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Accessibility of rail trails in Huelva, Andalusia (Spain)

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ABSTRACT
The rail trails (converted disused railways) are infrastructures which can be reused mainly as non-motorised itineraries for hiking and cycle touring. Andalusia (Spain) has a network of 1442 km of disused railways, out of which 606 km are found in Huelva province (42.1%) as heritage from its former mining activity. The aim of this article is to devise a method which determines the real accessibility to rail trails and the volume of resident population who can reach them in a time period of 5, 10 and 15 minutes by road in a private vehicle. This process involves the determination of real accesses with accuracy and the differentiated calculation of the average speed on the different types of routes. The method is used for the three rail trails which currently exist in Huelva (98.6 km), having as a result a Map at a scale of 1:325,000.

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1. Introduction

Unused railways offer great possibilities of reuse as non-motorised itineraries which are, increasingly, an alternative to car traffic (Bíl, Bílová, & Kubeček, 2012; Ryan, Fabos, & Allan, 2006). They are a way for the population to have greater contact with nature through physical exercise in the open air. Furthermore, authors such as Lamont (2009) and Fernández-Latorre (2015) confirm a revival of the use of the bicycle for leisure, recreation and tourism, linked to the use of disused railways adapted for this aim.

Once the disused railways have been properly converted for the aforementioned uses, they are considered rail trails (Reis & Jellum, 2012; Willard & Beeton, 2012). The development of rail trails in several European countries, such as Austria or Germany (Meschik, 2012), and the United States, is linked to activities and aims of an ecological, recreational, cultural and sports nature (Arendt, 2004; Floress, Baumgart-Getz, Stalker-Prokopy, & Janota, 2009), compatible with the concept of sustainable use (Lumsdon, 2000). The rail trails are also an important stimulating factor for the territory across which they run (Mundet & Coenders, 2010). On the other hand, they are a good example of how technical progress of the past (stations and railway lines, viaducts, tunnels, etc.) have left a heritage mark in the present (Porcal Gonzalo, 2011).

In connection with this, the Spanish Greenways Programme (Vías Verdes®) of the Spanish Railway Foundation (FFE) has been promoting the reconversion of disused railways into rail trails mainly for cycle touring and hiking since 1993. Nowadays the Spanish network has 99 itineraries and 2099.95 km.

Andalusia is the most populated region (8,399,043 inhabitants in 2015) and the second biggest in size (87,594.2 km^2; 17.31% of the total) in Spain. It has a total length of disused railways of 1442 km (25.4% of the state network), according to the *National Inventory of Disused Railway Lines*, provided by the FFE in 2014. Currently there are 24 rail trails, although there are real possibilities of increasing this number and connect some of them in order to develop longer itineraries to satisfy the increasing demand from foreign cycle tourists mostly (University of Seville, & FFE, 2014).

Taking this into account, this article puts forward a method which determines the accessibility of the resident population (main potential users) to the rail trails in Huelva province: Guadiana, Molinos del Agua and Litoral. To do so, the isochrones of 5, 10 and 15 minutes by road in a private vehicle from the real access points to these rail trails are calculated.

This methodological proposal, applicable to other rail trails, is tested in Huelva province for two reasons:

(a) The high density of disused railways in this province due to its intense mining activity during a big part of the nineteenth and twentieth centuries, whose extractive companies, mainly British and French, also obtained concessions to construct railway routes from the strip pits of the Andévalo to the port of Huelva (Romero-Macías, Fortes-Garrido, & Gómez-Díaz, 2010). However, the decline of the sector was evident in the second half of the twentieth century, which entailed a

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progressive closure of the lines (Gavira-Narváez & Ventura Fernández, 2013).

(b) The foreseeable use of this network of disused rails for the layout of EuroVelo 1 – Atlantic Coast Route, through Huelva, before reaching the Portuguese Algarve. It is a project of the European Cyclists' Federation which has as aim the development of a network of long distance routes for cycle tourists, making it possible to move across Europe. The routes are made available from existing itineraries or new trails. For this reason, the rail trails of Molinos del Agua and Litoral are addressed jointly in the Map 2 since both, which are very close, will be incorporated into the aforementioned route EuroVelo 1.

