Floristic studies on an urban ecological corridor: Via de Cintura Interna (Porto)

Sandra Cristina Ferreira de Almeida
Master Degree in Ecology, Environment and Territory
Department of Biology
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Supervisor
Rubim Manuel Almeida da Silva, Auxiliary Professor ,
Faculdade de Ciências da Universidade do Porto

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Resumo

As cidades em crescimento e o aumento da poluição destruíram habitats limitando a conexão entre os territórios, por esse motivo surgiu o conceito de corredor verde permitindo unir estes territórios fragmentados.

William Whyte surgiu com o termo “Greenway”, em meados dos anos 60, para descrever o conceito de um corredor linear que conecta zonas verdes permitindo a passagem de animais e plantas, mas que não permitia a passagem de automóveis.

Este conceito tem vindo a evoluir ao longo dos anos até se chegar ao conceito de um corredor verde que apesar de continuar a possuir um caracter linear, apresenta também múltiplas funções, entre elas, funções ecológicas e funções sociais.

A Via de Cintura Interna, na cidade do Porto, é uma estrutura viária que possui ao longo do seu comprimento taludes com vegetação que poderão apresentar algumas carateristicas associadas ao conceito de “greenways”.

Neste trabalho pretendeu-se estudar a flora presente nos taludes da VCI, verificar se estes se comportam como um “greenway”, averiguar se as espécies encontradas se dispersam ao longo do corredor ou, ainda, se estas espécies apresentavam algum padrão de distribuição.

Os resultados indicam que estes taludes não se comportam como um “greenway” pois encontram-se ausentes algumas das várias funções que caracterizam aquelas estruturas. O grande número de espécies encontradas não aparentou ter um padrão específico de distribuição. Muitas destas espécies eram exóticas mas a maioria não era invasora.

Estes resultados permitiram a obtenção do primeiro levantamento florístico daquela estrutura, identificar questões pertinentes sobre a utilização dos taludes e entre outras questões, perceber como se comporta a vegetação ao longo de uma via rodoviária urbana.

Palavras-chave: Greenway; corredor verde; fragmentação de habitats; ecologia da estrada; conectividade

Abstract

The growth of cities and the increase in pollution destroyed habitats by limiting the connection between separated territories. Thus, the concept of green corridor, allowing this fragmented territories to become connected facilitating the movement of life, has arose.

William Whyte suggested the word “Greenway”, in mid sixties, to describe the concept of a linear corridor that connects green zones allowing the movement of animals and plants but not of motorized vehicles.

This concept evolved over the years until the concept of a green corridor that still is a linear structure but also introduce multiple function, among them, ecological and social purposes.

The Via de Cintura Interna, in Porto, is a road infrastructure that has embankments with vegetation along its entire length and could show some characteristics associated to the “greenway” concept.

In this work embankments flora of VCI was studied for the first time and we sought to determine whether there were floristic patterns of dispersion, namely gradients.

The results indicate that the embankments don’t behave as a “greenway” because they don’t show many of the functions associated to such a structure. The high number of species found didn’t appear to have a specific pattern of distribution. Many of the species present were exotic but not many were invasive ones.

These results allow better knowledge of the flora of the area, identify some pertinent questions about embankments functions and understand how flora behaves along an urban road.

Key words: Greenway; green corridor; habitat fragmentation; road ecology; connectivity

Index

Figures Index

Tables Index

Greenways

In our society, the urban environment is of great importance and in many cases nature is put aside and neglected; sometimes it is used to conclude a project by filling an empty space (Magalhães, 1992), while cities grow and alter profoundly the landscape that surrounds them by building infrastructures that modify the topography, by introducing exotic plants, creating barriers or building roads, generating microclimatic areas, disturbing natural processes, such as ecological succession and destroying habitats connectivity by blocking animal and plants movement between patches (Lowry, 1967; Davis, 1973; Seiler, 2001; Hostetler,2011).

With the growing importance of the road in the human society, because of the expansion of cities, a new field of study appeared - road ecology - devoted to study the negative effects that roads and traffic corridors may create and the ways to mitigate them (Ranta, 2008).

Since the industrialization era, cities have become larger and filled with smoke, dust, heat, noise and many other hazards (Davis, 1973), most of the air and noise pollution mentioned were caused by increase of traffic and by the growth of habitants numbers living in cities (Ranta, 2008). The growth of cities caused by the increase of population, doesn't only impact the human lives but also the natural environment such as damage plants or even promote the disappearance of habitats with the consequent extinction of animal and plant species (Shaw, 1903; Mcdermontt 1961; Davis, 1973).

The destruction of the natural landscape made the urban areas highly modified and the habitats very fragmented. The lack of green spaces in cities encouraged the creation of urban greenways and wildlife corridors in the urban landscape planning (Angold, 2006), as a way to minimize the negative effects associated to that fact.

In an ideal situation all corridors should be naturally made, using the surrounding environment to structure them. Unfortunately most of the green corridors, despite being associated with natural features, are manmade and may follow human created features such as railroads (Flink, 1993; Magalhães, 1992).

The term greenway gives us two different images: on one hand, the word *green* may reminds us of nature and places like forests, rivers or a wide green plain; on the other hand, the word *way* implies movement, paths or roads (Flink, 1993).

Although the term “greenway” is recent, accordingly to Ervin Zube (1995) the concept has more than 100 years and could even go back to the Roman times and the building of their roads (Searns, 1995; Seiler, 2001).

In the literature, there isn’t an absolute definition for the term greenway, and it is modified accordingly with the country or the author. Other names given to greenways are ecological infrastructures, wild life corridors or green corridors (Ahern, 2002), so it is extremely difficult to define what a greenway is or is not. Some authors admit that a greenway is connected to forests or even riverbanks (Flink, 1993), while others consider it a secondary green structure that connects different spaces for the use of people, as walkways (Magalhães, 1992), or even as a set of lands that are protected for various uses (Ahern, 2002). Ahern (1995) defines greenways as “...*networks of land 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”.* Despite the variety of definitions, they all have in common the fact that it is a green, more or less linear structure, with a defined objective, at the ecological or social level.

There are several types of greenways. Some are more natural/rural, connected with streams, forests or riparian corridors, others are related to the connection between rural areas and urban ones, like river ways or walk ways that allow access to nature for urban citizens and take the rural areas into the city, and even just urban, connecting the fragmented urban land such as traffic corridors, park ways or just a network of small gardens (Flink, 1993;Taylor,1995; Maestas,2003; Bryant, 2006; Frischenbruder, 2006; Angold, 2006; Hahs, 2006).This work will only refer to the urban ones that connect fragmented land in cities.

1.1. Evolution of the concept

Some authors proposed an evolution of the greenway concept as presenting three different and consecutive phases.

The first phase started before the eighteenth century and ended in the second half of the twentieth century. It included structures such as axes, boulevards our even parkways. In this phase the term greenway wasn’t used yet.

The structures built during this phase were used for human and working animals’ movement or for aesthetical purposes and intended to bring the rural felling into the city but those corridors weren´t prepared for the use of motor vehicles such as cars or motorbikes (Searns, 1995).

It was in the industrial era that the concept of urban green space, as a substitute of nature in cities, started with the creation of parks and public foot walks (Magalhães, 1992) in an attempt to reintroduce nature in cities.

They provided connection between different points of interest and could present themselves in the form of walkways for strolling along, or as paths for horse-drawn carriage rides. They always respected the topography and the hydrology of the land (Ahern, 2002). In some cases they were corridors along canals.

This phase also represents the beginning of the greenbelt movement (Magalhães, 1992; Searns, 1995; Zube, 1995; Ahern, 2002). This idea consists in a strip of rural land that defines the limits of the urban area preventing the expansion of the city limits and was based in political boundaries. Although different, greenbelts and greenways have some similarities such as the linear form or the buffering capacity.

These corridors share the movement function of the corridors of the present days.

The second phase started in the sixties and went up to the mid-eighties. William Whyte is associated with the use of the word “Greenway”, which was related to a corridor that runs along a river and follows the topography patterns of the city limits, including some parks and other green structures for public use. During this period, the automobile becomes one of the most important means of locomotion in cities. Therefore, the levels of pollution increased and the need for locations for non-motorized route travels and without air pollution (Searns, 1995; Zube, 1995; Ahern, 2002) became a must. These corridors were paved allowing for bicycle rides, walks, as well as hiking trails.

Since then, many other corridors were created and most of them were associated to riversides, shorelines or other canals. With the growth of this movement came another type of corridors (Searns, 1995; Walmsley, 1995; Ahern, 2002), these were associated with the abandoned railroads. The railroad corridors had the advantages of having a predetermined linear structure.

These corridors constitute a more accessible adaptation of the nature trails in cities, allowing a greater contact between the common city people and nature, being accessible for a bigger segment of population. This didn’t occur in the previous phases, where the corridors were mainly accessible to wealthy people (Searns, 1995).

This third phase began in mid-eighties and it is still in development. In this phase there is a broader concept of greenway, that takes into account more functions and objectives. It is in these corridors that the idea of more environmentally concerned greenways began (Searns, 1995; Zube, 1995; Ahern, 2002).

This new phase is characterized by linear structures that are left alone and preserved with the intention of habitat protection and avoiding biodiversity reduction.

The initial corridors were paved, but in the beginning of the nineties, they were being built unpaved with more natural features.

These greenways were characterized as recreational places while allowing, at the same time, in some cases, much easier access to rivers and other water lines on the urban mosaic than the parks and wilderness.

Unlike the two previous phases, in this one, corridors are not just seen as recreational or aesthetic spaces but also as tools to prevent or help solving ecological problems. These "greenways" are multi-functional, serving several objectives such as education, reduction of hazards like pollution or erosion, recreation and many others such as conservation of habitats. They also promote cultural or historical learning (Flink, 1993; Searns, 1995; Zube, 1995; Ahern, 2002; Bryant, 2006).

Some schools adopted one segment of "greenway" and are using them to teach students about nature and how to preserve it (Searns, 1995; Walmsley, 1995; Ahern, 2002).

Every new generation of "greenways" is more complex than the previous ones, and is shaped in the culture and education of its users.

1.2. Greenways in the present

In the present day the greenway concept was found by the consensus between ecologists and landscape planners with the goal of protecting and preserving nature by using networks of land (Ahern, 2002).

The concept is very adaptive and flexible enough to support its application with various combinations of needs, values and conditions allowing for builders and community to dialogue (Flink, 1993; Ahern, 2002).

As mentioned before there are very different types of greenways. They can be associated with a waterfront such as rivers or shorelines, as a way to contain and preserve water quality. They can be associated with wildlife in its most pure form and sometimes used with ecological purposes such as providing migration routes. Others are associated to recreational services as trails and paths or they can be associated to roads, highways or waterways, in order to provide pedestrian routes and scenic or historic routes. Another type of “greenway” is a network of green infrastructures connecting valleys or rivers with the idea of uniting the various open spaces serving different objectives. All the different types can overlap, creating greater greenways that present multiple purposes (Flink, 1993; Fabos, 1995; Walmsley, 1995; Ahern, 2002; Frischenbruder, 2006).

According to Ahern (2002), the primary goal for the creation of greenways is the realization of a sustainable network of protected lands, and for that a mix of landscape ecology theories and several methods of landscape planning can be used.

