (Video S1: scenario1extract.avi); (**b**) scenario 2 shows a row of large trees with columnar canopies on both sides (Video S2: scenario2extract.avi); (**c**) the arrangement of scenario 3 consists of one row of large trees on the right side and shrubs on the left side (Video S3: scenario3extract.avi); (**d**) in scenario 4, shrubs were added on the left side and perennials on the right side (Video S4: scenario4extract.avi).

Table 2. Planting arrangements of the four experimental scenarios.

Scenario	Plant Types		Planting Layout		Canopies	
	Left Side	Right Side	Distance in the Row	Height	Left Side	Right Side
1	Spontaneous Ground cover		–		–	
2	Trees	Trees	9 m	20–30 m	Columnar	
3	Shrubs	Trees	2 m/9 m*	2–6 m/9 m*	Globose	Columnar
4	Shrubs	Perennials	2 m/0.5 m*	2–6 m/0.5 m*	Globose	–

* The first measure is for plants on left side, the second measure is for plants on right side.

Scenario 1 shows no designed planting materials along the greenway; the view is open to the background rural landscape. This scenario is the control condition. Scenario 2 shows a row of large trees with columnar canopies on both sides, which are 9 meters from one another. This tree pattern allows the view of the background and offers enough room for trees to grow, reducing maintenance costs. *Populus alba L.* is the selected native species. The arrangement of scenario 3 consists of one row of large trees on the right side and shrubs on the left side. The right side is the same as that of scenario 2, whereas the left side is composed of mixed shrubs that reduce the view of the background. Native shrubs were chosen: *Crataegus monogyna Jacq.* (A) and *Cornus sanguinea L.* (C), alternating according to the AABAA BBABB AABAA BBABB sequence to create variety and aesthetic flow. In scenario 4, shrubs were added on left side and perennials on the right side. The layout of shrubs is the same as that of scenario 3. The perennials on the right side are mixed and their 0.5 m height permits the view of the background landscape. The present species are *Aster dumosus*, *Geranium endressii*, *Liriope muscari*, *Molinia caerulea*, *Monarda didima*, *Phlox paniculata* and *Salvia superba*. These combinations were thought to be good choices to evaluate users' preferences between different planting sizes (trees vs. shrubs) and openness to the landscape (closed vs. open views).

3.3. Instruments

According to ART, to assess the experience of virtual greenways, participants were administered a questionnaire made up of the following scales: (i) the Perceived Restorativeness Scale-11 (PRS-11), to assess the perceived restorative capacity of a environment, with additional items considered to assess familiarity, compatibility, and preference; (ii) a set of physical and aesthetic attributes of landscape; and (iii) participants' socio-demographic information (age, gender, level of education, residence, occupation and bicycle use). All scales were administrated in Italian.

Perceived Restorativeness Scale (PRS). PRS-11 (Pasini et al. [65] based on the original version by Hartig et al. [66]) measures an individual's perception of 4 restorative components (alpha = 0.89 [67]; alpha = 0.87 [35]): being-away (a context that permits physical and/or psychological separation from request on directed attention); fascination (attention stimulated by interesting things; a context that induces curiosity and fascination, supposed to be effortless and without capacity limits); coherence (a context where activities and objects are ordained and well organized); and scope (a context that is sufficiently vast enough to no limit movement, becaming a "world of its own"). Since it was recently argued that the individual environment fit affects perceived restorativeness and environmental preference [68], 3 additional items were included to assess compatibility (referring to the fit between environmental supports for intended activities and the individual's inclinations); these items were taken from the original version of the PRS (made up of 29 items) [66]. Also taken from the original PRS were the items assessing preference and assessing familiarity, which is considered to play a role in both preference judgement [31] and the perceived restorative value of an environment [68]. All items are rated on a 10-point scale, where 0 = not at all, 6 = rather much and 10 = completely.

Physical–aesthetic attributes. A set of attributes, which have proven to be reliable in others researches, was used to assess the subjects' perception of these followingphysical–aesthetic attributes [37]: visual diversity/richness vegetation, harmony/congruence, luminosity, openness/spaciousness, representativeness, maintenance/upkeep, cleanliness, place for leisure activities, novel place and meeting place and (alpha = 0.83 [35]), by addition of tranquillity and safety (alpha = 0.75 [67]). Attributes are ranked on a 5-point scale, where 0 = not at all and 5 = a lot.