2. Methods

This article is a methodological example, applicable to the rail trails of Huelva province, which allows for the mapping of the areas of accessibility to these rail trails, bearing in mind the characteristics of its accesses and the population directly affected, considered as more regular users (Main Map). In order to do this, it has been necessary to solve two issues in advance: (a) to establish accurately real accesses to rail trails; (b) to calculate the average speed on the different roads (highways, conventional roads and urban roads). In this way, the volume of population affected because of their residence in areas included in the established accessibility isochrones (5, 10 and 15 minutes) can finally be determined.

2.1. Preparation of the cartographic basis

In the production of Map 1, three types within the disused railway network have been distinguished. (a) the ones classified as rail trails although with different degrees of reconditioning (the Litoral one very deteriorated in spite of its strategic position in the non-motorised connection with Portugal), in green; (b) the ones which are currently not classified as rail trails but in which there is a priority interest for reconversion, surrounded by a dashed line; and (c) the rest of disused railways, in red. All these shapefiles were provided by the FFE.

This Map also reflects the only two railway routes which are currently in use in Huelva, in black, which connect its capital city with Seville (eastbound) and with Badajoz and the region of Extremadura (northbound); the reservoir of Zufre, which interrupts the route of the former railway between Cala (Huelva) and Aznalcóllar (Sevilla). These shapefiles come from the cartographic product Basic Spatial Data of Andalusia (DERA) provided by the Institute of Statistics and Cartography of Andalusia (IECA, 2016), as a public organisation responsible for coordinating the Statistical and Cartographic System of Andalusia. DERA is the repository of cartographic bases with information in .shp format with ETRS89 geodetic reference system and projected in UTM Zone 30, of more than 20 thematic blocks and of different geometric nature, referred to the Andalusian territory.

The following Map focuses on the three rail trails which are the object of this article. As indicated, the rail trails of Huelva were selected from the shapefile provided by the FFE. Subsequently, they have been rectified, by adding to the project the shapefiles of the National Plan for Aerial Orthophoto (PNOA-Spain) periodically updated in ECW format, whose distribution and download unit is the sheet of the National Topographic Map 1:50,000 (MTN50), result of creating a mosaic with the orthophotos corresponding to each of these sheets.

This second Map includes the main types of roads for motor vehicles: highways (two lanes for each direction, represented in blue), conventional roads (one lane for each direction, in ochre) and urban roads (main roads through the populated centres, in grey), also originating from the DERA catalogue. The shapefile of populated centres is maintained. Furthermore, accesses to rail trails obtained through the related fieldwork are incorporated, through a representative icon, as explained in the following section.

2.2. Fieldwork: identification of accesses to rail trails

Through the related fieldwork carried out during the year 2015, all possible accesses to the three current rail trails have been georeferenced with GPS with the following criterion: intersection of the rail trails with highways, conventional roads and urban roads which allow for the possibility of parking a private motor vehicle. During the fieldwork, the different access points to each rail trail were taken with a Garmin Dakota 20 device, which is a high-sensitivity GPS receiver with WAAS. This device uses HotFix, which allows for it to locate the satellites with great ease and speed. The maps loaded on the device are from TODOHISPANIA 2, which is a combination of maps of Spain at a scale of 1:25,000 of free distribution, obtained from the National Geographic Institute (IGN), calibrated and with selection of metric units, so that they can be used both in the GPS terminal and in the route processing software.

During the tour of the different routes, the research team has taken the waypoints of the corresponding accesses to the rail trails, which are storable points. In order to download them, the option of exporting the internal storage in KML format, through the programme Garmin BaseCamp® is used. To import this file to the ArcGIS® project, Arctoolbox® has been used, storing it in shape format.

Then, the road shapefile of the DERA repository is refined through the elimination of the routes which do not permit motorised traffic (mainly rural roads). Finally, it has been checked that detected accesses coincide with a point of intersection of the selected road network with the rail trail. These accesses are shown in Map 2.

