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The Unexploited Potential of Converting Rail Tracks to Greenways: the Spanish *Vías Verdes*

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Abstract: The reuse of Spain's obsolete railway infrastructure as greenways, namely *vías verdes*, reflects a Europe-wide territorial strategy, which has resulted in the refurbishment of more than 2500 km of abandoned Spanish railway lines. The potential of these *vías verdes* as strategical green infrastructure linkers between settlements and their peripheral natural environments is assessed in two Spanish case studies of Girona and Alicante. The territorial elements that affect *vías verdes* (natural landscape areas, urban settlements and population) are obtained from public administration sources. Additionally, users' activity through the Wikilock social network is considered. The spatial analysis shows the role of *vías verdes* in terms of landscape value, accessibility and planning strategy: the itineraries of the *vías verdes* connect different valuable natural areas with diverse landscape patterns in near proximity to urban nuclei; more than 65% of the population can access a *vía verde* in less than 200 metres. Moreover, it offers the opportunity to complete a network which could link urban nuclei and their natural periphery through the refurbishment of the remaining stretches. Despite the fact that the full potential of these *vías verdes* as strategical greenways has not been fully considered in the green infrastructure planning, these corridors could meet environmental, cultural and social sustainable goals.

Keywords: greenway; *vía verde*; green infrastructure; landscape connectors; urban planning; regional planning; leisure infrastructure

1. Introduction

Railways played a fundamental role in articulating European territory from the mid-19th century onwards, and nowadays more than 70% of the original tracks remain operative [1]. Although railway networks were developed independently according to the transport plans of each country, there were many common technical considerations, which in turn meant that similar solutions were applied across Europe. Hence, once obsolete and no longer profitable, rail tracks underwent similar refurbishment projects and provided a remarkable range of routes suitable to be reused as a type of green infrastructure (GI) element known as rail-trails (*vías verdes* in Spanish).

Motivated by the fact that Spain has one of the most developed European network systems of refurbished rail trails, this research explores the extent to which these transformations have been carried out, considering the full potentiality of these new stretches as GI linkers, both in urban and regional planning.

The refurbishment of obsolete rail track itineraries, converting them into accessible greenways, is directly connected with the concept of GI. The term greenway brings together the notion of user-friendly standards, local journeys, leisure activities and environmental benefits [2]. In Spain, these *vías verdes* are being promoted as healthy and sustainable mobility paths by municipal authorities, mainly linked to leisure or tourism activities. Moreover, the refurbished stretches are a successful

initiative from the viewpoint of sustainable leisure activities, according to the Spanish Greenways Programme [3].

The most outstanding features of the adapted rail tracks include the following: connectivity between urban areas and their surroundings; interesting route paths linked with changing landscape areas; and universal accessibility due to gentle slopes [4,5]. All these features take advantage of the former railway corridor design conditions. Therefore, most of the reused stretches have been easily adapted in order to be used in a polyvalent way by municipalities so as to fulfil their full ecological functions, such as providing recreational areas or protecting remaining heritage landmarks [6]. In fact, the GI concept has evolved, and adopted slightly different meanings in line with specific research approaches which fit perfectly with the multifunctional roles of greenways. For instance, in the literature, GI has been referred to as:

- Biological corridors [7,8].
- Networks of green spaces or green elements, such as belts, avenues or green public realm, which introduce nature to the artificial urban environment [9].
- Urban networks that are designed in an environmentally friendly manner, i.e., water treatment facilities [10,11].
- Eco-corridors, ecological framework for environmental, social and economic health [12].

In the aforementioned cases, connectivity is one of the common key focuses of these approaches and relates to the GI network's structural and functional aspects. The structural aspect refers to the physical characteristics of the GI, and the functional aspect covers the goals aimed at improving ecological conditions, environmental livability and economic growth [6,9], which is fully aligned with the European Union strategy on GI as an essential component of spatial and physical planning [13,14].

Nowadays, one of the main objectives is to improve urban environmental conditions [14]. In this context, the planning and implementation of a GI network emerges as a strategy that is currently being adopted [13]. In addition, initiatives such as the refurbishment of obsolete rail-trail itineraries in the proximity of villages and cities are promoted as healthy outdoor activity routes [15], but surprisingly the role of these new *vías verdes* interrelated with the urban periphery has received limited attention in the research literature, and in their integration within planning strategy practice.

Thus, the focus of this study is to determine whether the transformation of these *vías verdes* could become strategical GI linkers between urban settlements and their peripheral natural environments. For this purpose, the distribution and accessibility of these refurbished rail-trails to the urban nuclei, population and natural landscapes has been addressed and evaluated.

Following a territorial planning approach, the specific objective of this study is to understand the full potential of the greenways as multiscalar linkers (local, city, regional or national) between elements of a different nature, both natural and human-made. Therefore, this study seeks to provide a reference framework in order to identify opportunities for improving urban environmental conditions through planning tools.

Since the mid-1980s, the European Greenways Association (EGWA) [16], following the wake of the Great American Rails-to-Trails Conservancy [15], has provided general information sources for public administration bodies, prospective investors and users, promoting the creation of leisure paths, both for walkers and cyclists [17]. The main focus of these strategies pursued the encouragement of healthy lifestyles and sustainable mobility. However, it was not until 2010 that an explicit recommendation for incorporating greenways into local planning policies and tourism strategies was made, thus urging the necessary harmonization of quality design standards. From this perspective, an additional objective of this research is to examine, by case-study analysis, the consideration of *vías verdes* as elements of a GI network where the key components are not only the physical and natural aspects, but also land-use planning strategies and values related to community engagement with landscape (i.e., environmental, strategic, cultural and visual planning) [5].

In connection with the latter, this research aims to demonstrate that the integration of greenways with other elements of spatial planning would help to better interlink the consolidated urban areas with their natural periphery. However, in addition, regardless of the large development of *vías verdes*

in Spain, these are not properly articulated within the territorial planning strategies, so their potentialities remain unexploited due to the late perception of greenways as strategical linkers, other than being considered an outdoor leisure option.

For this purpose, the methodology applied is followed throughout the structure of this paper in five stages (summarized in Figure 1). First, in order to define a theoretical framework, a literature review is presented, starting with the emergence and later definition of the greenway concept, followed by a wider approach to greenways as part of GI networks and a broader land-use planning strategy. Additionally, focusing on the European and Spanish context, the current rail-trails are analysed in terms of the amount of existing and transformed stretches per country and province in Spain. Second, two case studies have been carried out for their representativeness—Girona and Alicante are used as illustrative examples of the same landscape corridor reuse strategy with a contrasting implementation, which in turn permits us to reflect on the role of these refurbished rail tracks beyond their function as a leisure facility. Third, different public administration sources affecting greenway routes [3] are collected: landscape patterns [18], urban settlements [3] and population [19], as well as data retrieved from the Wikilock social network. Fourth, this data is contrasted and mapped, showing the different relations with the *vías verdes* routes. Fifth, a spatial analysis is conducted, following which the outcomes and conclusions that follow these are discussed in detail.