3.4. Procedure

The videos and assessment instruments were administered online. After accepting the invitation, each participant was given a brief general overview of the study, and then was randomly directed to the video of one scenario. The participant watched the video for 60 s and then answered the questionnaire. The questionnaire appeared after watching the video and was placed in the same web page below the video in order to permit repeat views when necessary. Each participant's informed consent was obtained and confidentiality guaranteed. Underage persons and uncompleted questionnaires were automatically excluded from the dataset. The data collection was in digital form and took 3 weeks.

4. Results

First, the mean scores of the sensorial, symbolic and aesthetic attributes were calculated for each scenario. Similarly, the mean score of the PRS-11, considering the summed overall score for all 11 items, of compatibility (COM), preference (PREF) and familiarity (FAM) were calculated for each scenario. Inferential statics were run on the descriptive statistics.

4.1. Sensorial, Symbolic and Aesthetic Attributes

The four scenarios had average scores for leisure activities and meeting places and were not considered novel places; the result concerning novelty does not come as surprise, as the scenarios were inspired by the most popular greenway types in the area.

All scenarios were assessed as safe places, though the sense of safety was slightly reduced in scenarios 2 and 3, characterized by trees on one or both sides, over scenarios 1 and 4, where they are lacking.

Table 3 shows scenarios 3 and 4 scoring the highest for vegetation and diversity; the participants' assessment reflects exactly the amount of greening, which increases from scenario 1 to scenario 4. Regarding diversity, though scenario 4 shows the most species, participants gave the highest evaluation for scenario 3; probably the richness of small perennial species in this scenario was not correctly perceived when cycling.

Table 3. Mean scores (and standard deviations) of sensorial, symbolic and aesthetic attributes of each scenario. Scores are on a 5-point Likert scale, where 0 = not at all and 5 = a lot.

Attributes	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
Vegetation	3.49	(1.01)	3.86	(0.92)	4.11	(0.81)	4.40	(0.75)
Diversity	1.93	(0.81)	2.62	(1.10)	3.11	(1.05)	3.04	(1.10)
Harmony	3.21	(1.14)	3.51	(0.96)	3.42	(1.04)	3.54	(0.92)
Openness	3.20	(0.99)	3.64	(1.00)	3.39	(1.04)	3.23	(1.14)
Luminosity	3.89	(0.85)	4.00	(0.92)	3.92	(0.85)	3.85	(0.91)
Representativeness	2.92	(1.07)	3.28	(1.16)	3.18	(1.11)	3.08	(1.16)
Cleanliness	4.21	(0.80)	4.45	(0.81)	4.35	(0.82)	4.43	(0.65)
Maintenance	3.96	(0.85)	4.28	(0.97)	4.17	(0.80)	4.20	(0.77)
Leisure activities	2.25	(1.13)	2.35	(1.15)	2.54	(1.13)	1.98	(1.10)
Meeting place	1.90	(0.77)	2.28	(1.22)	2.49	(1.11)	2.1	(1.14)
Novel place	2.11	(1.03)	2.32	(1.00)	2.71	(1.05)	2.56	(1.11)
Safety	3.61	(0.96)	3.58	(0.97)	3.57	(1.00)	3.63	(1.01)
Tranquillity	3.86	(0.79)	4.00	(0.90)	4.04	(0.83)	3.99	(0.97)

Scenarios 2 and 4 were appreciated for the harmony of the planting design, while scenario 3 scored the lowest among scenarios with planting combinations. Though scenario 1, the control condition, shows no planting design and the view is wide open, openness was more characterized for scenario 2, which is made up of double rows of trees; the same for luminosity, which scored the lowest for scenario 1 and the highest for scenario 2.

The presence of vegetation is positively related to the representativeness of the greenway. Once again, scenario 2, which shows a very simple planting combination, scored the highest on representativeness, whereas scenario 1 was the lowest. Scenarios scored almost the same on cleanliness: the absolute absence of waste, leaves or other materials on the ground is typical of virtual videos; the same for maintenance.