The actual “greenways” may present various values to those who use them, they can be a mere non-polluting area, a trail for horse riding or just for strolling, it can protect the quality of the water, preserve wildlife habitat, buffering land use or even safeguard some present or past characteristics of the region. They can also separate people from the traffic physically and in some cases provide business opportunities by attracting tourists (Flink, 1993; Magalhães, 1992).

The present greenways aim to protect urban lands and urban landscape and so they tend to be located closer to the focus of pollution: where people live and work, allowing for a better quality of life (Mcintyre, 2000; Frischenbruder, 2006; Ignatieva, 2011).

Nowadays, greenways are also associated with economy. The economic exploitation of the land has been causing many problems such as the degradation of the ecosystems by agriculture or even tourism (Jiangue Liu et al, 2007). It has been verified that land around greenways, parks or trails is more valuable than land that doesn’t have a green structure nearby, because those places tend to attract people (Flink, 1993; Alberti, 1996).

The creation of greenways needs to respect the “continuum natural”, meaning that corridors should be built respecting the surroundings and associated with the quality of human life. This is a granted right by the Portuguese Constitution (Magalhães, 1992).

The sustainability, sought by urban planners, might be obtained by promoting the existence of the multiple processes simultaneously, by integrating the cultural and aesthetical resources and values (Ahern, 2002). Another characteristic of a greenway is accessibility, and that involves the access and transportation to and from the greenway. That is important because the nearby land could be privately owned, which means that the land isn’t accessible to everyone (Flink, 1993).

Besides the previously mentioned objectives, such as ecological protection, recreational features, cultural resources, aesthetical or educational aspects, greenways must also have a linear form, the capacity for linking patches allowing movement and transportation of material, species or nutrients. (Flink, 1993).

These corridors tend to be longer in length than in width, the last varying according to the corridor, they should be continuous but sometimes it's impossible because of the network connections (Flink, 1993; Ahern, 2002).

Greenways could be studied in different scales such as local, regional, national our international because sometimes they expand beyond the political frontiers.

When it comes to planning greenways, there isn't a large consensus because it is necessary to take into account the previous land use and land cover as well as the historical context of the land (Ahern, 2002; Bryant, 2006).

The implementation of corridors may not be possible everywhere, so the implementation plans need to be made according to the region and the cultural landscape (Flink, 1993; Ahern, 2002; Ranta, 2008).

For example, authors such as Flink (1993) and Dawson (1995), propose six key indicators for a greenway, namely slope, vegetation, geology, soil, wildlife and hydrology. Lower slopes were recommended for use in greenways design because they facilitate the walk and use, especially when closer to waterlines. Vegetation types may help to identify the uses that the corridor supports and geological analyses may detect some features such as faults or others that are points of interest. The previous use given to the land and the type of soil as well as its hydrology may help to understand the potential of the area as a corridor. Also studying the presence of land wildlife allows us to determine if the corridor is a walkthrough path for the different species.

According to many authors there is still much more to do in this new generation of greenways (Flink, 1993; Dawson, 1995; Searns, 1995; Ahern, 2002; Bryant, 2006; Hostetler, 2011).

1.3. Advantages and disadvantages of greenways

1.3.1. Advantages

The creation of greenways carries along some very important advantages: they may control the flow of nutrients and sustain levels of land functions. These corridors can prevent processes of erosion and mass wasting, help to mitigate negative impacts such as invasion of non-native plant species, stabilizing the ecological factors that might favour the spread of invasive species and/or protect against habitat fragmentation and protect and promote animal and plant diversity

(Bryant, 2006). Corridors may also help clean the air and water, being this effect maximized by corridors length (Flink, 1993; Dawson, 1995; Fabos, 1995; Ahern, 2002; Frischenbruder, 2006; Ranta, 2008).

It might raise environmental awareness by making a profound impact on the physical and spatial characteristics of the landscape (Searns, 1995; Ahern, 2002). The fact that the resources are more concentrated in the corridors may allow a better protection in a smaller area of land, which will facilitate monitoring, and allowing for less land to be withdrawn from other uses (Flink, 1993; Ahern, 2002).

There are also some benefits for the community. On one hand, it would reduce costs caused by the ecosystem disturbances and the people that use the space. On the other hand, it could bring business opportunities and the increase of the property value (Flink, 1993).

Some corridors have open spaces that may be used for recreational activities, allowing its users a closer contact with nature (Flink, 1993; Ahern, 2002; Bryant, 2006; Frischenbruder, 2006).

Lastly, there is another more abstract advantage, and it is related to the connection between humans and nature, enabling people to feel better with themselves and their surroundings and appreciate nature by strolling in trails or offering visual relief. This connection also allows healthier life style by providing a place to walk without pollution. The most important advantage of greenways is the capacity to admit multiple functions at the same time (Flink, 1993; Fabos, 1995; Searns, 1995; Ahern, 2002; Ranta, 2008; Samways, 2011).

1.3.2. Disadvantages

Some authors argue that there’s no need for corridors because species are capable of dispersion in the landscape without them (Ahern, 2002).

Disadvantages include several types of problems and, of course, are noted by different authors. Therefore the difficulty into connecting different functions in the same corridor as well as the management of the greenways are pointed as disadvantages due to habitat degradation, for instance, caused by maintenance works such as mowing of the grass (Ranta, 2008).

Also when corridors are not ecologically balanced, they can promote the dispersion of invasive species into the protected area creating disturbance (Dawson, 1995; Fabos, 1995; Ahern, 2002; Frischenbruder, 2006; Samways, 2011).

Corridors can change the physical, cultural and visual landscape by leading to a greater uniformity of the land, being almost impossible to maintain a pristine state in all and each greenway (Dawson, 1995). The concept of greenway may obscure other projects that could be more important to the protection of the ecosystems as a whole (Ahern, 2002).

The greenways sometimes expand beyond political boundaries causing political and economic problems (Ahern, 2002).

Lastly the greenways initiative, may harm private owners who lose their lands or see them being occupied by people (Flink, 1993).

1.4. Ecology of greenways

Biodiversity defined by Bryant (2006) as *"... the variety and variability among living organisms and the ecological complexes in which they occur*" is a current theme that is being discussed all over the world due to the dangers of its disappearance and the search for ways of protecting it.

One way to prevent these extinctions may be the greenways which are systems or networks connecting the remaining open spaces and wild areas (Hostetler, 2011) that have been increasingly fragmented. Fragmentation is the destruction of the connection between patches that lead to the lack of habitat and the extinction (Flink, 1993) or the isolation of species (Dawson, 1995) and may be derived from the drastic habit transformations (Pereira, 2007).

According to Dawson (1995): "*the fragmented corridors have the disadvantage of separation from basic landscape patterns, however they may have some value as "stepping stones" for species with high dispersal potential",* even so, these corridors need to be connected to larger parks or reserves. Private gardens in the surrounding of corridors can be very important *stepping stones* (Ignatieva, 2011).

The extreme weather conditions force species to move in order to find better conditions (Roy, 2010). Natural corridors help species escape from danger, performance, fire and so on, but the narrow ones could actually trap species, doing little to their survival (Flink, 1993).

Many plants and animals use corridors as crossing points, while others inhabit the space. These habitats are semi-natural, in most cases, and are in the earlier stages of the ecological succession. One of the primary objectives of greenways is to encourage animals and plants to move into the urban fabric, that is called connectivity and it is related to the promotion of the movement of species (Pereira, 2007). Sometimes these corridors may act as buffers between rural and urban fringes (Taylor, 1995), trying to maintain sustainability, which imply the maintenance of the capacity for natural ecosystems to sustain human life over time (Alberti, 1996).

Roads are paved areas that extend outward and receive road maintenance. The roads have ecological effects on the land that surrounds them. The effects extend for some metres creating a road effect zone that is highly asymmetric because of the directional flows and the spatial patterns on opposite sides of a road (Forman, 2000).

The sides of the roads and railroads are typically corridor habitats, and have a predominance of edge species (Ranta, 2008). In some cases, this structure will enter a built area and it is modified to build traffic embankments for the pedestrians (Magalhães, 1992).

The abundance and the richness of the species that exist in the habitat vary according to the area, connectivity and the continuity of the patch. The pioneer and tall herbs survive longer in infertile substrate and under continual disturbance (Angold, 2006) such as the competition for available nutrients and space, between non-native species and native species (Zipperer, 2009).

Human population has been living mostly in cities that are organized systems of interacting biophysical and socioeconomic components (Alberti, 1996). Urban is the name given to a densely populated area, such as cities, and urbanization is the relation between ecological and social phenomena (McIntyre, 2000). It is believed that urban development causes the increase of biodiversity loss (Hepinstall, 2008). The greenways associated to these areas serve as urban biodiversity protection mechanisms (Bryant, 2006).

Species that may occur in the urban corridors have a wider distribution and may occur in different corridor types. According to Angold (2006) it’s possible that the nearby area of the corridors doesn’t influence the species richness unless the corridor is near derelict and wasteland sites. In his words *“green corridors may make little difference to the diversity of plants… in towns and cities…”*

These “ecosystems” can vary in the short distance because of the pressures to which they are subject to by the surroundings (Hostetler, 20011) or even by the management.

This management may include a regular mowing to keep the habitats in the early stages of succession and are influenced by aesthetic values and traffic safety (Ranta, 2008), creating an ecosystem that depends on humans to its sustainability (Jianguo Liu et al, 2007). These mowing regimes should vary according to the species that may exist in the place (Ranta, 2008).

Even though this isn´t required, it is recommended that the green corridor should be continuous to help the connectivity, but most of times highways tend to interrupt major travel corridors (Flink, 1993; Forman, 2000).

The road effect may cause habitat invasions, the salt “produced” in highways damages woody vegetation, barriers created subdivide populations into small ones, may provoke road kills or the noise produced drive away some species (Forman, 2000).

To better create a greenway it is recommended to inventory the resources available during different seasons of the year. If there are endangered species, it may help to get a protective state (Flink, 1993). The concept is applied successfully because it doesn’t attempt to transform or control the entire landscape (Ahern, 2002).

Corridors could have a vertical structure forming a system with specific functions. Hedgerows, vegetated hillsides, and stream corridors help break the wind and prevent the soil from blowing away. Trees and other plants remove carbon dioxide, carbon monoxide and other pollutants while producing oxygen (Flink, 1993; Alberti, 1996)

Most greenways are associated with rivers, waterways or riparian corridors because they are linear corridors by nature, they are considered environmental significant and have been object of worry and protection for a long time.

Greenways are characterized by its interrelationships among resources and land. It is believed that they are very vulnerable to society’s interference (Dawson, 1995).

When talking of “anthropogenic” environment, such as roads, it is necessary to take into account not only ecological processes but also socio-economic factors, like business, life style and size of matrix (Waldhardt, 2003).

Even though greenways are very important when we talk about conservation of nature, it is still very important to maintain an interior habitat with good quality (Ahern, 1995), so we should never forget about the species living in bigger areas outside greenways.