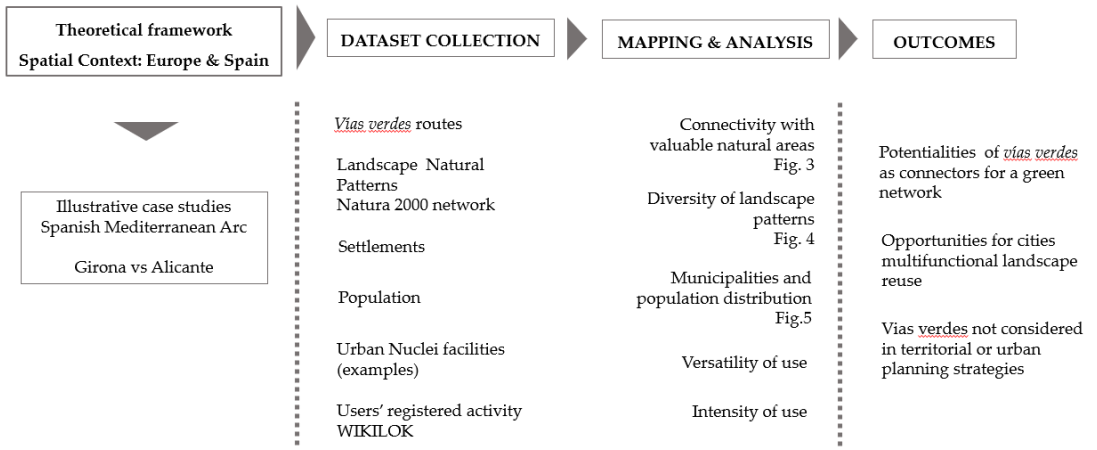

Figure 1. Overall research methodology scheme.

2. Literature Review

The first use of the term greenway is attributed to Whyte in 1959 [20], but it was not until the 1990s when the first compiling studies regarding greenways initiatives were published [21]. These seminal works considered both American and European contexts, where different proposals introducing landscape ecology methodologies to counter effects of landscape fragmentation were being developed [22]. Specifically, the idea of establishing greenways as linear fringes to be used as a landscape planning tool [23] emerged from plans that were based on the implementation of compatible and complementary multiple uses, which finally had to take into account ecological goals [24] together with social and cultural values [25].

The concept of the greenway gained momentum when, in 1995, the *Landscape and Urban Planning* journal published a Special Issue introducing the greenway movement, examining the existing literature and classifying the papers into groups according to their main approach to the greenways question [26]. This was "thought to be the first international publication on greenways" [27]. Furthermore, in this publication, the first comprehensive definition for the greenway concept was proposed:

"Greenways are networks of land containing linear elements that are planned, designed and managed for multiple purposes including ecological, recreational, cultural, aesthetic or other purposes compatible with the concept of sustainable land use" [22].

The topics covered in this special issue show how greenways represent a human endeavour [25] and reflect the several advantages provided by these linear systems, such as:

- Functionality, enhancing connectivity [28–30] and boosting urban biodiversity [31,32] at multiscale level, territorial to local
- Versatility, facilitating multi-functionality and multi-objective assets [25,33]
- Capacity for offering different spatial opportunities, providing places for public recreation and protecting heritage [30], [34–38].
- Potential of encouraging the need for social involvement through participatory processes [30], [39–42].

At present, greenways are part of the broader and complex concept of GI network which encompass, among other spaces, linear corridors such as canal towpaths, old pathways, cattle routes or disused railway lines (rail-trails [43]) exclusively reserved for non-motorized journeys. The literature related to GI focusing on introducing green planning issues into spatial planning practice has been dealt with thoroughly from different perspectives. Indeed, previous research undertook by Benedict and McMahon [12] or by Di Marino et al. [44] introduced the GI concept to improve the connection of conservation values with "smart" growth management, linking local communities. Also, Davies et al. [45] carried out the development of a methodological guide for GI planning processes, looking for a balance between land and infrastructural planning with natural assets. In addition, Mell [46] conducted the proposal of a green matrix of spaces for effective urban sustainability as a means by which to achieve economic, leisure and social goals. Moreover, Tian et al [9] highlighted the importance of the connectivity through corridors and stepping-stones for improving any urban living environment.

Basically, following different authors' approaches, it can be stated that GI involves the sustainable and multiscale provision of multifunctional green spaces [47] that must promote a connected network, in line with environmental sustainability practices that encourage a healthy lifestyle [48]. Moreover, the interdisciplinary literature explores the connection between urban GI, ecosystems and human health, introducing the concept of ecosystem services (ES) as the benefits people obtain from ecosystems [49]. Furthermore, research has been carried out related to the benefits of restoring ES in urban areas, implying additional economic benefits [50], as well as classifying and providing a value to ES for urban planning [51]. However, there are few studies which address the socio-cultural preferences that have emerged as a tool to identify relevant services for users [52,53].

Although there are a broad number of different landscapes and elements that have been covered, the lack of introducing farmlands as an important issue related to GI is highlighted by Rolf et al. [54], who consider that low-intensity farmland bears potential for agriculture-based urban GI. Specifically, rail-trails, as converted rail tracks into green pathways, are primarily considered as a valued asset for recreation, more in rural areas than in suburban ones [4,43,55–57]. In addition, beyond the leisure perspective, in Spain, the converted green paths (*vías verdes*) also function as connectors for intermodal transport systems in cases where there is connectivity to alternative methods of transport, as observed by the Competitiveness and Innovation Framework Programme of the European Union [58]. Also, some initiatives have been approached from the environmental and employment policies, providing evidence that new opportunities for so-called green jobs can emerge together with these projects [59].

Notwithstanding the given consensus in scholarship about the relevant and positive strategic role that linear corridors have, the consideration of rail-trails as connectors for urban spaces has received little coverage. In this regard, two references should be underlined: the study of Ferretti and Degioanni [60] in developing a methodological framework to reach decision-making processes related to the requalification of disused rail-trails and the research conducted by Guerrieri and Ticaly [61] related to the design standards for converting disused railway trails into greenways. In Spain, the existing research mainly addresses the approaches related to environmental benefits, as well as

the advantages for accessible leisure aspects, together with the importance of associations to develop initiatives in connection with other European countries [4,62,63]. The main focus is on the itineraries at the rural and territorial levels, but there is hardly any approach related to the urban–periurban transition or with landscape planning or urban planning practice.

3. The European and Spanish Context: Rail-Trails as a Special Type of Greenway

Spanish initiatives to develop *vías verdes* first date from the 1990s, when several European countries also started to pursue similar strategies. The practice of converting rail tracks into rail-trails throughout Europe is shown by Dr. Bartoschek's inventory [64]: in 2017, approximately 18,000 km of rail tracks were transformed, representing 1700 individual rail-trails throughout Europe. The top four countries with the most rail-trails are: Germany, with 4900 km and 731 trails—sustaining the most developed network; France, with 3450 km and 185 trails; Sweden, with 2200 km and 133 trails; and Spain, with 2100 km and 122 trails [5].

3.1. Spanish Vías Verdes, a Successful Leisure Infrastructure

In the 1950s, the Spanish railway network comprised more than 18,000 km of rail lines at its pinnacle. From the 1950s to the1980s, a decline occurred due to several economic and social factors that made it feasibly unviable to maintain railway lines in competition with the construction of new roads [63]. In 1993, the Spanish Railways Foundation (Fundación de Ferrocarriles Españoles, FFE) was entrusted by the Spanish Ministry of Publics Works, Transports and Environment [65] to carry out an inventory of disused or underused train lines, as well as all the elements related to them—bridges, viaducts, tunnels, railway stations, and unstaffed stopping places. Furthermore, information regarding the natural or urban environment surrounding these tracks was also included in the inventory. As a result, it was discovered that more than 8000 km of the Spanish railway network was out of service and all the civil and cultural heritage linked to this network was in danger of gradual disappearance [63].

The idea of reusing these railway corridors in a way that would meet environmental, cultural, social and tourism aims started to take shape in the form of an initial strategy for encouraging and promoting their preservation [62]. During the 1990s, the FFE started promoting a specific plan (Programa *vías verdes*) for the reconversion of obsolete stretches, and, almost 25 years after its launch, 2800 km have been converted, according to FFE 2019 data. In Spain, the funding for developing *vías verdes* is generally supported by the Ministry of Environment and is sometimes co-financed by other public bodies, such as provincial or regional governments, local councils, and, sometimes, companies or foundations set up for the specific purpose of the management and maintenance of the refurbished stretch. On a less frequent basis, some small-scale actions are funded by exclusively local resources. The distribution all over the country of *vías verdes* stretches can be seen in the updated map provided by FFE (Figure 2).