At this point, principal component analysis (PCA) was run on the sensorial, symbolic, and aesthetic attributes; however, before performing PCA, the data sampling adequacy was investigated. The correlation matrix (see Table 4) shows that all the correlations are significant (except for diversity*cleanliness), and most of them are equal to or higher than 0.3.

Table 4. Pearson's bivariate correlation between sensorial, symbolic and aesthetic attributes.

	Vegetation	**Diversity**	**Harmony**	**Openness**	**Luminosity**	**Representativeness**	**Cleanliness**	**Maintenance**	**Leisure activities**	**Meeting place**	**Novel place**	**Safety**	**Tranquillity**
Vegetation	1	0.552**	0.463**	0.239**	0.246**	0.431**	0.349**	0.341**	0.254**	0.250**	0.301**	0.240**	0.331**
Diversity	0.552**	1	0.446**	0.245**	0.196**	0.429**	0.068	0.145*	0.365**	0.382**	0.514**	0.156**	0.284**
Harmony	0.463**	0.446**	1	0.378**	0.399**	0.524**	0.330**	0.283**	0.328**	0.366**	0.386**	0.281**	0.357**
Openness	0.239**	0.245**	0.378**	1	0.592**	0.412**	0.384**	0.311**	0.342**	0.330**	0.267**	0.389**	0.398**
Luminosity	0.246**	0.196**	0.399**	0.592**	1	0.383**	0.538**	0.451**	0.324**	0.272**	0.260**	0.444**	0.513**
Representativeness	0.431**	0.429**	0.524**	0.412**	0.383**	1	0.344**	0.301**	0.423**	0.459**	0.450**	0.286**	0.293**
Cleanliness	0.349**	0.068	0.330**	0.384**	0.538**	0.344**	1	0.693**	0.129**	0.153**	0.154**	0.434**	0.483**
Maintenance	0.341**	0.145*	0.283**	0.311**	0.451**	0.301**	0.693**	1	0.171**	0.134**	.1	0.323**	0.373**
Leisure activities	0.254**	0.365**	0.365**	0.342**	0.324**	0.423**	0.129*	0.171**	1	0.669**	0.488**	0.242**	0.302**
Meeting place	0.250**	0.382**	0.366**	0.330**	0.272**	0.459**	0.153**	0.134**	0.669**	1	0.515**	0.247**	0.289**
Novel place	0.301**	0.514**	0.386**	0.267**	0.260**	0.450**	0.154**	0.100**	0.488**	0.515**	1	0.290**	0.312**
Safety	0.240**	0.156**	0.281**	0.389**	0.444**	0.286**	0.434**	0.323**	0.242**	0.247**	0.290**	1	0.641**
Tranquillity	0.331**	0.284**	0.357**	0.398**	0.513**	0.293**	0.483**	0.373**	0.302**	0.289**	0.312**	0.641**	1

**, * Correlation is significant at the 0.01 level and 0.05 level (two-tailed), respectively.

From the greenway planting design perspective, the most interesting correlations are for vegetation and diversity, harmony and luminosity, and safety and tranquillity. The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy is 0.85 ($p > 0.05$), i.e., higher than the suggested value of 0.7, and Bartlett sphericity test ($p < 0.05$) suggests that factor analysis is useful because a proportion of variance may be caused by underlying factors.

From the varimax rotation applied to the PCA run on the sensorial, symbolic and aesthetic attributes, it turned out that three components accounted for 62.99% of the total variance. The first component was mostly correlated with openness, luminosity, cleanliness, maintenance, safety and tranquillity; the second component clustered leisure activities, meeting place and novel place; the third component gathered vegetation, diversity, harmony and representativeness (see Table 5). Attributes loading on component 1 recalled legibility [52] and actually referred to the greenway display, while those loading on component 3, more concerned with aesthetics and vegetation, recalled variety; these components were named legibility and variety, respectively. Attributes loading on component 2 were more concerned with opportunities for play activities and encountering people, and it was named sociality.

Table 5. Rotated components matrix with clustered variables.