Ecological networks have properties and functions beyond those of corridors and could be used to improve natural conditions and stem the loss of biodiversity across the landscape. It is recommended to be at least 200m wide to start being a habitat or simply a conduit for invertebrates. These corridors should be maintained, monitored and considered a habitat, not just a conduit, to be able to act as a source with ecosystem functions (Samways, 2010).

The study of greenways needs a time scale of decades to make sure that the habitat corridor is efficient (Ahern, 2002).

2. Via de Cintura Interna

The study area is the VCI (Via de Cintura Interna), (see Figure 1), located in the north of Portugal, in the city of Porto. It is a 10 km long highway with a ring shape that goes from Arrabida Bridge to Freixo Bridge and surrounds the town till the edges of Douro River, from west towards east, and receives several traffic routes from the north.

VCI was idealized from 1948 to 1952 and its purpose was to solve traffic problems in Porto city. The project included the construction of two new bridges, offering more exits to the town. The structure planned was conceived to be both a pedestrian and a traffic corridor, with inherent social and recreational functions (Sucena, 2004; Fernandes, 2005).

In 1962 the project was approved but it was altered to “gain” a barrier effect between the patches it separates, losing its recreational characteristics (Sucena, 2004).

The project was assumed and executed by JAE (Junta Autónoma de Estradas), but was delayed several times and ended up by being developed in several different stages and different periods of time.

The first portion was finished and opened in 1963. In 1979, the state took the responsibility to finish the project but only in 1985 did the search for building companies start to conclude another two portions of the high way.

Today the highway is finished, and includes a fast track. VCI has two major functions: to receive traffic from the city, domestic (inner) circulation; to transfer traffic going north from other towns - national traffic.

The entire structure is followed by verges and slopes, with some interruptions, and may allow the survival of animal and plant species or just their passage.

Figure 1: Map of VCI. Picture taken from the Google Earth. The VCI highway is represented in dark yellow. The surveyed points are indicated by the yellow drawing-pins.

3. Objectives of the work

The main objectives of this work are centred in the answers to the following questions:

1. Is VCI (Via de Cintura Interna), an artificial corridor composed mainly of slopes with vegetation and surrounding an inner ring road in Porto, in fact a greenway?
2. Which plant species inhabit that corridor and how does plant diversity vary along the structure?
3. Is there some sort of vegetation gradient established when it comes to the proximity to the sea and to the river?
4. Can the corridor act as potential “freeway” for invasive plants?
5. Is vegetation composition influenced by the surrounding areas, e.g., agricultural fields versus residential blocks and other impermeable areas?
6. Can VCI be valued as an amenity-recreation venue, wildlife refuge and an essential liveable-city ingredient?
7. How have ecological goals been set out to influence the planning, design and management processes? Is there any evidence that these goals have effectively influenced the planning processes within the study area?

4. Methodology

The development of this work involved an intensive bibliographic research so as to better define the concepts of ecological corridor, greenway and others.

At the same time there was a need to study the vegetation growing in the corridor composed by road embankments that surround the highway, VCI, in Porto. Fieldwork was carried away during winter and spring campaigns.

Fifty study points were chosen along the two sides of the highway (see Figure 1). The number of points was defined taking into account the length of VCI, so the data collected would be representative.

In each point a floristic survey was carried away along a 10-meter transept (whenever possible). Also several parameters (see table 1) were measured or surveyed *in situ* or with the help of a GIS programme. Those parameters were analysed with only some simple statistical methods since the floristic survey did not allow procedures to be made deeper.

Characteristics associated to the greenway were surveyed to determine if the VCI was in fact a greenway.

Vegetation was analysed to identify the presence of exotic species that may interfere with the native species present and with the good function of the greenway.

The movement in the corridor of the highway was determined by the analysis of the dispersal of the plants species along the structure.

To determine the relation between the vegetation and the proximity of the river/sea it was compared the data collected in the several points and the distance from that point to the river/sea; the relation between the vegetation present in the corridor and the distance to the near green space was also determined.

Finally, the surrounding area was studied to determine its influence over the corridor.

5. Results

In the survey it was possible to determine the variables present in Table 1. The entire highway embankments, on both sides, are turned inwards to the highway and have slopes that vary from 0% to 75.38%. The orientation followed by highway goes from south-west to west on one side of the embankments while on the other it goes from northeast to east.

The smallest embankment measured 1m width and the largest 100m. In the largest the survey only considered the first 10m mark. The signal + before the 10m in Table 1 means that the corridor is more them 10m width.

Sun exposure is constant in 78% of the points analysed, the other 22% of the points have some shade during part of the day, mostly given by the buildings or trees that surround them.

Some of the corridors that follow the highway had previous uses in the matrix that surrounds them. One of the uses found is “private garden”; point 2 is associated to Porto’s botanical garden; points 41, 42 and 44 are made of concrete because two subway stations and train station respectively were build on them. The other points are simple embankments of the highway without any apparent use.

“Estradas de Portugal” and Brisa are responsible for the maintenance of the highway and its embankments, what happens around twice a year (although it was possible to observe a more or less erratic behaviour of these operations), while the private gardens have a more frequent management provided by their owners. The information present in Table 1 refers to the periods the surveys were undertaken.

Under the Portuguese law it is forbidden to walk in a highway, so from the highway it is impossible to access the embankments that follow VCI. The data collected refers to the accessible side of the embankment, as shown in table1.
Fifty per cent of the points under study are not of public access, as an example point 47 is a closed private garden. Fourteen percent of those points were easily accessible, such as point 7 that is a private garden open to community and 36% of those points were not easily accessible, like point 21 that is a fenced private garden.

Fencing is a right that private owners have to protect their property but in this case it may difficult the pedestrian access to the highway corridors. Forty six percent (46%) of the embankments had fences that didn’t allow the access, mostly private properties. Another 46% were non-fenced embankments associated with road corridors, for example point 38 which was a roundabout. There were also semi-fenced areas (only 8%), some of those areas have a fence in the middle of the embankment while others, as result of vandalism, don’t have any barrier and the fence hadn’t been replaced yet.

Table 1: Measures obtained during the surveys or using a GIS: measures of slope, width, sun exposure, corridor use, maintenance, accessibility, fencing, distance from the river, distance from sea and distance to the nearest green space, associated with the 50 points of survey, were taken.

Point	**Slope**	**Orientation**	**Width**	**Sun exposure**	**Use**	**Maintenance**	**Accessibility**	**Fencing**	**Distance from the river**	**Distance from the sea**	**Nearest green space**
1	13,70 %	230 south-west	+ 10 m	constant	garden	No	accessible	Not fenced	0,52km	2,66km	90m northwest
2	0,00%	north east	1m	constant	Botanical garden	Yes, frequently	inaccessible	fenced	0,53km	2,70km	2m north
3	0,00%	south-west	+ 10m	constant	cemetery	no	inaccessible	fenced	0,91km	2,55km	40m northeast
4	19,60 %	77.º East - north east	5m	constant	Embankment	Yes, not frequently	not easily accessible	Not fenced	0,90km	2,58km	10metros northeast
5	30,00 %	62º East - north east	+10m	constant	building garden	Yes, not frequently	not easily accessible	Not fenced	1,32km	2,55km	100m northeast
6	0,00%	219º south-west	2m	constant	Embankment	Yes, not frequently	not easily accessible	Not fenced	1,30km	2,59km	80m northeast
7	38,00 %	283 west - north east	10m	constant	building garden	Yes, not frequently	accessible	Half fenced	1,70km	2,61km	45m west
8	5,80%	273 west	10m	With shade	building garden	Yes, not frequently	accessible	Not fenced	1,71km	2,63km	36m east
9	0,00%	174 south	+10m	With shade	Road separator	no	not easily accessible	half fenced	2,15km	2,97km	100m
10	14,30 %	305 north west	+10m	With shade	building garden	Yes, frequently	accessible	Not fenced	2,03km	2,98km	80m
11	27,30 %	184 south	3m	constant	Road separator	Yes, not frequently	inaccessible	fenced	2,23km	3,38km	108m west
12	0,00%	300 west north west	+10m	constant	Embankment	Yes, not frequently	inaccessible	fenced	2,19km	3,39km	60m east
13	26,70 %	167 south south-west	+10m	constant	Highway edge	no	inaccessible	fenced	2,43km	3,79km	120m northeast
14	24,70 %	288 west north east	+10m	constant	Highway edge	no	inaccessible	fenced	2,54km	3,80km	30m
15	19,00 %	185 south	6m	constant	Highway edge	Yes, not frequently	inaccessible	fenced	2,77km	4,21km	20m north
16	17,00 %	334 north north west	4m	constant	Supermarket garden	Yes, not frequently	inaccessible	fenced	3,07km	4,21km	100m south-west
17	3,00%	south	6 m	constant	Highway edge	Yes, not frequently	inaccessible	fenced	2,96km	4,60km	1m
18	13,00 %	north	+10m	constant	Highway edge	Yes, not frequently	not easily accessible	fenced	2,95km	4,60km	1m
19	39,00 %	140 south-west	+10m	constant	Embankment	Yes, not frequently	inaccessible	fenced	3,25km	4,98km	30m north

Table 1: (Cont.) Measures obtained during the surveys or using a GIS: measures of slope, width, sun exposure, corridor use, maintenance, accessibility, fencing, distance from the river, distance from sea and distance to the nearest green space, associated with the 50 points of survey, were taken.

Point	Slope	Orientation	Width	Sun exposure	Use	Maintenance	Accessibility	Fencing	Distance from the river	Distance from the sea	Nearest green space
20	25,80%	60 north	+10m	constant	Highway edge	no	inaccessible	fenced	3,20km	4,97km	50m West
21	24,00%	180 south	+10m	constant	building garden	Yes, not frequently	not easily accessible	fenced	3,35km	5,43km	18m north
22	0,00%	342 north north west	+10m	constant	Embankment	Yes, not frequently	inaccessible	fenced	3,34km	5,41km	50m
23	3,00%	south south-west	4,3m	constant	Embankment	Yes, not frequently	not easily accessible	Not fenced	3,51km	5,81km	25m west
24	3,00%	north	2,45m	constant	Embankment	Yes, not frequently	not easily accessible	Not fenced	3,43km	5,78km	40m east
25	3,00%	south south-west	+10m	constant	Embankment	Yes, not frequently	not easily accessible	Not fenced	3,88km	6,18km	50m north
26	3,00%	north	+10m	constant	Embankment	Yes, not frequently	not easily accessible	Not fenced	3,81km	6,14km	60m south-west
27	0,00%	south-west	+10m	constant	Embankment	Yes, not frequently	inaccessible	fenced	3,78km	6,39km	50m north
28	0,00%	north east	+10m	constant	Embankment	Yes, not frequently	inaccessible	Not fenced	3,70km	6,34km	60m south
29	10,00%	south	+10m	constant	Embankment	Yes, not frequently	not easily accessible	Not fenced	3,65km	6,66km	70m north
30	7,14%	north east	7m	With shade	Highway edge	Yes, not frequently	inaccessible	Not fenced	3,58km	6,63km	49m east
31	0,00%	south east	1m	constant	Community road	no	not easily accessible	half fenced	3,65km	7,04km	18m west
32	29,40%	north	+10m	constant	Embankment	Yes, not frequently	inaccessible	fenced	3,59km	7,01km	18m west
33	5,00%	East	7,7m	constant	Highway edge	no	accessible	Not fenced	3,37km	7,35km	1m north
34	0,00%	north east	8m	With shade	building garden	Yes, frequently	accessible	Half fenced	3,35km	7,32km	20m south-west
35	0,00%	south south-west	+10m	With shade	Privet garden	no	inaccessible	fenced	3,26km	7,55km	1m north
36	0,00%	East	3m	constant	building garden	no	not easily accessible	fenced	3,23km	7,52km	20m south
37	2,00%	south east	+10m	With shade	roundabout	no	not easily accessible	Not fenced	3,22km	7,82km	5m north
38	2,00%	north	+10m	With shade	roundabout	no	not easily accessible	Not fenced	3,18km	7,78km	5m south
39	0,00%	south-west	+10m	With shade	roundabout	Yes, not frequently	inaccessible	fenced	2,89km	7,98km	10m north
40	13,3%	north east	+10m	With shade	roundabout	Yes, not frequently	inaccessible	fenced	2,88km	7,94km	15m north
41	0,00%	south-west	8m	constant	Subway station	no	inaccessible	Not fenced	2,18km	7,91km	30m east
42	0,00%	north east	10m	constant	Subway station	no	inaccessible	Not fenced	2,21km	7,87km	113m south-west
43	0,00%	west	+10m	With shade	garden	Yes, frequently	accessible	Not fenced	1,87km	7,73km	25m east

Table 1: (Cont.) Measures obtained during the surveys or using a GIS: measures of slope, width, sun exposure, corridor use, maintenance, accessibility, fencing, distance from the river, distance from sea and distance to the nearest green space, associated with the 50 points of survey, were taken.