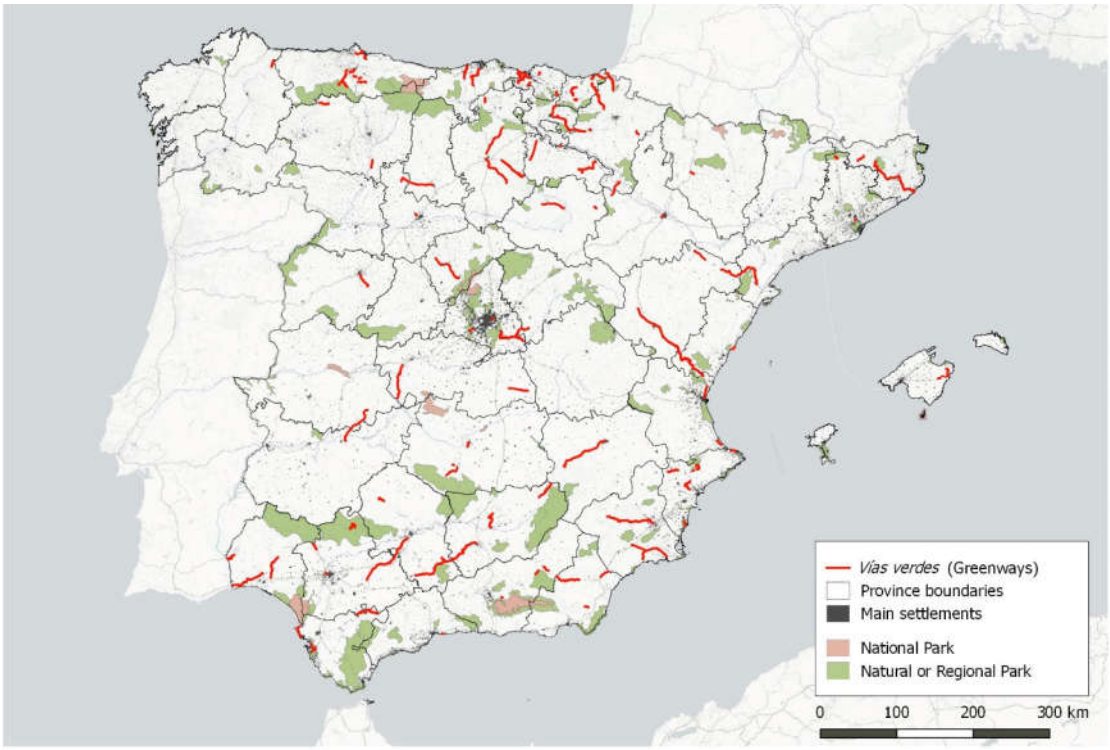

Figure 2. Distribution of *vías verdes* in the Spanish territory, October 2017. Source: IGN-CNIG and the Spanish Railways Foundation (FFE) [3].

3.2. *Vías Verdes in the Spanish Mediterranean Arc*

The Spanish Mediterranean peninsular Arc (Figure 3) is one of the most touristic European areas, as well as one of the most densely populated fringes of the Iberian Peninsula, with an average population density of 93 inhab/km², with peaks of more than 700 inhab/km² in the province of Barcelona, as detailed in Table 1 [19].

Generally speaking, there is a remarkable number of *vías verdes* which have been refurbished, concentrated along provinces of the Spanish Mediterranean Arc (17% of Spanish peninsular surface [19]), comprising almost 550 km, which represents 21% of the total of the renewed routes in Spain [3]. These *vías verdes* represent a very varied sample of paths in length, from short paths of less than one kilometre in an urban context, to long country tracks of over tens of kilometres crossing over varied landscapes, as shown in Table 2 and Table 3.

Figure 3. Provinces in the Spanish Mediterranean Arc. Research area.

Table 1. Spanish Mediterranean Peninsular Arc provinces and refurbished greenways (*vias verdes*).

Autonomous Community	Province	Surface (km²)	Population Density (inhab/km²)	No. Stretches of Refurbished Greenways (*Vías Verdes*)	Total Refurbished km
Cataluña	Girona	5910	128.9	3	166.64
	Barcelona	7726	721.0	2	
	Tarragona	6303	125.8	2	
Valencian Community	Castellón	6612	87.3	2	162.88
	Valencia	10,763	239.6	2	
	Alicante	5816	334.2	6	
Murcia Region	Murcia	11,313	129.3	4	145.72
Andalucía*	Almería	8774	79.7	5	72.31
	Granada	12,531	72.41	3	
	Málaga	7308	223.13	1	

Data source: Spanish Statistical Office [19] and FFE [3]. *Andalucia is only partially considered with the three Mediterranean coastal provinces.

Table 2 presents detailed information about each province with the number of stretches and kilometres refurbished, highlighting the selected study areas in context with other Spanish Mediterranean Arc provinces.

Table 2. Spanish Mediterranean Arc *vías verdes*' refurbished stretches.

Autonomous Community	Province	Id. Greenway or *Vía verde*	Stretch km	Prov. total km
Cataluña	Girona	VV del Carrilet (Girona-Sant Feliu de Guixols)	39.28	108.15
		VV del Carrilet (Olot-Girona)	57.19	
		VV del Ferro i del Carbo	11.68	

	Barcelona	VV del Nicolau (el Bergueda)	8.22	9.73
		VV del Vallés	1.52	
	Tarragona	VV del Baix Ebre	25.31	48.76
		VV de Terra Alta	23.45	
Comunidad Valenciana	Castellón de la Plana	VV del Mar	5.70	74.69
		VV de Ojos Negros I	68.99	
	Valencia	VV Xurra	16.18	24.04
		VV de la Safor	7.86	
	Alicante	VV de Denia	5.91	64.15
		VV de Alcoi	13.19	
		VV de Ibi (Tramo FC Alicante-Alcoy)	1.41	
		VV del Xixarra (Las Virtudes-Villena-Biar)	15.88	
		VV del Maigmó	21.14	
		VV de Torrevieja	6.61	
Región de Murcia	Murcia	VV del Noroeste	79.88	145.72
		VV Cartagena-Totana	50.06	
		VV la Pinilla-Mazarron	13.82	
		VV Barrio del Peral	1.96	
Andalucía	Almería	VV de Lucainena de las Torres	4.98	53.82
		VV de Almanzora (Tramo del Hierro)	11.92	
		VV de Almanzora (Alcontar-Olula)	22.09	
		VV de Almanzora (Tramo de Olula del Río)	1.55	
		VV de Almanzora (Tramo Huercal-Overa)	13.28	
	Granada	VV de Sierra Nevada	1.66	17.68
		VV de la Sierra de Baza	9.41	
		VV de la Sierra de Baza (ampliación)	6.61	
	Málaga	VV del Rincón de la Victoria	0.81	0.81

Data source: authors, based on data retrieved from IGN-CNIG and FFE [3].

There are also variations in their tread width, trail surface material or surrounding vegetation, among other characteristics. Furthermore, greenways have proven to be linear connectors between diverse ecosystems with a relevant landscape function from an ecological perspective [22]. Given this fact, it is important for this study to identify the number of different types of landscape connected by each *vía verde* and the proportion along each different stretch. With the purpose of highlighting the environmental importance in the territorial context, two main sources were used to detect relevant ecological areas and changes in landscape patterns: firstly, Natura 2000 data [66] as the European network of ecological protected sites (Figure 4); and, secondly, the forest map of Spain [18]. The latter is a conceptual model of hierarchical land uses, specifically focused on ecology and structure of the woodland, dense, scattered or sparse, but includes other categories, such as treeless areas, waterscapes, wetland, farmlands and artificial areas (Table 3).