	Component 1	Component 2	Component 3
Vegetation	0.208	0.055	0.822
Diversity	−0.033	0.419	0.710
Harmony	0.301	0.295	0.619
Openness	0.603	0.376	0.094
Luminosity	0.758	0.248	0.107
Representativeness	0.292	0.426	0.544
Cleanliness	0.805	−0.138	0.286
Maintenance	0.690	−0.180	0.362
Leisure activities	0.179	0.791	0.141
Meeting place	0.146	0.801	0.180
Novel place	0.097	0.681	0.354
Safety	0.699	0.268	−0.003
Tranquillity	0.700	0.270	0.141

As far as the first component is concerned, there are no significant differences among scenarios, which all scored high on attributes loading on legibility (see Figure 2); regarding sociality, where scores are average, scenario 3 turned out to be the most suitable as a place for meeting and leisure activities. Finally, the variety component shows significant differences between scenario 1 (control condition, no designed planting) and the other scenarios.

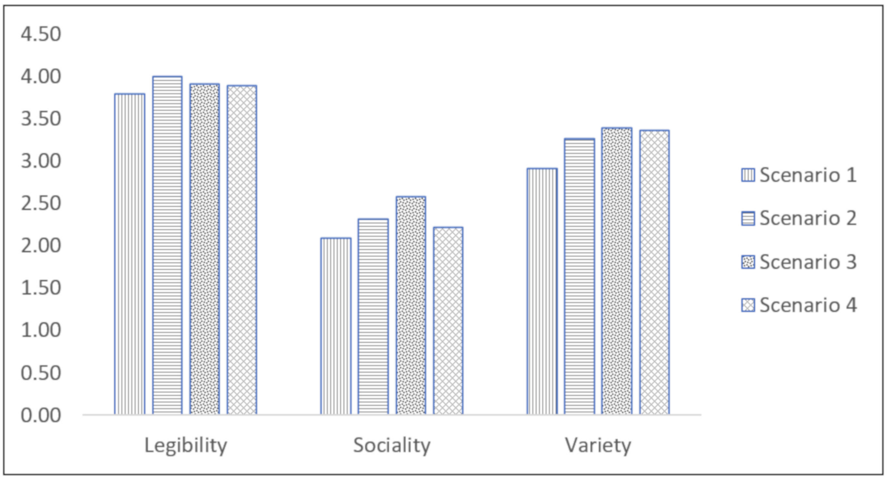

Figure 2. Mean scores for the three components of sensorial, symbolic and aesthetic attributes.

4.2. PRS-11, Restorative Factors, Preference and Familiarity

The PRS measured the subjects' perception of the restorative value of the scenarios. The highest PRS scores were for scenarios 3 and 2, followed by scenarios 4 and 1 (see Table 6). Focusing on the restorative factors, being-away (BA) and fascination (FA) scores showed the same trend of the PRS total score across scenarios; in particular, scenario 3 scored the highest for PRS and BA and FA. Scenario 3 was also assessed as the most coherent across scenarios, although coherence (COH) is a feature that highly characterizes all scenarios in the same way. On the contrary, all scenarios scored low on scope (SCO), as if the virtual greenways were not perceived as places to be explored. Compatibility (COM) scores were average for all scenarios, though scenario 2 and 3 were perceived as the most compatible.

Table 6. Mean scores (and standard deviations) of Perceived Restorativeness Scale (PRS-11) (summary score) of the five restorative factors making up the scale of preference and familiarity for each scenario. Scores are on an 11-point Likert scale, where 0 = not at all, 6 = rather much, 10 = completely.

	Scenario 1		**Scenario 2**		**Scenario 3**		**Scenario 4**	
PRS-11 (PRS)	5.70	(1.98)	6.03	(1.60)	6.27	(1.92)	5.81	(1.97)
Being-away (BA)	5.36	(2.88)	5.99	(2.48)	6.56	(2.24)	5.93	(2.74)
Fascination (FA)	5.08	(2.67)	5.53	(2.40)	5.68	(2.35)	5.09	(2.70)
Coherence (COH)	7.25	(1.59)	7.25	(1.82)	7.59	(1.64)	7.44	(1.63)
Scope (SCO)	4.81	(2.179)	4.99	(2.29)	4.76	(2.62)	4.26	(2.48)
Compatibility (COM)	5.47	(3.019)	5.67	(2.68)	5.64	(2.56)	5.47	(2.66)
Preference (PREF)	5.80	(3.16)	6.55	(2.60)	6.69	(2.54)	5.95	(3.04)
Familiarity (FAM)	6.55	(2.98)	6.73	(2.78)	6.15	(2.59)	4.99	(2.75)

As far as preference (PREF) is concerned, these scores show exactly the same trend as the PRS total score, with scenarios 3 and 2 turning out to be the most preferred. Finally, the most familiar (FAM) were scenarios 2 and 1, representing a rural landscape very common in the North Italian Plain.