Point	**Slope**	**Orientation**	**Width**	**Sun exposure**	**Use**	**Maintenance**	**Accessibility**	**Fencing**	**Distance from the river**	**Distance from the sea**	**Nearest green space**
44	0,00%	East	10m	constant	Railroad station	no	inaccessible	Not fenced	1,84km	7,69km	14m west
45	0,00%	west	9m	constant	Embankment	Yes, not frequently	not easily accessible	Not fenced	1,33km	7,79km	1m east
46	17,50 %	East	+10m	constant	Comboios de Portugal Privet property	Yes, not frequently	inaccessible	fenced	1,50km	7,65km	1m west
47	66,7%	west	3m	constant	Privet garden	no	inaccessible	fenced	1,08km	7,98km	1m north
48	42,86 %	East	7m	constant	Embankment	no	not easily accessible	Not fenced	0,99km	7,93km	1m west
49	50,00 %	west	+10m	constant	Embankment	Yes, not frequently	not easily accessible	Not fenced	0,59km	7,89km	20m east
50	75,38 %	East	+10m	constant	Privet property	no	inaccessible	fenced	0,57km	7,75km	1m west

The distance from the different points of the corridor to the river was calculated with a transect of each point to a point in the river and it varies from 0.53km in the nearest point to 3.88km in the furthest. The distance from the sea varies from 2.66km in the closest point to the 7.98km to the furthest. The nearest green space was also measured with a transect from the study point to the nearest green space and it varies from 1m, when the point was closely associated with a great green space, to 120m, (most of the green spaces were small gardens associated to buildings in the neighbourhood).

The results of the floristic survey are shown in table 2. In the 42 points surveyed, around 219 different species of plants were found. Eight points were excluded from the survey, for different reasons, for example, point 2 was excluded because it was connected with the botanical garden. Points 3, 17 and 27 were excluded because it was difficult to obtain data. Point 35 was excluded because it was a private garden and all the specimens found were the results of human planting (exotic plants). Finally, points 41, 42 and 44 were excluded because they were covered in concrete and had no floristic data.

Table 2: Species of the floristic surveys, their respective families and the points in which they were found.

specimes	Families	Survey points
Abelia x grandiflora (André) Rehder	Caprifoliaceae	47
Acacia longifolia (Andrews) Willd.	Fabaceae	38
Acacia melanoxylon R. Br.	Fabaceae	14
Acanthus mollis L.	Acanthaceae	8
Acer negundo L.	Sapindaceae	10
Acer pseudoplatanus L.	Sapindaceae	9;32;37
Achillea millefolium L.	Asteraceae	22
Adenocarpus lainzii (Castrov.) Castrov.	Fabaceae	22
Agapanthus africanus (L.)Hoffmanns.	Amaryllidaceae	36
Ageratina adenophora (Spreng.) King & H.Rob.	Asteraceae	5;14
Aira caryophyllea L.	Poaceae	14;25
Ailanthus altissima (Mill.) Swingle	Simaroubaceae	1
Allium triquetrum L.	Amaryllidaceae	5;21
Ammi majus L.	Apiaceae	16;18
Anagallis arvensis L.	Primulaceae	4;24
Anagallis monelli L.	Primulaceae	1;6
Andryala integrifolia L.	Asteraceae	1;6;11;14;21;22;28;29;38;39;45;50
Anthoxanthum amarum Brot.	Poaceae	5;39
Anthoxanthum doratum L.	Poaceae	13
Apium nodiflorum (L.) Lag.	Apiaceae	37
Arctotheca calendula (L.) Levyns	Asteraceae	18
Artemisia verlotorum Lamotte	Asteraceae	39;40
Arum italicum Mill.	Araceae	19;30;49
Arum maculatum L.	Araceae	5
Aster squamatus (Spreng.) Hieron.	Asteraceae	37
Avena barbata Pott ex Link	Poaceae	14;28;29;36;45;48;49
Bellis perenis L.	Asteraceae	7;23;25;26
Bidens pilosa L.	Asteraceae	13;15;23
Brachypodium sylvaticum (Huds.) P. Beauv	Poaceae	6
Brassica rapa L.	Brassicaceae	4
Briza maxima L.	Poaceae	29;40
Briza minor L.	Poaceae	12;39;40
Bromus catharticus Vahl.	Poaceae	45;50
Bromus diandrus Roth.	Poaceae	4;5;6;11;12;14;21;30;31;33;38;45;47;48;49;50
Bromus sterilis L.	Poaceae	19
Buddleja davidii Franch.	Scrophulariaceae	15
Calystegia silvatica (Kit.) Griseb.	Convolvulaceae	5;9;16;40;46
Camellia japonica L.	Theaceae	10
Canna indica L.	Cannaceae	10

Table 2: (Cont.) Species of the floristic surveys, their respective families and the points in which they were found

specimes	Families	Survey points
Capsella bursa-pastoris (L.) Medik.	Brassicaceae	8;14
Cardamine hirsuta L.	Brassicaceae	4;19
Carduus pycnocephalus L.	Asteraceae	11;49
Carduus tenuiflorus Curtis	Asteraceae	48
Carex sp.	Cyperaceae	16;22
Carex divulsa Stokes in With.	Cyperaceae	10
Celtis australis L.	Ulmaceae	25;34
Centaurea sp.	Asteraceae	20
Cerastium glomeratum Thull.	Caryophyllaceae	4;7;10;19;21;23;25;26;30;33;34;49
Cestrum sp.	Solanaceae	8
Chamaecyparis lawsoniana (A. Murray) Parl.	Cupressaceae	4;8;23
Chamaemelum mixtum (L.) All	Asteraceae	37
Chenopodium sp.	Chenopodiaceae	19
Chelidonium majus L.	Papaveraceae	5;22;45
Chrysanthemum segetum L.	Asteraceae	37;48
Cirsium vulgare (Savi) Ten.	Asteraceae	16;18;23;33;39
Cistus salvifolius L.	Cistaceae	28
Coleostephus myconis (L.) Cass.	Asteraceae	7;16;18;29;40
Convolvulus sp.	Convolvulaceae	5
Convolvulus arvensis L.	Convolvulaceae	12;14;45;48;49;50
Conyza sp.	Asteraceae	10;13;14;16;20
Conyza sumatrensis (Retz.) E.Walker	Asteraceae	1;4;5;7;8;11;12;18;19;21;24;26;31;33;37;38;45;48
Cortaderia selloana (Schult. et Schult. f.) Asch. et Graebn.	Poaceae	12;13;14;16;21;22
Cotula australis (Sieber ex Spreng.) Hook.	Asteraceae	23;24;26
Crepis capillaris (L.) Wallr.	Asteraceae	1;6;8;12;20;23;24;25;33;43;47
Cupressus sempervirens L.	Cupressaceae	23;25;26
Cynodon dactylon (L.) Pers.	Poaceae	5;14;49
Cyperus eragrostis Lam.	Cyperaceae	7;16;25;46
Cyperus longus L.	Cyperaceae	24
Cytisus grandiflorus DC.	Fabaceae	50
Cytisus scoparius (L.) Link	Fabaceae	12
Dactylis glomerata L.	Poaceae	1;4;6;12;18;19;21;22;26;28;29;31;45;46;49;50
Datura stramonium	Solanaceae	11
Daucus carota L.	Apiaceae	1;4;5;11;12;14;16;18;19;20;22;28;29;40;45;48;49
Digitalis purpurea L.	Scrophulariaceae	20
Dittrichia viscosa (L.) Greuter	Asteraceae	18;39;49
Duchesnea indica (Jackson) Focke	Rosaceae	19
Echium plantagineum L.	Boraginaceae	1;15;48
Echium rosulatum Lange	Boraginaceae	12;29;33;50
Epilobium tetragonum L.	Onagraceae	14;22;39;40;49
Erigeron karvinskianus DC.	Asteraceae	15;40

Table 2: (Cont) Species of the floristic surveys, their respective families and the points in which they were found

specimes	Families	Survey points
Erodium moschata L'Hér	Geraniaceae	1;14;21;24;25;26;37;38;45;48;49;50
Euphorbia sp.	Euphorbiaceae	8;16;19;21
Euonymus japonicus Thunb.	Celastraceae	47
Festuca arundinacea Schreb.	Poaceae	22
Festuca rubra L.	Poaceae	21;33;39
Foeniculum vulgare Mill.	Apiaceae	1;5;6;9;11;12;13;15;16;21;22;28;29;30;31;36;39;40;46;48
Fraxinus americana L.	Oleaceae	10
Freylinia lanceolata (L.f.) G.Don	Scrophulariaceae	15
Fumaria sp.	Papaveraceae	7;9
Fumaria bastardii Boreau	Papaveraceae	5;6;18;22;30;31;32;38;45;47;50
Fumaria muralis Sond. ex W. D. J. Koch	Papaveraceae	4;16;20;22
Galactites tomentosus Moench	Asteraceae	19;45
Galinsoga quadriradiata Ruiz & Pav.	Asteraceae	7;10;37
Galium aparine L.	Rubiaceae	5;11;12;14;19;21;22;29;30;31;38;47;48
Galium mollugo L. subsp. erectum Huds. ex Syme	Rubiaceae	40
Gamochaeta procumbens (Phil.) Cabrera	Asteraceae	23
Gamochaeta spicata Cabrera	Asteraceae	26
Geranium dissectum L.	Geraniaceae	18;22;50
Geranium molle L.	Geraniaceae	6;7;23;24;25;28;31
Geranium purpureum Vill.	Geraniaceae	4;11;14;18;19;21;22;30;31;33;36;37;38;39;40;46;49;50
Geranium rotundifolium L.	Geraniaceae	1;11;16;33;50
Ginkgo biloba L.	Glinkgoaceae	39;40
Hedera madeirensis K. Koch ex A. Rutherf. subsp. iberica McAllister	Araliaceae	8;32;38
Hedera maderensis K. Koch ex A.Rutherf.	Araliaceae	50
Hirschfeldia sp.	Brassicaceae	6
Hirschfeldia incana (L.) Lagr.-Foss.	Brassicaceae	4;11;14;18;31;38;45;46;48;49
Holcus lanatus L.	Poaceae	16;19;20;22;45
Holcus mollis L.	Poaceae	29
Hordeum murinum subsp. leporinum (Link) Arcang.	Poaceae	12;22;40
Hydrangea macrophylla (Thunb.) Ser.	Hydrangeaceae	47
Hypericum sp.	Hypericaceae	14;21
Hypericum humifusum L.	Hypericaceae	12
Hypericum perfoliatum L	Hypericaceae	11
Hypericum perforatum L. subsp. angustifolium (DC.) A.Fršhl.	Hypericaceae	22;28
Hypochaeris radicata L.	Asteraceae	1;5;6;11;23;24;25;26;28;34;40;43;49
Ipomoea indica (Burm.) Merr.	Convolvulaceae	7;37
Lamium purpureum L.	Lamiaceae	30
Lapsana communis L.	Asteraceae	14
Lavatera cretica L.	Malvaceae	7;11;12;13;14;15;18;22;29;31;32;33;38;48;50
Leontodon sp.	Asteraceae	1;6
Leontodon taraxacoides (Vill.) Mérat	Asteraceae	15;23;34