The maps in Figure 4 show the complete rail-trail routes which have been drawn, including refurbished and non-refurbished stretches, and the existing habitat directive sites [66] which have been presented and overlapped in order to reveal the connectivity between the itineraries and the valuable natural areas. More specifically, three categories of protected areas are shown: the green shaded areas correspond to Sites of Community Importance (SCIs); the blue shaded areas to the Birds' directive Special Protection Areas (SPAs); and the purple shaded areas correspond to the overlapping of SCIs and SPAs, which correspond to Special Areas of Conservation (SCA). This approach permits a better appreciation of the landscape potentialities in the studied *vías verdes*.

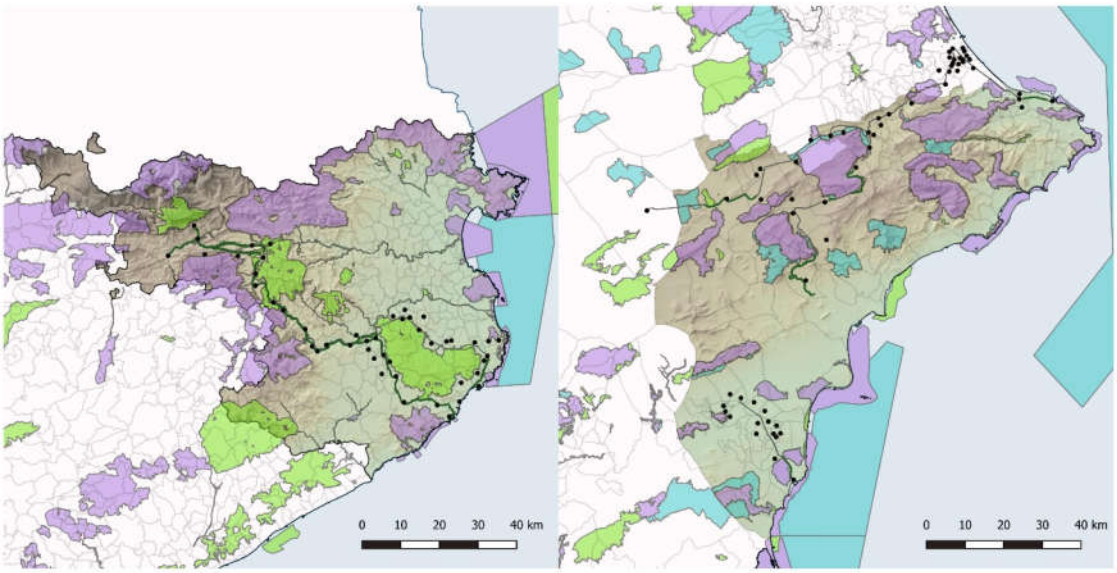

Figure 4. Natura 2000 Network—existing habitat directive sites in Girona (left) and Alicante (right) provinces (brown areas) along rail-trail routes. Data source: authors, based on data retrieved from MITECO [18,66].

Cataluña was the first autonomous community to implement the initiative of refurbishing rail-trails as a means by which to recover old train routes for environmental and leisure purposes. Currently, Cataluña has the highest number of refurbished kilometres, a total of 166.64 km, and the longest continuous route belonging to a single province—Girona, with the *vía verde* 'VV del Carrilet'. The Valencian Community follows with 162.88 km of renewed rail-trails and the highest number of separate sections—ten stretches of *vías verdes* adapted. Within the provinces in this community, Alicante is the one with the highest number of stretches—six out of ten. The third highest community, Murcia Region, is a single-province community with the highest number of refurbished kilometres in one province but divided in four different *vías verdes* routes. Finally, in the autonomous community of Andalucía, only three of the eight provinces are geographically included in the Spanish Mediterranean Arc; for this reason, it is only partially represented.

Given the information from the forest map of Spain [18], Table 3 shows an in-depth approach to the diversity of landscape patterns which characterize each *vía verde's* refurbished stretch. These data enable us not only to verify the variety of landscapes by types of habitat or by land use, but also to better understand the landscape perception and route experience.

Table 3. Landscape patterns along Spanish Mediterranean Arc *vías verdes*' refurbished stretches.

Province	Id. Greenway or Vía verde	Water		Forest		Disperse Woodland		Shabby Woodland		Artificial Soil		Agricultural Crops		Treeless	
		km	%	km	%	km	%	km	%	km	%	km	%	km	%
Girona	Carrilet II (Girona-St.Feliu Guixols)	-	-	8.65	22.0 %	-	-	-	-	7.32	18.6%	22.88	58.2 %	0.43	1.1%
	Carrilet I (Olot-Girona)	0.09	0.2 %	23.39	40.9 %	-	-	-	-	7.84	13.7%	25.86	45.2 %	0.02	0.0%
	Ferro i del Carbo	-	-	4.23	36.2 %	-	-	-	-	2.10	18.0%	5.35	45.8 %	-	-
Barcelona	El Nicolau (El Bergueda)	-	-	5.01	60.9 %	-	-	-	-	1.39	16.9%	1.67	20.3 %	0.15	1.8%
	El Vallés	-	-	1.09	72.0 %	-	-	-	-	0.16	10.6%	0.00	0.2%	0.26	17.2 %

Tarragona	Baix Ebre	-	-	7.78	30.7%	-	-	-	-	1.24	4.9%	14.20	56.1%	2.09	8.3%
	Terra Alta	-	-	11.45	48.8%	-	-	0.10	0.4%	0.17	0.7%	11.51	49.1%	0.21	0.9%
Castelló n de la Plana	Mar	-	-	3.48	60.9%	-	-	-	-	1.88	33.0%	0.34	6.0%	-	-
	Ojos Negros I	6.44	9.3%	11.59	16.8%	-	-	0.09	0.1%	4.19	6.1%	32.65	47.3%	14.03	20.3%
Valencia	Xurra	0.03	0.2%	-	-	-	-	-	-	5.28	32.6%	10.87	67.1%	-	-
	La Safor	0.09	1.1%	-	-	-	-	-	-	1.87	23.7%	5.90	75.1%	-	-
Alicante	Denia	0.12	2.0%	-	-	-	-	-	-	-	-	5.79	98.0%	-	-
	Alcoi	-	-	6.13	46.5%	-	-	0.22	1.6%	1.59	12.0%	4.59	34.8%	0.67	5.1%
	Ibi (FC Alicante-Alcoy)	-	-	-	-	-	-	-	-	-	-	1.41	99.9%	-	-
	Xixarra II (Las Virtudes-Villena - Biar)	0.05	0.3%	0.33	2.0%	-	-	0.12	0.8%	2.27	14.3%	11.32	71.3%	1.79	11.3%
	Maigmó	-	-	1.39	6.6%	0.28	1.3%	0.15	0.7%	0.56	2.6%	10.26	48.5%	8.51	40.2%
	Torrevieja	-	-	-	-	-	-	-	-	3.19	48.3%	1.54	23.2%	1.88	28.5%
Murcia	Noroeste	0.94	1.2%	5.22	6.5%	-	-	-	-	6.26	7.8%	52.82	66.1%	14.63	18.3%
	Cartagena-Totana	-	-	0.06	0.1%	-	-	-	-	2.33	4.7%	43.40	86.7%	4.27	8.5%
	Pinilla-Mazarron	-	-	-	-	-	-	-	-	-	-	9.17	66.4%	4.65	33.6%
	Barrio del Peral	-	-	-	-	-	-	-	-	1.55	79.4%	0.40	20.6%	-	-
Almería	Lucainena de las Torres	0.07	1.3%	-	-	-	-	-	-	-	-	1.92	38.6%	2.99	60.1%
	Almanzora (Tramo del Hierro)	0.19	1.6%	0.19	1.6%	-	-	0.32	2.6%	0.41	3.4%	7.07	59.3%	3.75	31.5%
	Almanzora (Alcontar-Olula)	0.11	0.5%	0.03	0.1%	-	-	-	-	1.61	7.3%	12.88	58.3%	7.47	33.8%
	Almanzora (Olula del Río)	-		-	-	-	-	-	-	0.48	30.8%	1.07	69.2%	-	-
	Almanzora (Huercal-Overa)	0.11	0.9%	-	-	-	-	-	-	0.05	0.3%	12.34	92.9%	0.79	5.9%
Granada	Sierra Nevada	-	-	0.25	15.0%	-	-	-	-	-	-	0.77	46.5%	0.64	38.5%
	Sierra de Baza	-	-	-	-	-	-	-	-	1.66	17.6%	4.39	46.7%	3.36	35.7%
	Sierra de Baza (Ampliación)	-	-	0.31	4.7%	-	-	-	-	0.19	2.9%	6.07	91.8%	0.04	0.5%
Málaga	Rincón de la Victoria	-	-	-	-	-	-	-	-	0.79	97.9%	-	-	0.02	2.1%

Data source: authors, based on data retrieved from the forest map of Spain [18].