As is already known in the literature [33,35,36,68], our results show a linear relationship between the perception of the restorative value of a scenario and the preference assessment (see Table 7). This is particularly true for scenario 3, which not only is the most preferred, but also the most restorative, being highly characterized by BA, FA and COH. The role of familiarity is not that clear in the perception of the restorative value of a place though our results show a positive relationship between PRS, PREF and FAM (see Table 7), with a clear trend for the less familiar scenario, scenario 4, which is also the less restorative and less preferred among the scenarios with planting combinations; the most familiar scenario, scenario 2, is not characterized by the opposite trend.

Table 7. Pearson's bivariate correlation between PRS-11, preference and familiarity.

	PRS-11	**Preference**	**Familiarity**
PRS-11	1.0	0.865**	0.518**
Preference	0.865**	1.0	0.484**
Familiarity	0.581**	0.484**	1.0

** Correlation is significant at the 0.01 level (two-tailed).

Table 8 shows the correlations between PREF, FAM and the five restorative factors; these values confirm the role of BA and FA on PREF value.

Table 8. Pearson's bivariate correlation between preference, familiarity and the five restorative factors.

	Being-away	**Fascination**	**Coherence**	**Scope**	**Compatibility**
Preference	0.857**	0.854**	0.496**	0.604**	0.572**
Familiarity	0.473**	0.483**	0.352**	0.412**	0.497**

** Correlation is significant at the 0.01 level (two-tailed).

Pearson's bivariate correlation between PRS and PREF is high and positive across all scenarios, whereas the correlation between PRS and FAM shows differences across scenarios (see Table 9); in particular, it is higher for scenarios that were rated as more familiar.

Table 9. Pearson's bivariate correlation between PRS-11, preference and familiarity across the four scenarios.

		Preference	Familiarity
Scenario 1	PRS-11	0.892**	0.674**
Scenario 2	PRS-11	0.827**	0.535**
Scenario 3	PRS-11	0.845**	0.462**
Scenario 4	PRS-11	0.891**	0.448**

** Correlation is significant at the 0.01 level (two-tailed).

4.3. Preference

Preference (PREF) was analyzed in terms of participants' socio-demographic characteristics, and with the sensorial, symbolic and aesthetic attributes. Spearman's rank correlation showed no correlation between participant's age and PREF for the scenario: Rs = –0.074 (< 24 years: M = 6.52 (SD = 2.60); 25–34 years: M = 6.50 (SD = 2.80); 35–44 years: M = 6.21 (SD = 2.76); 45–54 years: M = 6.12 (SD = 2.91); > 54 years: M = 5.80 (SD = 3.25). There is a low correlation between participant's gender and PREF for the scenario: Rs = 0.228 for men (M = 5.58, SD = 2.69), lower than women (M = 6.75, SD = 2.88). The PREF scores across levels of education are: primary school: M = 8.26 (SD = 2.40); junior high school: M = 6.37 (SD 2.79); high school: M = 5.46 (SD = 2.73); degree: M = 6.25 (SD = 2.86). Participant's level of education and PREF for the scenario are inversely related: Rs = –0.323.

Table 10 shows that the correlations between preference and all sensorial, symbolic, and aesthetic attributes are positive and significant (except for cleanliness); however, the most interesting (> 0.40) concern the attributes assessing the opportunity to engage in physical and/or social activities (leisure activities, meeting place) along the greenway, and the greenway's representativeness and harmony. Vegetation positively correlates with preference, though the relation is not strong as expected. Table 11 shows the correlation between PREF and the three components from the PCA, legibility, sociality and variety; PREF positively correlates with the three factors, showing the highest relation with sociality, followed by variety.

Table 10. Pearson's bivariate correlation between preference (PREF) and sensorial, symbolic and aesthetic attributes.