Table 2: (Cont) Species of the floristic surveys, their respective families and the points in which they were found

specimes	Families	Survey points
Ligustrum japonicum Thunb.	Oleaceae	10
Lotus hispidus Desf. ex DC.	Fabaceae	16
Lotus pedunculatus Cav.	Fabaceae	5;16;40
Mahonia Nutt. sp.	Berberidaceae	43
Medicago sp.	Fabaceae	8;11
Medicago arabica (L.) Huds.	Fabaceae	31
Medicago lupulina L.	Fabaceae	12;16;18;28;47
Medicago polymorpha L.	Fabaceae	14;18;26;31;45
Medicago sativa L.	Fabaceae	6;21;46;48;49
Melilotus indicus (L.) All.	Fabaceae	16
Mentha suaveolens Ehrh.	Lamiaceae	12;22;39;40;46;49
Mercurialis ambigua L.f.	Euphorbiaceae	18;19;28;32;38
Myoporum acuminatum R. Br.	Scrophulariaceae	16
Nostochordum gracile (Aiton) Stearn	Amaryllidaceae	26
Oenanthe crocata L.	Apiaceae	7;16;22;39;40;49
Oenothera affinis Cambess.	Onagraceae	49
Oenothera biennis L.	Onagraceae	11;12;16
Oenothera rosea L'H.	Onagraceae	15;22
Oenothera stricta Ledeb. ex Link	Onagraceae	11;12
Ornithopus compressus L.	Fabaceae	1;6;18;21;25;28;29;33;48
Oxalis corniculata L.	Oxalidaceae	8;24;26;34
Oxalis pes-caprae L.	Oxalidaceae	4;6;8;10;14;40
Papaver dubium L.	Papaveraceae	38
Parentucellia viscose (L.) Caruel	Scrophulariaceae	13
Parietaria judaica L.	Urticaceae	5;6;7;8;9;12;13;14;15;19;21;22;25;30;31;32;33;36;37;38;40;47;48;50
Parthenocissus quinquefolia (L.) Planch.	Vitaceae	39
Paspalum dilatatum Poir. in Lam	Poaceae	22
Pelargonium sp.	Geraniaceae	15;36
Phytolacca americana L.	Phytolaccaceae	13;19
Phytolacca heterotepala H.Walter	Phytolaccaceae	7
Picris echioides L.	Asteraceae	4;5;12;14;22;40;45;46;48;49
Pinus pinaster Ait.	Pinaceae	50
Pinus pinea L.	Pinaceae	16
Piptatherum miliaceum (L.) Coss.	Poaceae	40
Plantago coronopus L.	Plantaginaceae	23;24;25;26
Plantago lanceolata L.	Plantaginaceae	1;4;6;7;8;11;12;14;15;21;22;23;24;25;26;28;29;30;31;39;45;46
Plantago major L.	Plantaginaceae	16;18;33;40
Platanus × acerifolia (Aiton) Willd.	Platanaceae	1;10;19;21
Platycladus orientalis (L.) Franco	Cupressaceae	24
Poa annua L.	Poaceae	1;6;7;14;19;26;33;37;50
Poa pratensis L.	Poaceae	5

Table 2: (Cont) Species of the floristic surveys, their respective families and the points in which they were found

specimes	**Families**	**Survey points**
Polycarpon tetraphyllum L.	Caryophyllaceae	4;8
Polygonum persicaria L.	Polygonaceae	46;50
Populus alba L.	Salicaceae	34
Populus nigra L.	Salicaceae	4;8;11;12;13;14;15;33
Populus x canescens (Aiton) Sm.	Salicaceae	33
Prunella vulgaris L.	Lamiaceae	43
Prunus lusitanica L.	Rosaceae	15
Pseudognaphalium luteo-album (L.) Hilliard & B.L.Burtt	Asteraceae	18
Pteridium aquilinum (L.) Kuhn	Dennstaedtiaceae	18;20;22;30;31;33;45;46;48
Quercus palustris Münchh.	Fagaceae	19
Quercus robur L.	Fagaceae	16;29;40
Ranunculus muricatus L.	Ranunculaceae	40;50
Raphanus raphanistrum L.	Brassicaceae	16
Reichardia intermedia (Sch.Bip.) Cout.	Asteraceae	38;39
Robinia pseudoacacia L.	Fabaceae	37;38;45
Rubus sp.	Rosaceae	13;15;16;20
Rubus ulmifolius Schott.	Rosaceae	4;5;14;18;21;22;28;33;34;36;37;39;45;46;49;50
Rumex sp.	Polygonaceae	8;10
Rumex conglomeratus Murray	Polygonaceae	30
Rumex crispus L.	Polygonaceae	5;16;40
Rumex obtusifolius L.	Polygonaceae	16;19;30
Salix atrocinerea Brot	Salicaceae	14
Salpichroa origanifolia (Lam.) Baill.	Solanaceae	9
Sagina procumbens L.	Caryophyllaceae	12
Sambucus nigra L.	Adoxaceae	8;30
Sanguisorba verrucosa (Link ex G.Don) Ces.	Rosaceae	33
Saponaria officinalis L.	Caryophyllaceae	36
Saxifraga sp.	Saxifragaceae	8
Scrophularia scorodonia L.	Scrophulariaceae	49
Senecio vulgaris L.	Asteraceae	12;14;26;33;34;46
Setaria parviflora (Poir.) Kerguélen	Poaceae	12
Setaria pumila (Poir.) Roem. et Schult	Poaceae	22
Sherardia arvensis L.	Rubiaceae	24
Silene gallica L.	Caryophyllaceae	29;49
Silene latifolia Poir.	Caryophyllaceae	5
Sisymbrium officinale (L.) Scop.	Brassicaceae	18;50
Solanum lycopersicum L	Solanaceae	7
Solanum nigrum L.	Solanaceae	4;8;19
Solanum sublobatum Roemer & Schultes	Solanaceae	1;5;9;38;45;50
Soliva pterosperma (Juss.) Less.	Asteraceae	23;24;40
Sonchus oleraceus L.	Asteraceae	1;4;5;6;7;9;12;14;15;16;18;19;21;22;24;26;29;30;31;34;36;38;40;43;45;46;47;48;49;50

Table 2: (Cont) Species of the floristic surveys, their respective families and the points in which they were found

specimes	Families	Survey points
Spergularia sp.	Caryophyllaceae	8
Sporobolus indicus (L.) R.Br.	Poaceae	43
Stellaria media (l.) Vill.	Caryophyllaceae	9;24;30
Stenotaphrum secundatum (Walt.) Kuntze	Poaceae	47
Taraxacum sp.	Asteraceae	1;8
Taraxacum ekmanii Dahlst.	Asteraceae	19;25;50
Teucrium scorodonia L.	Lamiaceae	28
Thuja plicata Donn ex D.Don	Cupressaceae	4;6;8
Tilia americana L.	Tiliaceae/ Malvaceae	8;28
Tilia tomentosa Moench	Tiliaceae/ Malvaceae	30
Torilis arvensis (Huds.) Link	Apiaceae	33;45;50
Tradescantia fluminensis Vell.	Commelinaceae	8;34
Trifolium arvense L.	Fabaceae	28
Trifolium campestre Schreb.	Fabaceae	39;40;49
Trifolium dubium Sibth.	Fabaceae	23;33;43
Trifolium pratense L.	Fabaceae	4;5;7;11;12;16;18;22;39;40;48;49
Trifolium repens L.	Fabaceae	1;6;8;11;16;18;19;20;22;23;26;28;33;37;43;50
Trifolium resupinatum L.	Fabaceae	43
Trifolium subterraneum L.	Fabaceae	1;25
Ulex europaeus L. subsp. Latebracteatus (Mariz) Rothm.	Fabaceae	1;11;12;14;39
Ulex minor Roth	Fabaceae	20
Urtica dioica L	Urticaceae	14
Urtica membranacea Poir.	Urticaceae	7;8;30;47
Verbascum sp.	Scrophulariaceae	13
Verbascum simplex Hoffmanns. & Link	Scrophulariaceae	48
Verbena bonariensis L.	Verbenaceae	12;18
Verbena officinalis L.	Verbenaceae	14;18;37
Veronica arvensis L.	Scrophulariaceae	10;19;34
Veronica officinalis L.	Plantaginaceae	18;26
Viburnum tinus L.	Adoxaceae	34
Vicia disperma DC.	Fabaceae	15;28
Vicia hirsuta (L.) Gray	Fabaceae	18;29;30;38;39;49
Vicia sativa L.	Fabaceae	14;15;22;33;36;38;39;40;49;50
Vitis vinifera L.	Vitaceae	46
Vulpia myuros (L.) C.C. Gmel.	Poaceae	6;25;26
x Cuprocyparis leylandii	Cupressaceae	34

The species observed belong to 57 different families, as could be observed in Table 2. Figure 2 allows us to establish the relation between the number of species and the points where they were observed:

- The point with the most species observed is point 14, which has 35 different species;
- The point with the lowest number of species is point 32 with just 6 species.