2.3. Calculation of average speed for private vehicles according to type of road

To calculate the average speed of private vehicles according to the type of road, the road shapefile of Huelva province is selected from the regional shape, to be used by the Network Analyst extension for ArcGIS®. Then, the numerical fields of length and time were created for each road section. The length of the section is measured with the geometry calculator in metres and, in order to obtain the journey time in minutes for each section, the formula that Environmental Systems Research Institute (ESRI®, 2010) establishes in its tutorial for Network Analyst.

To apply the formula used by Network Analyst, it is necessary to find out, as a first step, the average speed for each type of road. To calculate the average speed in highways and conventional roads for light vehicles, the data of the Subdirectorate of Exploitation and Network Management, General Directorate for Roads, Spanish Ministry of Public Works and Transport for the year 2014 have been used. This body offers data of percentage distribution of vehicles which drive around these types of roads.

In order to be able to calculate the average speed, each aforementioned interval provided by the Ministry of Public Works and Transport has been assigned our own reference value, established as follows. In the intervals with two extremes, the arithmetic mean of the two is used. For the last and first interval, its original value plus/minus 10 km/h respectively is taken, as can be seen in Table 1. This way, with our own reference value of each interval and the percentage distribution, the average speed is calculated as the weighted average of the reference value according to its percentage distribution:

$$v_{\mathrm{m}} = \sum_{i=1}^{6} \frac{v_i \times p_i}{100},$$

where v_i is the reference value of each interval, and p_i the percentage value of the vehicles which drive around during that same interval. The results obtained are: v_{m} (average speed) = 101.27 km/h in highways; $v_{\mathrm{m}} = 76.32$ km/h in conventional roads.

The calculation for urban roads is more complex since, unlike average speed for highways and conventional roads, there are no official data. In order to address this deficiency and calculate the average urban speed in Huelva, the data provided by the City Council of Huelva in its Plan for Sustainable Urban Mobility (2014) have been used as reference. The following values have been obtained from this document:

(1) Commercial speed of urban buses for the days of the week according to type (working day, Saturday or holiday) in morning and afternoon schedule.
(2) Road traffic intensity, which determines the quantity of vehicles which drive around the capital city each day of the week according to type.

With this data, the average speed of urban buses has been calculated according to the type of day of the week, by weighing it depending on the importance of each type of day of the week and its road traffic intensity.

The formula used is the following:

$$v_{\mathrm{BH}} = \frac{\sum_i v_i \times n_i \times \mathrm{IV}_i}{\sum_i n_i \times 100},$$

where v_{BH} is the average speed of the buses of Huelva; v_i is the average speed according to the day of the week; n_i is the number of days of the week according to type and IV_i is the Road Traffic Intensity according to day of the week (expressed in per cent). The result obtained is 13.88 km/h.

Since this is the average speed of buses and with the aim of calculating the speed of private vehicles, the research by Burón, López, Aparicio, Martín, and García (2004) has been taken as reference. These authors use the commercial speed of buses in Madrid (14.6 km/h) to estimate the average speed of private vehicles in that city (20 km/h). In our study, we use the relationship between both values to calculate the average speed of private vehicles in Huelva, resulting in a value of 19.01 km/h.

Table 1. Average speeds according to type of road.

Speed interval according to the Ministry of Public Works and Transport (km/h)[a]	Own reference value (km/h)	Percentage distribution of vehicles in highways[a]	Percentage distribution of vehicles in conventional roads[a]
<50	40	1.44	8.90
51–80	65	10.39	48.61
81–100	90	33.94	30.70
101–120	110	37.51	9.26
121–140	130	14.75	2.15
>140	150	1.97	0.37

Source: prepared by the authors from the data of the Subdirectorate of Exploitation and Network Management, General Directorate for Roads, Spanish Ministry of Public Works and Transport for the year 2014.

[a]The data of the Ministry of Public Works and Transport come from the speeds in highways of 4517 million of vehicles in 1401 traffic count station for 3,063,044 hours, and in conventional roads of 521 million of vehicles in 948 traffic count station for 1,741,769 hours.