	PREF
PREF	1.0
Vegetation	0.240**
Diversity	0.336**
Harmony	0.420**
Openness	0.363**
Luminosity	0.334**
Representativeness	0.484**
Cleanliness	0.103
Maintenance	0.151**
Leisure activities	0.530**
Meeting place	0.514**
Novel place	0.362**
Safety	0.286**
Tranquillity	0.316**

** Correlation is significant at the 0.01 level (two-tailed).

Table 11. Pearson's bivariate correlation between PREF and the three components gathering sensorial, symbolic and aesthetic attributes.

Heading	Legibility	Sociality	Variety
PREF	0.359**	0.560**	0.483**
Legibility	1.0	0.393**	0.497**
Sociality	0.393**	1.0	0.580**
Variety	0.497**	0.580**	1.0

** Correlation is significant at the 0.01 level (two-tailed).

4.4. Perceived Restorativeness

The perception of the restorative value of the scenarios (PRS) was analyzed in terms of the participants' socio-demographic characteristics and the sensorial, symbolic and aesthetic attributes. One-way ANOVA showed no significant effect of age (5 levels: < 24, 25–34, 35–44, 45–54, > 54 years) on participants' perceived restorativeness score, though the mean score of participants younger than 24 years was the highest (PREF scores: < 24 years: M = 6.18, SD = 1.73; 25–34 years: M = 5.95, SD = 1.70; 35–44 years: M = 6.13, SD = 2.14; 45–54 years: M = 5.95, SD = 1.96; > 54 years: M = 5.47, SD = 2.26). Spearman's rank correlation showed a low correlation between gender and PRS score: Rs = 0.243, with men (M = 5.52, SD = 1.99) scoring higher than women (M = 6.27, SD = 1.86). The descriptive statistics showed an inverse correlation between the PRS score and the participant's level of education: the perception of restorative value decreases with education (primary school: M = 7.42, SD = 1.84; junior high school: M = 7.37, SD 1.71; high school: M = 6.05, SD = 1.877; degree: M = 5.37, SD = 1.86).

The restorative value positively correlates with all sensorial, symbolic and aesthetic attributes (see Table 12), though the most interesting correlations are, again, with those attributes assessing the possibility to engage in social/physical activities (leisure activities, meeting place, novel place) and stressing the representativeness of the greenway. Unexpectedly, the perceived restorative value shows a low correlation with vegetation.

Table 12. Pearson's bivariate correlation between PRS and sensorial, symbolic and aesthetic attributes.

	PRS
	1.0
Vegetation	0.214**
Diversity	0.361**
Harmony	0.409**
Openness	0.368**
Luminosity	0.312**
Representativeness	0.464**
Cleanliness	0.129*
Maintenance	0.133**
Leisure activities	0.574**
Meeting place	0.612**
Novel place	0.439**
Safety	0.281**
Tranquillity	0.316**

*, ** Correlation is significant at the 0.05 level and 0.01 level (two-tailed), respectively.

Table 13 shows the correlation between PRS score and the three components from PCA: legibility, sociality and variety. The scenario restorative value positively correlates with the three attributes, the highest with sociality, followed by variety.

Table 13. Pearson's bivariate correlation between PRS and the three components gathering sensorial, symbolic and aesthetic attributes.

	Legibility	Sociality	Variety
PRS	0.355**	0.646**	0.474**
Legibility	1.0	0.393**	0.497**
Sociality	0.393**	0.1	0.580**
Variety	0.497**	0.580**	1.0

** Correlation is significant at the 0.01 level (two-tailed).

5. Discussion

This exploratory study aimed to verify whether greenway vegetation (varying in quantity and quality) affects people's preferences and perceived restorativeness on a virtual bicycle tour. Participants' gender and age did not affect scenario preference, whereas level of education showed an inverse correlation with preference. Participants' characteristics did not affect the perception of the scenario's restorative value either, except, once again, for the level of education. Individual characteristics may affect preference directly or moderate its relationship with perceived restorativeness. The inverse relation between participant preference and level of education highlights the different use and, accordingly, appreciation of technology and simulated environments by individuals of different ages, i.e., younger people appreciate virtual scenarios more than older people. However, preference was affected by the participant's perception of the restorative factors characterizing the scenario: fascination, being-way, coherence, scope and compatibility, as the literature suggests.