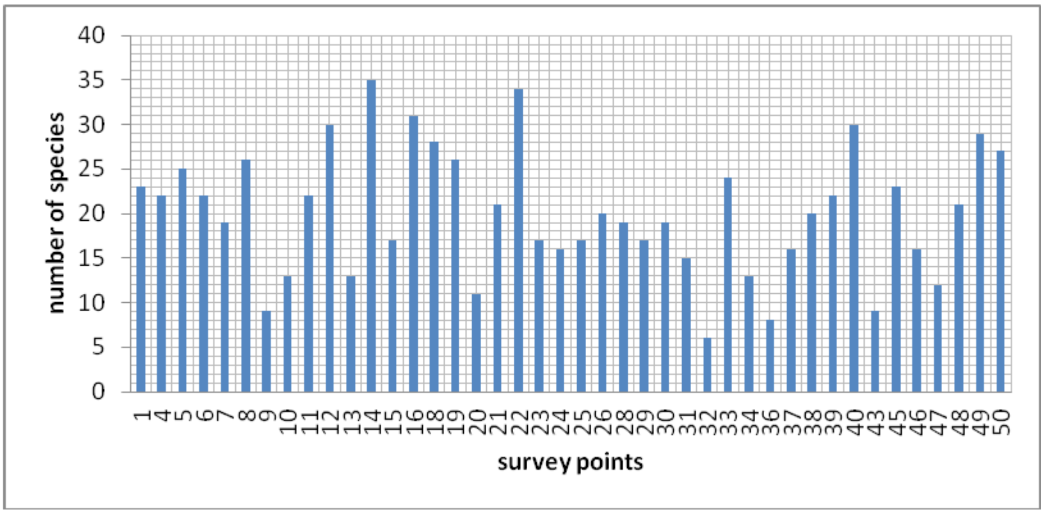


Figure 2: Relation between number of species and the points where they were observed.

For study of the embankments of VCI, it was necessary to identify both sides of VCI. To each side of VCI was given an acronym, taking in consideration its' orientation. Each side was named west and east respectively. To better understand these designations consult scheme of Figure 3.

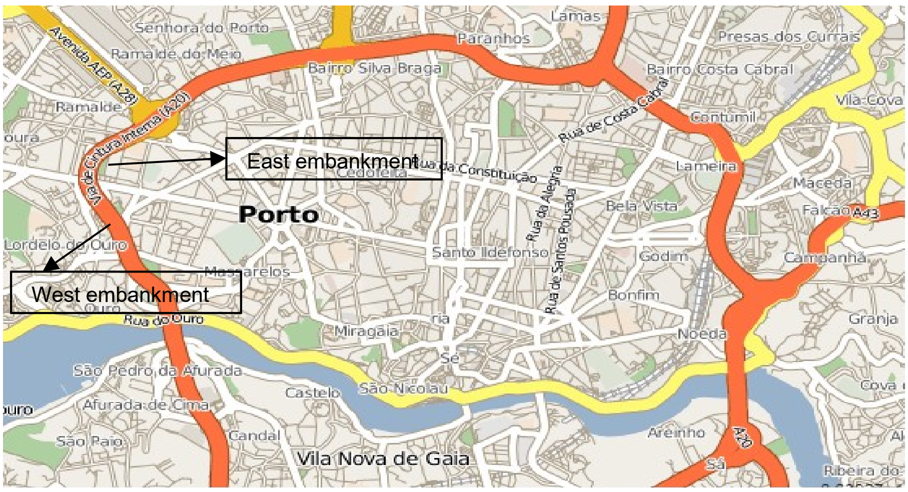


Figure 3: Scheme of VCI map showing both sides of the VCI. The arrows show the names given to which side of the highway

In corridor east (even numbers), the number of species doesn't seem to be related to the width of the embankment, represented in Figure 4a.

It seems that in general as the width of the embankment increases, the number of species also increase. The higher increase is seen for a width comprehended between 8m and 10 m.

The higher number of species found in this embankment was 35 and it was found in a 10m width embankment. The lowest number of species present in this embankment was also in the 10m of width and was 6 species.

a)

b)

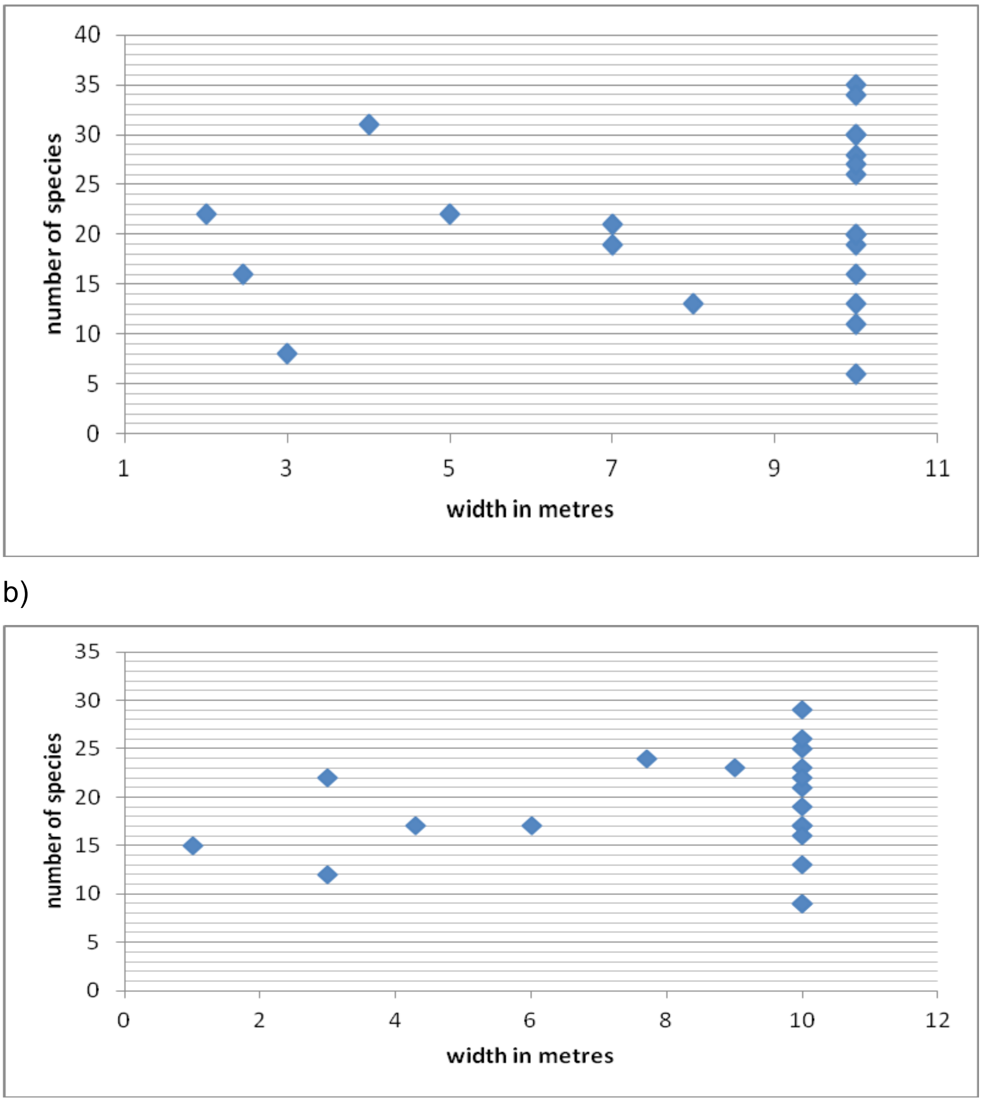


Figure 4: a).This graphic show the relation between the width of the embankment, in metres, and the number of species present, for the east corridor. b) Relation between the width of the embankment, in metres, and the number of species present, for the west corridor.

The other side of the highway is the west corridor (odd numbers). In Figure 4b it is possible to observe that, in general, the number of species tends to increase with the width of the corridor, the exception being for embankments with 4 to 6 metres width, where the number of species is the same.

The highest number of species found was 29 and they were observed in the 10m width slopes. The lowest number of species found was also observed in the 10m width ramps which had 9 species.

The 10m was a theoretical measure used to define a limit in the survey as said before. In the two graphics above it is possible to observe that there isn't a large difference between the number of species found in embankments in the interval of 1 - 9m and the number of species found in a 10m width slope.

In both graphics the increase in the number of species, as the width of the corridor increases, is very similar.

In Figure 5a it can be observed that up to 1km from the river (distance measured from the sampled point, perpendicularly, to a spot on the river), the number of species decreases. From 1km to around 2,6km the number of species rises. Moving away from the river, the number of species oscillates, growing and diminishing, reaching its maximum at 2,54 km away from the river. It is possible to observe 9 points presenting a lower number of species for higher distances away from the river. The highest number of species in this embankment was 35 and was found 2.5 km away from the river. The lowest number of species was 6 and they were located 3.6km away from the river.

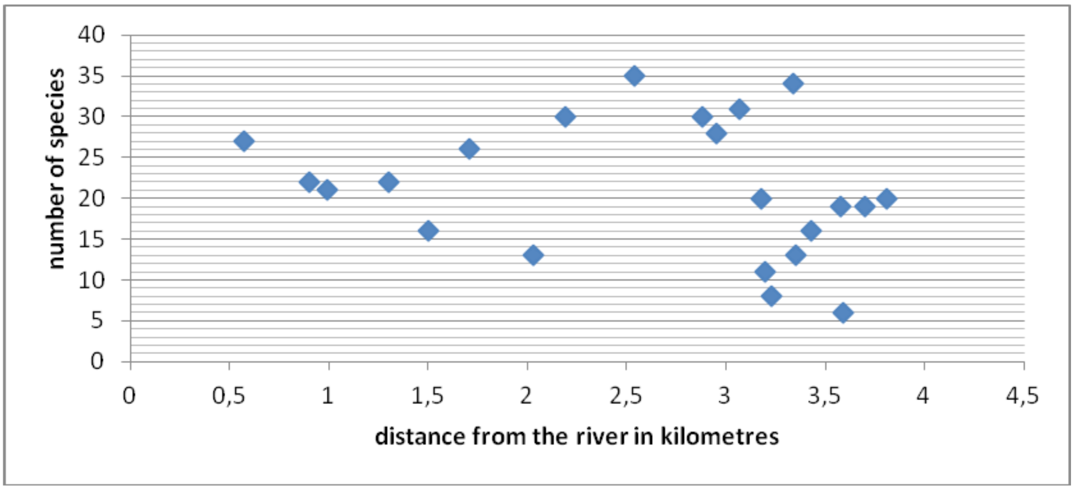
In Figure 5b it is possible to observe that is closer to the river that the higher the number of species is observed. However this is an isolated case and do not represent a tendency.

From 2km until around 3.5km from the river there is an increase in the number of species (with some oscillations), and from there the number of species decreases suddenly, after which remain stable.

The highest number of species is 29 at kilometre 0.59. The lowest number found was 9 species around 2km from the river.