2.4. Isochrones of accessibility and population affected

The accessibility areas, established from the isochrones of 5, 10 and 15 from each access to the rail trails, are represented by means of different colour intensities, as seen in Map 2. The choice of these time intervals is supported by its regular use to measure the accessibility to the different public services with a private vehicle, and in the consideration of 15 minutes as the maximum time of ideal accessibility (Escalona Orcao & Díez Cornago, 2005).

To measure the population living in the different accessibility areas, the source shapefile has been the polygons created through Network Analyst and the target shapefile the one from the affected populated centres. The data of the latter come from the Nomenclature of Population Entities which is published yearly by the Spanish Statistics Institute (INE), through the point-type centres shapefile offered by DERA, so that the resident population is reflected in Table 2.

Finally, in the resulting Map, at a scale of 1:325,000, the accessibility areas of the rail trails of Molinos del Agua and Litoral were jointly calculated and mapped due to its close proximity. Once the latter has been reconditioned, they will both be part of the Atlantic Route of EuroVelo, as mentioned before. The results of this fusion are the following: 35,150 inhabitants less than 5 minutes away; 80,316 inhabitants less than 10 minutes away and 290,989 inhabitants less than 15 minutes away.

This way, the hierarchy of populated centres included in the three isochrones for each of the two itineraries of the rail trails finally established is also reflected. Circles proportional to the five interval levels are employed. They are used according to the Spanish demographic statistic and the reality of the Andalusian population to reflect the population diversity of the human settlements in Andalusia and which are the following (Table 3).

The last element included is the mark of the main populated centres affected, eight specifically, which correspond to those with more than 10,000 inhabitants which, from a statistical point of view, are considered to be urban in Spain.

Table 2. Population living in the accessibility areas of the rail trails of Huelva (2015).

Rail trail	Population living less than 5′ away	Population living less than 10′ away	Population living less than 15′ away
Guadiana	508 inhab.	936 inhab.	6676 inhab.
Molinos del Agua	20,202 inhab.	21,280 inhab.	190,056 inhab.
Litoral	14,948 inhab.	59,036 inhab.	100,933 inhab.

Source: Prepared by the authors from the data of polygon-type area shapefile provided by DERA.

Table 3. Hierarchical organisation of the population centres in the field of study.

Icons	Hierarchy of population centres	Number of population centres
	Centres with less than 5001 inhab.	42
	Centres between 5001 and 10,000 inhab.	1
	Centres between 10,001 and 20,000 inhab.	6
	Centres between 20,001 and 100,000 inhab.	1
	Centres with more than 100,000 inhab.	1

Source: prepared by the authors from the works by Camarero Rioja (1991) and Cano García (2008).

3. Conclusions

This article is a methodological advance since there are no previous studies which assess the accessibility to rail trails in Spain. Determining the accesses is no simple task, since establishing them through a unique use of a Geographic Information System which links the road network to its intersection with the rail trail can lead to definition mistakes, even if there is a subsequent review through satellite images. Therefore, it is essential to carry out fieldwork which confirms the real viability of potential accesses initially detected.

Determining the average speed of the different types of roads is also an essential condition to calculate the accessibility areas accurately. In this sense, differentiated information sources for each of them, not always available, reach significant importance. It is for this reason that, in this case, it has been necessary to carry out previous operations to obtain average speeds with the value as close as possible to the reality of travel.

Another contribution has been to include the resident population in all populated centres included in the selected accessibility isochrones (5, 10 and 15 minutes). Normally, in studies of accessibility to equipment and infrastructures, the whole population in the basic administrative unit (municipalities in Spain) is taken into account, although only one part of its territorial extension is affected. All populated centres have been taken into account here independently, in such a way that quantifying resident population in the different accessibility areas is very accurate.

In the end, the ultimate intention of the article is that this method can be used to determine the accessibility of the resident population (main potential users) to any rail trail, or to any type of non-motorised itinerary, which proliferate as a mean of contact with the natural environment and even for the population to move around.

Software

Diverse software packages were used: Garmin BaseCamp® was used to mark and save waypoints in the accesses to rail trails; average speed on different roads were calculated with Microsoft Excel® 2013 and ESRI® ArcGIS® 10.0 was used to design maps, as well as to obtain accessibility areas with Network Analyst tools.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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