The graph in Figure 5 shows the diversity of Mediterranean landscape patterns and their proportion among all the refurbished routes. The analysis reveals that the most common landscape patterns crossed by the majority of the refurbished *vías verdes* stretches (58%) are agricultural crop areas, which are included in the farmland category. The woodland category then follows this,

representing 16.54% of the stretches, 90% of which are mainly concentrated in Catalonia (Girona and Tarragona provinces), followed by the Valencian Community; specifically, the northern areas of Castellón de la Plana and Alicante provinces. The treeless category, with 13.27% of the *vías verdes* sections, is mainly concentrated in the southern provinces. Finally, the artificial soil areas (mostly urban settlements) characterize 10.30% of these routes. Additionally, the information gathered in Table 2 highlights that almost all *vías verdes* intersect a minimum of three different landscape patterns.

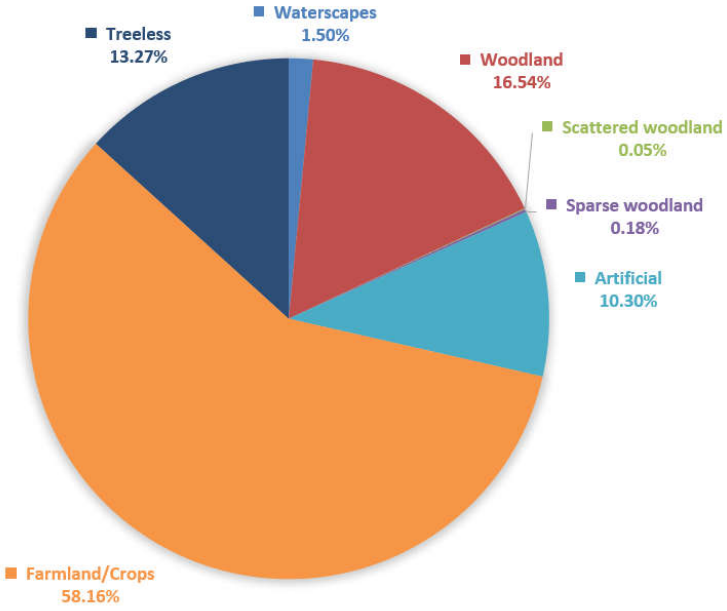

Figure 5. Diversity of landscape categories along the studied *vías verdes* along the Spanish Mediterranean Arc.

4. Selected Case Studies: Girona and Alicante Provinces

Two case studies are compared—Girona and Alicante—as representative and contrasting examples of the same *vías verdes* landscape strategy. Both provinces share some of the following common features: a near equal size (Alicante 5817 km^2 and Girona 5909 km^2); their geographic location in the Spanish Mediterranean Arc; the existence of stretches of obsolete narrow-gauge train routes refurbished as *vías verdes*; and, tourism as one of their primary economic activities.

With regard to the *vías verdes* territorial organization, some similarities in terms of distribution and proximity of settlements and concentration of population can be seen in Table 4 and Table 5. These tables show the classification of the existing urban settlements along each *vía verde* considering their proximity to the rail-trail itinerary. The complete route is considered, including the non-refurbished sections. In general, Table 4 shows that each *vía verde* is a means by which several urban nuclei are connected, as well as there being a significant amount of local population that implies their potential for use in relation to such users.

Table 4. Distribution of urban nuclei and population along each *vía verde* itinerary.

	Vía Verde	**Total length Railtrack**	**Upgraded Sections**	**Total Urban Nuclei**	**Total Inhabitants**
		km	km	num	
Girona	Carrilet I	57.19	57.19	14	172,633
	Carrilet II	39.28	39.28	10	44,473
	El Ferro	15.00	11.68	6	14,554
Alicante	Denia	30.77	5.91	12	70,643
	Alcoi	64.58	13.19	1	58,977
	Ibi		1.41	2	31,201
	Maigmó		21.14	3	13,056
	Xixarra I	53.35	0	17	90,936
	Xixarra II	72.64	15.88	12	98,649
	Torrevieja	26.00	6.61	16	149,873

Keywords:	Carrilet I: Carrilet (Olot-Girona)	VV Ferro: Vía Verde del Ferro I del Carbó
	Carilet II: Carrilet (Girona-S. Feliú de Gixols)	VV Ibi: Vía Verde FC Alicante-Alcoi
	Xixarra I: V.V. Xixarra (Alcoi-Gandía)	Xixarra II: V.V Xixarra (las Virtudes-Villena-Biar)

Data source: Spanish Statistical Office [19] and FFE [3].

In Table 5, settlements (urban nuclei) are grouped into five sets, A to E, attending to specific intervals based on parameters of accessibility by distance [67,68]. Within the sets, A is the interval ranging from 0 meters to 200 meters, so highly accessible for daily walking routes. Between 40% and 79% of the urban nuclei in the case of Girona are situated in this category, and between 13% and 100% in the Alicante case study. What is more, if we attend to the where the population is settled, ratios vary between 42% in the lesser case and 100%, showing a significant proportion of the population concentrated in the close vicinity of these routes in both case studies (Figure 6). According to the analysis of the rest of datasets, Table 5 shows that in a maximum of two kilometres from any *vía verde* (sets A,B,C), there are between 75% and 100% of the settlements and population of almost all the routes. However, none of the *vías verdes* are connected to urban green infrastructure networks.

Table 5. Accessibility to urban nuclei and population along each *vía verde* itinerary.

		A				**B**				**C**				**D**				**E**			
		0–200 m				200–750 m				750–2000 m				2000–4000 m				+ 4000 m			
	Via Verde	Urban nuclei		Population		Urban nuclei		Population		Urban nuclei		Population		Urban nuclei		Population		Urban nuclei		Population	
		N	%	hab	%	N	%	hab	%	N	%	hab	%	N	%	hab	%	N	%	hab	%
Girona	Carrilet I	11	79	168,848	98	0		-		3	21	3785	2	0				0	0	-	
	Carrilet II	4	40	28,328	64	2	20	6167	14	0		-		4	40	9978	22	0	0	-	
	El Ferro	4	67	12,454	86	0		-		2	33	2100	14	0				0	0	-	
Alicante	Denia	4	33	50,290	71	2	17	6612	9	4	33	7594	11	1	8	6147	9	0	0	-	
	Alcoi	1	100	58,977	100	0		-		0		-		0		-		0	0	-	
	Ibi	2	100	31,201	100	0		-		0		-		0		-		0	0	-	
	Maigmó	0		-		0		-		1	33	4017	31	2	67	9039	69	0	0	-	
	Xixarra I	9	53	80,193	88	0		-		8	47	10,663	12	0		-		0	0	-	
	Xixarra II	5	42	81,350	82	4	33	11,794	12	3	25	5,505	6	0		-		0	0	-	
	Torreviej a	2	13	62,935	42	0		-		6	38	35,236	24	5	31	25,190	17	3	19	26,512	18
Keywords:		Carrilet I: Carrilet (Olot -Girona)										VV Ferro: Vía Verde del Ferro I del Carbó									
		Carrilet II: Carrilet (Girona-S. Feliú de Gixols)										VV Ibi: Vía Verde FC Alicante-Alcoi									
		Xixarra I: V.V. Xixarra (Alcoi-Gandía)										Xixarra II: V.V Xixarra (las Virtudes-Villena-Biar)									

Data source: Spanish Statistical Office [19] and FFE [3].