In both Figures (5a, 5b) it is observed a slight tendency to a decrease in the number of species present in the embankments as distance increase to the river, even though it is observe a higher number of species away from the river. This decrease is more accentuated in Figure 5a.

a)



b)

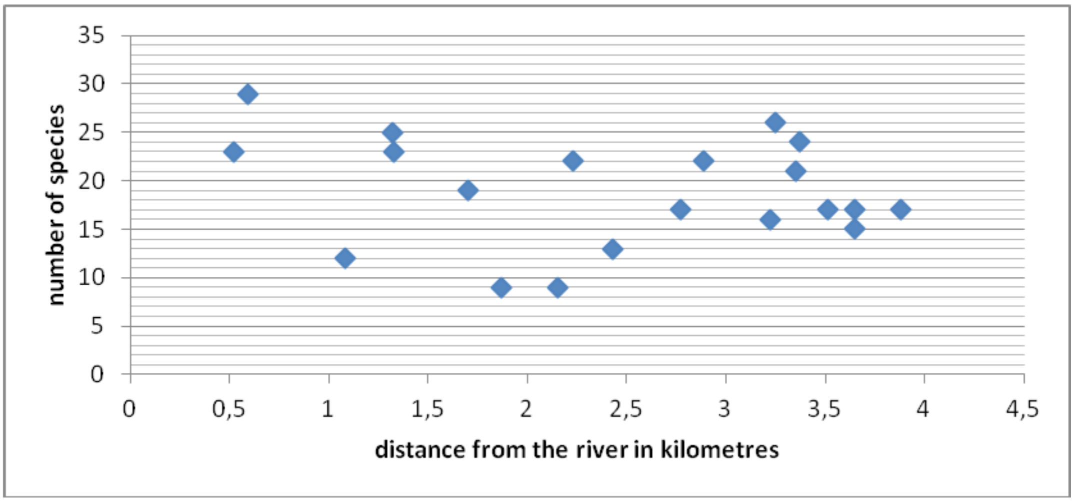
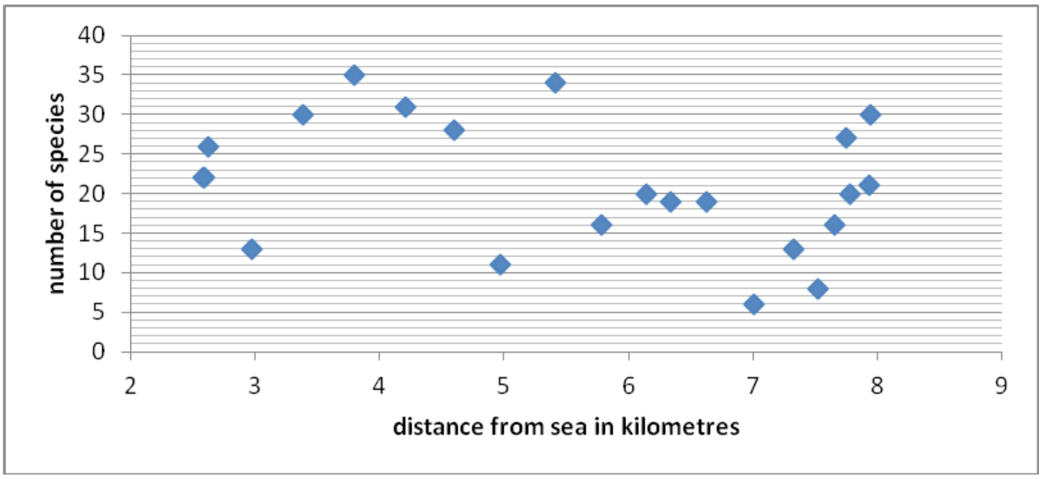


Figure 5: a) Represent the relation between the number of species present in the embankments and the distance from the river, in kilometres, for the east corridor. b) Relation between the number of species present in the embankments and the distance from the river, in kilometres, for the west corridor.

In the Figure 6a it is possible to observe that there is a tendency to a decrease in species numbers, in the embankment, as the distance from sea increases. From the 5th km forward there is a decrease in the number of species present in the embankment. The highest number of species is shown between kilometres 3 and 4.

In Figure 6b it is possible to observe that the number of species is higher around 2 km from sea but it decreases in the next kilometre. From kilometre 3 to 5 the number of species increases. From kilometre 5 to 7 again it is possible to observe a decrease in the number of species present in the embankments. Around the 8th kilometre it seems that the number of species increases again. The higher number of species is found at 7.89km where 29 different species were found. It is possible to observe that for this embankment it isn't shown a pattern of decrease or increase in the number of species present.

a)



b)

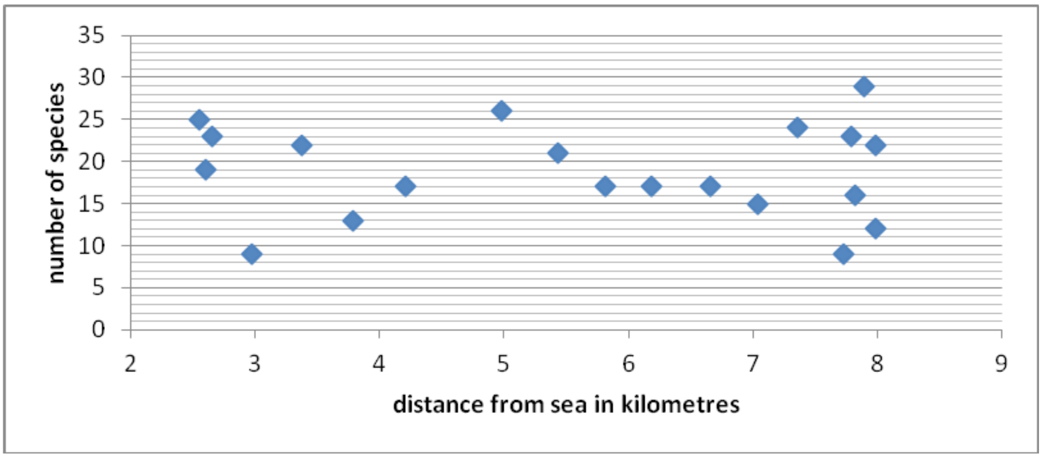
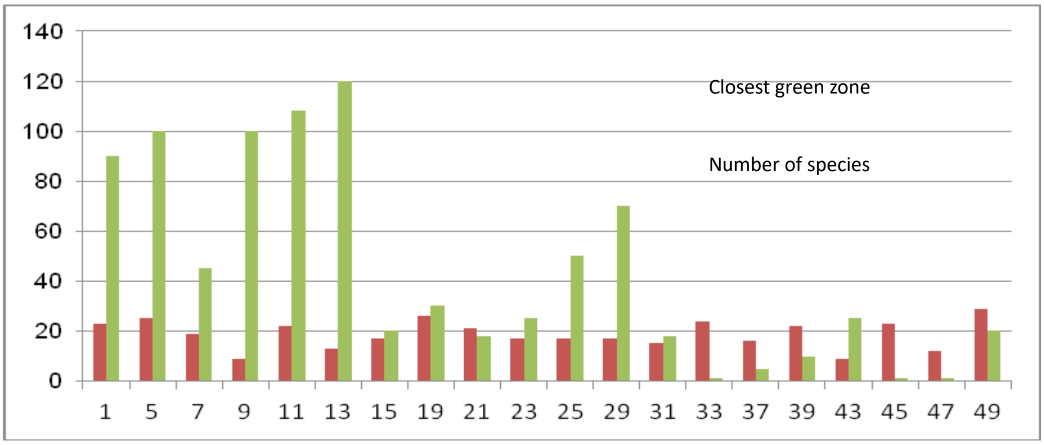


Figure 6: a). Show the relation between the number of species present in the embankments studied and the distance of each point from sea, in kilometres, for the east corridor. b) Relation between the number of species present in the embankments studied and the distance from that point to sea, in kilometres, for the west corridor.

In Figure 6a data oscillates as distance increase from the sea. However oscillation is not so visible for the other embankment. In the range from 6km to 7km, in both graphic, there is a decrease in the number of species.

Associated to the embankments are several different green structures, with different sizes and at several distances from the sampled points. Figure 7a show that, when the embankment is closer to a green structure, there is a higher number of species present in it and when the green structure is further away from the embankment there is a lower number of species present in the slope, but some exceptions can be observed. Similar characteristics are observed in Figure 7b.

a)



b)

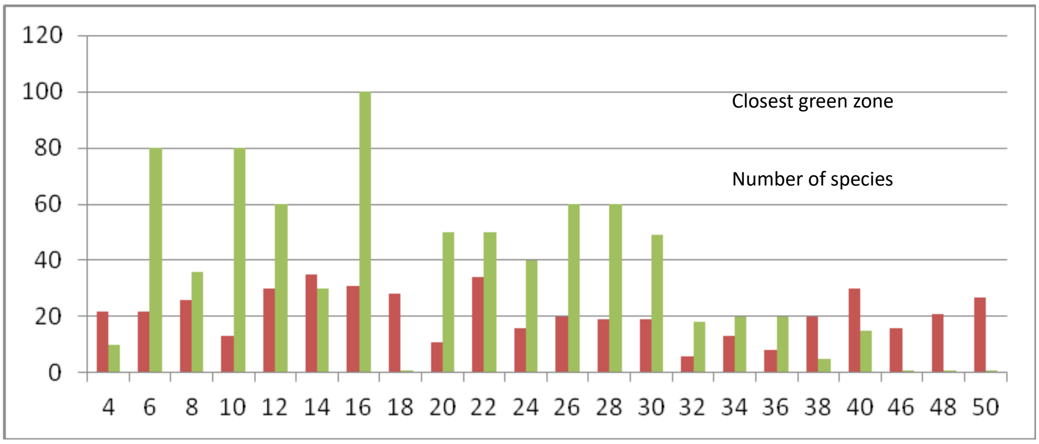


Figure 7: a) Show the number of species present in the points study and its distance to the closest green zone, in metres, for the east corridor. b) The number of species present in the points study for the west embankments and the distance to the closest green zone, in metres. For both graphics, green bar represents the distance to the closest green zone and the red bar represents the number of species. The bars are arranged by the survey points (the number indicated in the x axis is the number given to the point surveyed).

From the observation of Figure 7a and 7b it is not possible to observe any distribution pattern correlated with distance to nearer green structure; although in some case the number of species seems to follow a pattern of proximity.

As far as floristic is concerned, table 2 also indicates the families of species observed during the survey. Fifty seven (57) families were found in this study with the family best represented being Asteraceae that has around 15% of the species found. Most of the families (31.58%) only have one species associated.

When table 2 is closely observed it is possible to detect one endemic specie *Hedera madeirensis subspecie iberica* in points 8, 32, 38. It was also found invasive species such as *Solanum sublobatum* in points 1, 5, 9, 38, 45, 50.

Table 3: List of the species distributed in the survey points where they were found, for the west corridor.