Regarding the sensorial, symbolic and aesthetic attributes, those that affected preference more were not concerned with the greenway display exclusively, but also the opportunity the greenway offers to engage in social and/or physical activities. This means that the degree of naturalness, i.e., planting quality/quantity, is not the main factor affecting preference. The landscape "naturalness" is one of the most accounted predictors for preference [28]. However, Sevenant and Antrop indicate "varied," "quiet and silent" and "attractive vegetation" as good predictors of landscape preference [69], whereas for Zhang et al. [70] "accessibility" and "safety" are the most predictive attributes. All of these attributes were included in our list of greenway attributes to be assessed. The relationship between landscape aesthetics and physical attributes and preference may be of great interest to landscape designers to better define design criteria for greenway planting; the most interesting correlations concern vegetation and diversity, harmony and luminosity, safety and tranquillity.

Familiarity seems to not play a role in preference and the perception of the restorative value of the scenarios. An individual's familiarity with a planting combination makes it easier to comprehend the surroundings and sustain greenway exploration in a situation where information is gathered at a certain speed of movement and uncertainty may be expected. Our study shows that the quantity of vegetation along a greenway does not affect preference and perceived restorativeness, as expected, whereas, the quality (planting combination) seems to play a bigger role. Of course, the presence of designed vegetation makes a difference to participants' preference; in fact, the only scenario with no designed vegetation, scenario 1, was the least preferred among scenarios. Among scenarios with designed vegetation, scenario 3, which scored the highest on diversity, was the most appreciated and perceived as the most restorative. A variety of vegetation combinations prompts fascination and enhances pleasure along a greenway. Among the stimulus materials, scenario 4 was devised as the most "varied"; nevertheless, scenario 3, characterized by a lower degree of variety, turned out to be the most preferred. Regarding preference for scenario 4, this result suggests that: (1) variety planned by designers may not be perceived by cyclists because they do not have enough time to grasp all the features; and (2) planned variety may be perceived as "complex" by people, i.e., too many features to attend to, which negatively affects preference. On the contrary, the vegetation combination of scenario 3 matches Blumentrath and Tveit's [52] road design criteria, showing a mix of trees and shrubs to guarantee variety and supporting way-finding and orientation, and shrubs of different sizes to give aesthetics of flow and rhythm to the path.

6. Conclusions

Through exploratory analysis, this study shows that combinations of vegetation along a greenway matter. Landscape designers should take into account planting, in particular how it matches the surrounding landscape (i.e., sustains familiarity) and may arouse interest (i.e., evoke fascination) in order to enhance preference and perceived restorativeness.

Virtual videos may be of great help in planning a greenway. Referring to the protocol devised by Toccolini, Senes and Fumagalli [57], greenway simulation could easily become part of the phase where each element of the greenway is assessed in relation to the identified target users. This study focused on the preference and perceived restorativeness of cyclists, the most representative greenway users, but greenways are multifunctional and multiuser routes, therefore a next step in research would be to investigate and compare assessments for vegetation combinations of walkers, runners, skaters, etc. Other aspects to take into account in future research include: (1) seasonal changes of the greenway; to boost use of the greenway all year round, users' preferences and perceived restorativeness should be verified in relation to combinations of vegetation typical of the winter/cold season too; and (2) perception of greenways with curves and other difficulties in which the vegetation can hinder visibility. A geographic information system can be very useful to create surrounding landscape with various altitudes and exposures. Finally, it will be necessary to evaluate whether people's preferences and perceived restorativeness may be influenced by their cultural and social background; for example, considering participants from other parts of Italy or from other countries who are not familiar with this kind of landscape. In this study, participants were asked only to assess the restorative value of the greenway, and there was no research on the restorative effect of the vegetation combinations on their cognitive abilities (attentional performance). This exploratory study is the very first step of a broader project aimed to give hints for planning and designing greenways from the restorative perspective.

Supplementary Materials: The following are available online at http://www.mdpi.com/2071-1050/12/5/2120/s1, Video S1: scenario1extract.avi, Video S2: scenario2extract.avi, Video S3: scenario3extract.avi, Video S4: scenario4extract.avi.

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