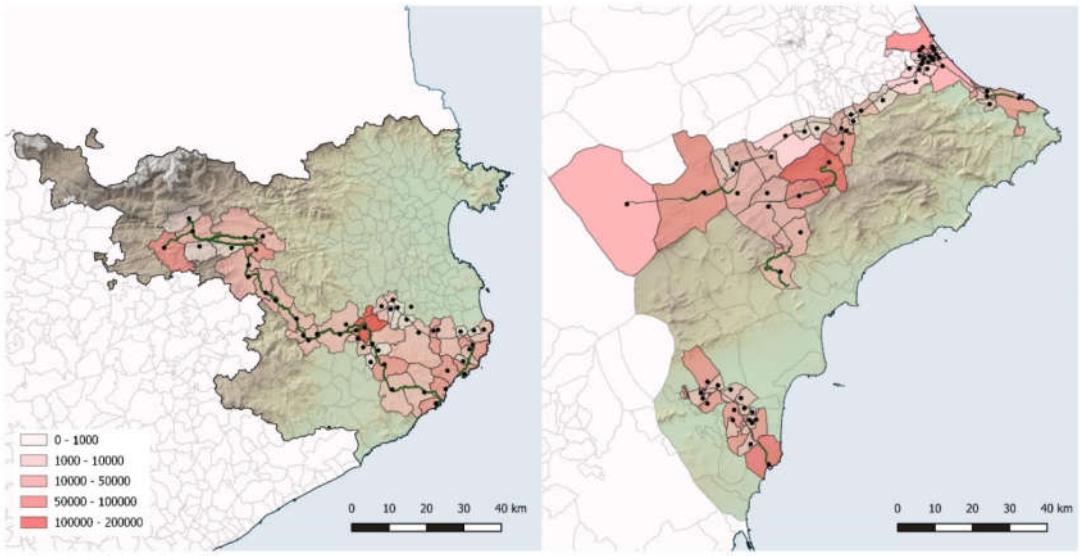

Figure 6. Municipalities and population inhabitants along rail-trail routes considering both, refurbished and non-refurbished stretches. Girona (left) and Alicante (right). Data source: authors, based on data retrieved from IGN-CNIG, Spanish Statistical Office [19] and FFE [3].

Girona represents the starting point of the Spanish *vías verdes* initiative. The 'El Carrilet I' was the first Spanish *vía verde* implemented by following the FFE aims of preserving railway heritage, promoting sustainable uses of infrastructures and developing a complementary touristic offer. It was finished between 1995 and 1997 and is a nationally awarded example of a high-profile dynamic itinerary. Nowadays, this is one of the longest and most highly consolidated itineraries, divided into two main stretches—Carrilet I and II. Generally, the *vías verdes* itineraries connect several settlements of different urban scales, from the main capital, such as Girona, to small villages. In the case of Girona, there are a total of 30 urban centres in the vicinity of the *vías verdes* routes, representing over 230,000 residents within these areas [19].

Alicante province presents a different situation. Out of all the Spanish Mediterranean Arc provinces, it is the one with the highest amount of *vía verde* refurbished sections, implemented in very different locations. Additionally, these stretches present, as a whole, a high diversity of landscape categories (Table 2) within those typified by the forest map of Spain. Moreover, they serve double the number of urban settlements, with a total of 63 situated in the proximity of these *vías verdes*. In terms of population, this represents overall more than 500,000 residents in the area of influence of the routes [19].

4.1. Girona: A Poly-Nuclear Connectivity Following the Vías Verdes' Routes

The *vía verde* 'El Carrilet I' in Girona, Catalonia, is a 57-km itinerary which connects Olot and Girona and was the first stretch to be refurbished. Later, in 2000, a second section between Girona and San Feliu de Guíxols in the Mediterranean coast, 'El Carrilet II', was refurbished, adding 37 km. Both comprise a complete route of almost 100 km, connecting 24 towns. This old infrastructural corridor has become an accessible green connection, with gentle average slope of 1.5% in its first stretch, and 0.5% in the second section, near the coast.

The itinerary (Figure 7) interconnects several landscape characteristic areas, such as: the Olot volcanic valley, which includes various forests (e.g., Holm oak, oak, beech), not very extensive pastures and crop fields; the Rocacorba area, with volcanic cones covered by dense forests; Les Guilleries area of middle and low relief with forests; and the plain of Girona, with crop fields and patches of mixed forest from which Girona is the predominant image. The second stretch, 'El Carrilet II', between Girona and the coastline, is mainly a plain area with a natural wetland ecosystem which, nearing the coast, becomes gradually more artificial due to the influence of the periurban settlements [69].

These *vías verdes* articulate the territory from the mountainous hinterland to the coast, providing connectivity and accessibility. In addition, these rail-trails have become a core axis for the location of town facilities, such as schools, playgrounds, sports facilities or cultural centres (Figure 8). Old stations and other heritage buildings have been transformed into new tourist services [70] and other businesses, such as bed and breakfasts, restaurants, and bike rentals, among others. Their interconnection to a wide range of other trails converts the 'Carrilet I and II' into a backbone corridor within a territorial network. Therefore, the *vía verde*'s main function remains as a short connector between nearby towns, generating a lively and dynamic environment that is frequently used by the local population and visitors [71].

In consequence, the connectivity is not only related to the territorial scale—the two stretches in which "El Carrilet" is divided converge in Girona city centre and are partially absorbed by the city street network structure. Considering that Girona is the main capital city in the route, with a population of close to 100,000 inhabitants, this *vía verde* itinerary provides an extraordinary linking opportunity at several scales with multiple uses integrated. What is more, Girona is the unique city from the two case studies that constituted a research project in 2014, led by Martí Franch, known as "Girona shores" [72]. The project proposal rethought the suburban areas as linkers of a green infrastructure in order to provide "value, increase permeability and structure urban borders" [73].

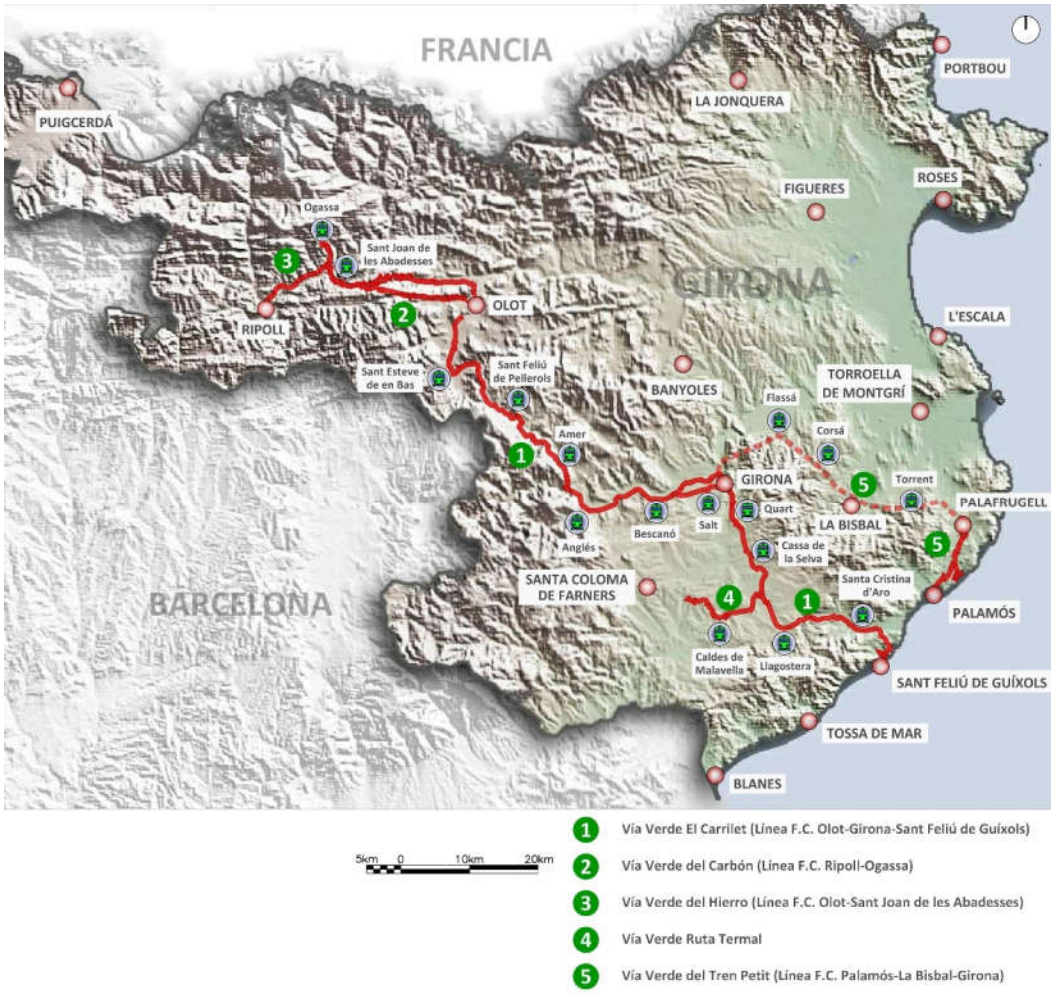

Figure 7. Distribution of *Vías verdes* in Girona province. The Carrilet I and Carrilet II connect the pre-Pyrenean mountain ecosystem inland with the coastline. Data source: authors, based on data retrieved from IGN-CNIG, Spanish Statistical Office [19] and FFE [3].

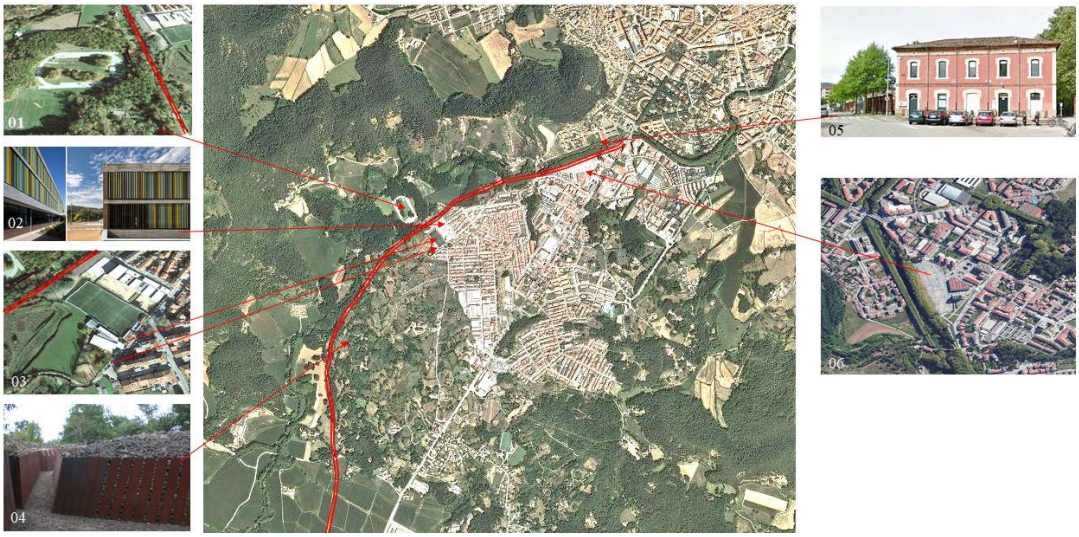

Figure 8. Distribution of town facilities along a stretch of the 'Carrilet I' in Olot. 01-Olot Stadium; 02-Sant Roc School; 03-Olot Football Club; 04-Pedra Tosca Park; 05-Carrilet city old Station—nowadays the neighbourhood council and adult school—; 06-Olot exhibition ground. Data source: authors, based on fieldwork.

4.2. Alicante: Multi-Landscape Scenery in a Fragmented Network

Alicante province, in the Valencian Community, has most of its old rail-trails interconnected as routes in the mountainous north and central area, providing a huge potential in terms of reusable strategies for a landscape corridor network. Just one of the routes is located in the south, disconnected from the northern ones. This last one was formerly part of the Alicante-Murcia railway before becoming obsolete (Figure 9). Among these train routes, six scattered stretches have been refurbished into *vías verdes*, constituting a total of 64.15 km of the 151.99km, which is 42% of the network (Table 2). Despite being 'unlinked' stretches (in the sense that they are neither connected to each other nor integrated with the public urban space of nearby towns) they are a successful resource in terms of leisure activities and tourism because the six itineraries enable different landscape experiences, reinforcing their role as green corridors.

The evidence of their potential role as territorial linking elements is affirmed by the classification of the *vías verdes* routes as cultural landscape resources. Moreover, according to the Green Infrastructure and Landscape Plan of the Valencian Community [74], the diverse landscape units that they connect are included in the Regional Relevant Landscape (RRL) catalogue (Figure 9).

Figure 9. Distribution of *vías verdes* in Alicante province related to regional landscape units. Refurbished stretches are represented by a red line; non-refurbished line stretches are represented by a broken red line. Source: Base map sourced from the Green Infrastructure and Landscape Plan of the Valencian Community. Prepared by the authors based on FFE updated information.

There are significant differences between existing *vías verdes* stretches in terms of route length, landscape context and the existence of historical assets, facilities or auxiliary constructions. The northern and central old rail network has five refurbished rail-trails. First, the coastal plain is the landscape context of the six-kilometre-long sea-level *vía verde* of Denia, a mosaic of agricultural plots and orange groves with panoramic views of the Montgó mountain range nature reserve. In the centre of Alicante province, there are three *vías verdes* along the characteristic Aleppo-pine forestry mountain ranges: Maigmó (Figure 10), Ibi and Alcoy (Figure 11). The existence of a total of sixteen tunnels and five bridges in these routes evidence the topographic difficulties, from 220 m rising to 610 m above sea level, with an average 2% gentle-slope path. At the westernmost point, the agricultural valley and vineyards of the Vinalopó River are the main landscape patterns of the *vía*

verde del Xixarra [75]. This 15-km stretch runs near the province's borders, between 500 and 620 metres above sea level, with an average slope of under 2%. Finally, in the south, the *vía verde* of Torrevieja follows the most arid path, linking the Huerta agricultural cropland, the natural park of salted lakes and several suburban residential areas within a seven-kilometre plane refurbished route.

Figure 10. The itinerary of the *vía verde del* Maigmó is away from Agost town location. Source: Prepared by the authors, superimposed Google Earth satellite photos.

Figure 11. Distribution of town facilities along a stretch of the *vía verde de* Alcoy in Alicante. 01-Vocational School; 02-Bridge of the Seven Moons; 03-Natural Park Carrascal de la Font Rotja; 04-Football Field and Batoi Park; 05- Town Cemetery; 06-Municipal sports centre. Source: Prepared by the authors, superimposed Google Earth satellite photos.

5. Discussion

One of the basic questions to approach in this study was to determine whether or not the *vías verdes* achieve their full potential as strategical linkers between urban nuclei and peripheral natural

environments. For this purpose, the itineraries should fulfil two conditions—the existence of natural assets along the routes and to be part of the strategical territorial plan for connecting people and place. The existence of protected landscapes (Figure 4), the diversity of landscape characters and patterns (Table 3), the identification of the number of urban nuclei and their population in the proximity of the different *vías verdes* (Table 4 and Table 5) have all been analysed in the previous sections. All the mentioned factors provide a whole picture of the potentiality of these *vías verdes* to be considered as key elements for a green infrastructure strategy.

Moreover, with respect to the strategical planning, Figure 12 provides additional information regarding the relationship between the *vía verde* upgraded sections, public investment, and the number of existing settlements able to be connected along a *vía verde* itinerary. Analysing the graph in Figure 12, the scatter plot indicates a strong, positive linear relationship within the refurbished stretches and the proximity to the urban nuclei in the case of Girona (Figure 12, dashed line)—that is to say, there is a clear strategy of connecting all nuclei along the complete itinerary. On the contrary, in the case of the data for Alicante, the scatter plot shows a weak negative linear association which is representative of the disconnection between the refurbished stretches and the location of the closest urban nuclei (Figure 12, continuous line). This means that the decision-making for selecting which sections should be upgraded does not prioritize the connection between urban nuclei along a *vía verde* route.

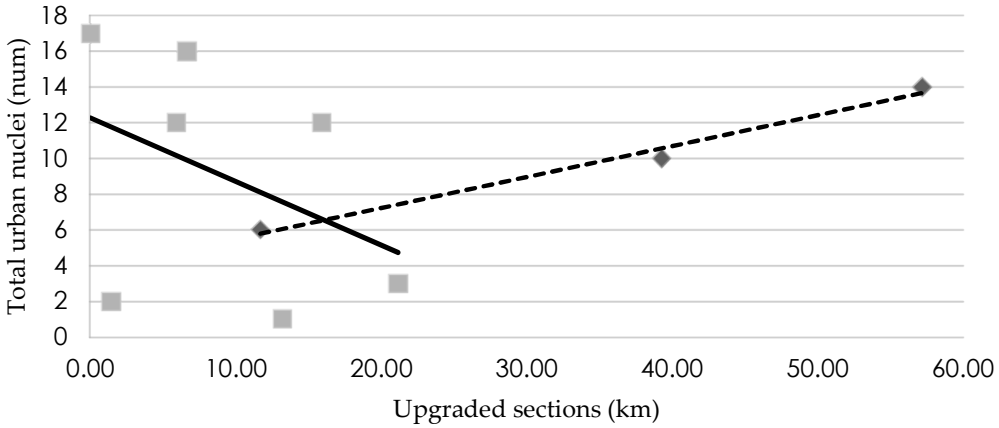

Figure 12. Correlation between the urban nuclei location and the *vías verdes* refurbished stretches. Girona (dashed line) and Alicante (continuous line).

The contrasting Girona and Alicante case studies indicate that the refurbishment of *vías verdes* is more effective when all the following criteria are met, as observed in the case of 'El Carrilet I and II' in Girona: i) the connection of urban and natural areas; ii) the provision of socially inclusive peri-urban mobility as well as leisure facilities; and iii) the protection of natural, cultural, and landscape heritage. Therefore, investment in the refurbishment of *vías verdes* stretches needs to be strategically planned in order to contribute successfully to territorial connectivity.

In further developing the idea of reusing obsolete railway corridors in a way that could meet environmental, cultural, social and tourism goals, this is partially achieved, mainly with regard to the leisure activities. In both Girona and Alicante, it is easy to find the routes clearly promoted by public institutions, such as municipalities' web sites, as well as from users' generated content of social networks, such as Wikiloc [76], where the itineraries are explained and offered as a reference to the rest of users. To provide evidence of the importance of users' activity, Table 6 indicates the total number of routes published in Wikiloc for each one of the *vía verde* stretches, showing the success in terms of open-air activity dynamism. Additionally, it can be observed that there are thirty times more entries for routes from Alicante than for Girona, thus reflecting the specialization of these stretches.

Table 6. Number of routes uploaded by users of Wikiloc wesite particularized for each *vía verde* refurbished stretch.

Vía Verde	Refurbished km	WIKILOC number of routes
VV del Carrilet (Olot-Girona)	57.19	4219
VV del Carrilet (Girona-Sant Feliu de Guixols)	39.28	1879
VV del Ferro i del Carbo	11.68	2696
VV de Denia	5.91	42,584
VV de Alcoi	13.19	44,292
VV de Ibi (Tramo FC Alicante-Alcoy)	1.41	46,441
VV del Maigmó	21.14	45,106
VV del Xixarra (Las Virtudes-Villena-Biar)	15.88	42,524
VV de Torrevieja	6.61	46,425

Data source: Wikiloc website [77,78].

Both case studies have highlighted that the *vía verde* refurbishment initiative can play a monofunctional and multifunctional role in landscape and user connectivity. The case of Alicante province is an example of a monofunctional role, where tourism and leisure activities have been the major beneficiaries of the development. By contrast, 'El Carrilet' in Girona reuses stretches of the rail-trail that connect people to small scale facilities serving urban settlements, in addition to meeting tourism and leisure demands that may involve multiscale trips. This multifunctional role means that Girona's *vía verde* is better integrated into people's daily routines and, therefore, the sections of the itinerary connecting facilities and peri-urban tissues are more intensively used.

Despite being a successful leisure facility, in both Girona and Alicante case studies, it has been clearly established that there is an unexploited potential for converting these rail-trails into part of a GI network. Even in the case of Girona, which is the only city with an innovative green infrastructure plan, "la Vora", which is well studied and sensitive to the needs of the city, there is no reference to the existence of the *vía verde* "El Carrilet" as a possible element for connecting the city centre's urban tissue with the periphery natural and cultural assets.

6. Conclusions

This study has shown the potentialities of the *vías verdes* as connectors for a green network, with a cultural and historical origin, and the characteristics necessary to make nature and leisure activities accessible to the centre of the urban nuclei that are located in the vicinity of each rail-trail route. What is more, these *vías verdes* are already part of the outdoor leisure option, sport and nature, for many residents and visitors, even when they are not easily connected with the city centre (as occurs in the example of Alicante province).

Due to their accessibility and the distribution of resident population in close proximity, these itineraries are suitable for introducing auxiliary services for users, connecting territory, cultural and commercial activities in the peripheral neighbourhoods, thus promoting community cohesion. Furthermore, they can be part of an intermodal transport system in cases where there is connectivity to alternative methods of transport, thereby meeting the municipalities' sustainable transport policy objectives.

The results from the previous analysis reveal that these *vías verdes* are effective connectors between relevant natural landscapes and settlements, although the urban and regional planning has not considered their full linking potential.

Given the above, the *vías verdes* offer an opportunity for multifunctional landscape reuse, enabling obsolete rail trails to evolve into a versatile green corridor network. In addition, the initial difficulties of the implementation of the old rail-trail routes should now be seen as an opportunity, making them ideal connectors between Natura 2000 networked areas and natural and semi-natural spaces near cities' periphery, as shown in Figure 4. This last finding is aligned with the European Union strategy regarding GI as an essential component of spatial and physical planning [75],[76]. For

this reason, there is room for future studies in other European regions to identify planning strategies in order to consider the full potential of these greenways. In addition, further research should be undertaken to investigate the existence of other obsolete heritage elements and infrastructures to be transformed and reused as sustainable planning opportunities to meet environmental, cultural and social goals.

Author Contributions: C.G.-M. and P.M. conceived and designed the research and method, conducted the analysis and wrote the paper; M.C. and A.B.-B. made the data collection and performed the data visualization; C.G.-M., P.M. and M.C. validated the results. All authors have read and agreed to the final version of the manuscript.

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