Species	Survey points																							
	1	3	5	7	9	1	1	1	1	1	2	2	2	2	2	3	3	3	3	3	4	4	4	4	4

						1	3	5	7	9	1	3	5	7	9	1	3	5	7	9	1	3	5	7	9
Abelia x grandiflora																								X	
Acer pseudoplatanus					X														X						
Ageratina adenophora			X																						
Aira caryophyllea													X												
Ailanthus altissima	X																								
Allium triquetrum			X								X														
Anagallis monelli	X																								
Andryala integrifolia	X					X					X				X					X			X		
Anthoxanthum amarum			X																	X					
Anthoxanthum doratum							X																		
Apium nodiflorum																			X						
Artemisia verlotorum																				X					
Arum italicum										X															X
Arum maculatum			X																						
Aster squamatus																			X						
Avena barbata															X								X		X
Bellis perenis.				X								X	X												
Bidens pilosa.							X	X				X													
Briza maxima															X										
Briza minor.																				X					
Bromus catharticus																							X		
Bromus diandrus			X			X					X					X	X						X	X	X
Bromus sterilis										X															
Buddleja davidii								X																	
Calystegia silvatica			X		X																				
Cardamine hirsuta										X															
Carduus pycnocephalus						X																			X
Celtis australis													X												
Cerastium glomeratum				X						X	X	X	X				X								X
Chamaecyparis lawsoniana												X													
Chamaemelum mixtum																			X						
Chenopodium sp.										X															
Chelidonium majus			X																				X		
Chrysanthemum segetum																			X						
Cirsium vulgare												X					X			X					
Coleostephus myconis				X											X										
Convolvulus sp.			X																						
Convolvulus arvensis																							X		X
Conyza sp.							X																		
Conyza sumatrensis	X		X	X		X				X	X					X	X		X				X		
Cortaderia selloana							X				X														
Cotula australis												X													
Crepis capillaris	X											X	X				X					X		X	X
Cupressus sempervirens												X	X												
Cynodon dactylon			X																						X
Cyperus eragrostis				X									X												
Dactylis glomerata	X									X	X				X	X							X		X
Datura stramonium						X																			
Daucus carota	X		X			X				X					X								X		X
Dittrichia viscosa																				X					X
Duchesnea indica										X															
Echium plantagineum	X							X																	
Echium rosulatum															X		X								
Epilobium tetragonum																				X					X
Erigeron karvinskianus								X																	
Erodium moschata	X										X		X						X				X		X
Euphorbia sp.										X	X														
Euonymus japonicus																								X	
Festuca rubra											X						X			X					
Foeniculum vulgare	X		X		X	X	X	X			X				X	X				X					
Freylinia lanceolata								X																	
Fumaria sp.				X	X																				
Fumaria bastardii			X													X							X	X	
Galactites tomentosus										X													X		
Galinsoga quadriradiata				X															X						
Galium aparine			X			X				X	X				X	X								X	
Gamochaeta procumbens												X													
Geranium molle				X								X	X			X									
Geranium purpureum						X				X	X					X	X		X	X					X
Geranium rotundifolium	X					X											X								
Ginkgo biloba																				X					
Hirschfeldia incana						X																	X		X
Holcus lanatus										X													X		
Holcus mollis															X										
Hydrangea macrophylla																								X	
Hypericum sp.											X														

Table 3: (Cont.) List of the species distributed in the survey points where they were found, for the west corridor

species	Survey Points

	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49
Hypericum perfoliatum						X																			
Hypochaeris radicata	X		X			X						X	X									X			X
Ipomoea indica				X															X						
Lavatera cretica				X		X	X	X							X	X	X								
Leontodon sp.	X																								
Leontodon taraxacoides							X					X													
Lotus pedunculatus.			X																						
Mahonia sp.																						X			
Medicago sp.						X																			
Medicago arabica.																X									
Medicago lupulina																								X	
Medicago polymorpha																X							X		
Medicago sativa											X														X
Mentha suaveolens																				X					X
Mercurialis ambigua										X															
Oenanthe crocata				X																X					X
Oenothera affinis																									X
Oenothera biennis						X																			
Oenothera rosea								X																	
Oenothera stricta						X																			
Ornithopus compressus	X										X		X		X		X								
Parentucellia viscosa							X																		
Parietaria judaica			X	X	X		X	X		X	X		X			X	X		X					X	
Parthenocissus quinquefolia																				X					
Pelargonium sp.								X																	
Phytolacca americana							X			X															
Phytolacca heterotepala				X																					
Picris echioides			X																				X		X
Plantago coronopus												X	X												
Plantago lanceolata	X			X		X		X			X	X	X		X	X				X			X		
Plantago major																	X								
Platanus × acerifolia	X									X	X														
Poa annua	X			X						X							X		X						
Poa pratensis			X																						
Populus nigra						X	X	X									X								
Populus x canescens																	X								
Prunella vulgaris																						X			
Prunus lusitanica								X																	
Pteridium aquilinum																X	X						X		
Quercus palustris.										X															
Quercus robur															X										
Reichardia intermedia																				X					
Robinia pseudoacacia																			X				X		
Rubus sp.							X	X																	
Rubus ulmifolius			X								X						X		X	X			X		X
Rumex crispus			X																						
Rumex obtusifolius										X															
Salpichroa origanifolia					X																				
Saponaria officinalis																	X								
Scrophularia scorodonia																									X
Senecio vulgaris																	X								
Silene gallica															X										X
Silene latifolia			X																						
Solanum lycopersicum				X																					
Solanum nigrum										X															
Solanum sublobatum	X		X		X																		X		
Soliva pterosperma												X													
Sonchus oleraceus.	X		X	X	X			X		X	X				X	X						X	X	X	X
Stellaria media					X																	X			
Stenotaphrum secundatum																								X	
Taraxacum sp.	X																								
Taraxacum ekmanii										X			X												
Torilis arvensis																	X						X		
Trifolium campestre																				X					X
Trifolium dubium												X					X					X			
Trifolium pratense			X	X		X														X					X
Trifolium repens	X					X				X		X					X		X			X			
Trifolium resupinatum																						X			
Trifolium subterraneum	X												X												
Ulex europaeus subsp. latebracteatus	X					X														X					
Urtica membranacea																								X	
Verbascum sp.				X			X																		
Verbena officinalis																			X						
Veronica arvensis										X															
Vicia disperma								X																	
Vicia hirsuta															X					X					X
Vicia sativa								X									X			X					X
Vulpia myuros													X												

In the west corridor we found a total of 155 different species. Most of the species found don't spread across the corridor; they were traced occasionally, and when discovered more than once it was within a few kilometres of distance between them. Some species seem only to spread a few metres. As can be verified in table 3, those species can be observed in 2 or 3 nearby points. Species like *Conyza sumatrensis, Sonchus oleraceus, Plantago lanceolata, Foeniculum vulgare* were observed in the majority of the survey points for this embankment, being well spread across the west corridor.

Table 4: List of the species distributed in the survey points where they were found, for the east corridor.

	Survey points																								
species	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
Acacia longifolia																			X						
Acacia melanoxylon							X																		
Acanthus mollis				X																					
Acer negundo					X																				
Acer pseudoplatanus																X									
Achillea millefolium											X														
Adenocarpus lainzii											X														
Agapanthus africanus																		X							
Ageratina adenophora							X																		
Aira caryophyllea							X																		
Ammi majus								X	X																
Anagallis arvensis		X										X													
Anagallis monelli			X																						
Andryala integrifolia			X				X				X			X					X						X
Arctotheca calendula									X																
Artemisia verlotorum																				X					
Arum italicum															X										
Avena barbata							X							X				X						X	
Bellis perenis													X												
Brachypodium sylvaticum			X																						
Brassica rapa		X																							
Briza maxima																				X					
Briza minor						X														X					
Bromus catharticus																									X
Bromus diandrus		X	X			X	X								X				X					X	X
Calystegia silvatica								X												X			X		
Camellia japonica					X																				
Canna indica					X																				
Capsella bursa-pastoris				X			X																		
Cardamine hirsuta		X																							
Carduus tenuiflorus																								X	
Carex sp.								X			X														
Carex divulsa					X																				
Celtis australis																	X								
Centaurea sp.										X															
Cerastium glomeratum		X			X								X		X		X								
Cestrum sp.				X																					
Chamaecyparis lawsoniana		X		X																					
Chelidonium majus											X														
Chrysanthemum segetum																								X	
Cirsium vulgare								X	X																
Cistus salvifolius														X											
Coleostephus myconis								X	X											X					
Convolvulus arvensis						X	X																	X	X
Conyza sp.					X		X	X		X															
Conyza sumatrensis		X		X		X			X			X	X						X					X	
Cortaderia selloana						X	X	X			X														
Cotula australis												X	X												
Crepis capillaris			X	X		X				X		X													
Cupressus sempervirens													X												
Cynodon dactylon							X																		
Cyperus eragrostis								X															X		
Cyperus longus												X													
Cytisus grandiflorus																									X
Cytisus scoparius						X																			
Dactylis glomerata		X	X			X			X		X		X	X									X		X
Daucus carota		X				X	X	X		X	X			X						X				X	
Digitalis purpurea										X															
Dittrichia viscosa									X																
Echium plantagineum																								X	

Table 4: (Cont.) List of the species distributed in the survey points where they were found, for the east corridor.

	Survey Points																								
Species	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50

Echium rosulatum						X																			X
Epilobium tetragonum							X				X									X					
Erigeron karvinskianus																				X					
Erodium moschata							X					X	X						X					X	X
Euphorbia sp.				X				X																	
Festuca arundinacea											X														
Foeniculum vulgare			X			X		X			X			X	X			X		X			X	X	
Fraxinus americana					X																				
Fumaria bastardii			X						X		X				X	X			X						X
Fumaria muralis		X						X		X	X														
Galinsoga quadriradiata					X																				
Galium aparine						X	X				X				X				X					X	
Galium mollugo																				X					
Gamochaeta spicata													X												
Geranium dissectum									X		X														X
Geranium molle			X									X		X											
Geranium purpureum		X					X		X		X				X			X	X	X			X		X
Geranium rotundifolium								X																	X
Ginkgo biloba																				X					
Hedera madeirensis subsp. iberica				X												X			X						
Hedera maderensis																									X
Hirschfeldia sp.			X																						
Hirschfeldia incana		X					X		X										X				X	X	
Holcus lanatus								X		X	X														
Hordeum murinum subsp. leporinum						X					X									X					
Hypericum sp.							X																		
Hypericum humifusum						X																			
Hypericum perforatum subsp. angustifolium											X			X											
Hypochaeris radicata			X									X	X	X			X			X					
Lamium purpureum															X										
Lapsana communis							X																		
Lavatera cretica						X	X		X		X					X			X					X	X
Leontodon sp.			X																						
Leontodon taraxacoides																	X								
Ligustrum japonicum					X																				
Lotus hispidus								X																	
Lotus pedunculatus								X												X					
Medicago sp.				X																					
Medicago lupulina						X		X	X					X											
Medicago polymorpha							X		X				X												
Medicago sativa			X																				X	X	
Melilotus indicus								X																	
Mentha suaveolens						X					X									X			X		
Mercurialis ambigua									X					X		X			X						
Myoporum acuminatum								X																	
Nostochordum gracile													X												
Oenanthe crocata								X			X									X					
Oenothera biennis						X		X																	
Oenothera rosea											X														
Oenothera stricta						X																			
Ornithopus compressus			X						X					X										X	
Oxalis corniculata				X								X	X				X								
Oxalis pes-caprae		X	X	X	X		X													X					
Papaver dubium																			X						
Parietaria judaica			X	X		X	X				X				X	X		X	X	X				X	X
Paspalum dilatatum											X														
Pelargonium sp.																		X							
Picris echioides		X				X	X				X									X			X	X	
Pinus pinaster																									X
Pinus pinea								X																	
Piptatherum miliaceum																				X					
Plantago coronopus												X	X												
Plantago lanceolata		X	X	X		X	X				X	X	X	X	X								X		
Plantago major								X	X											X					
Platanus × acerifolia					X																				
Platycladus orientalis												X													
Poa annua			X				X						X												X
Polycarpon tetraphyllum		X		X																					
Polygonum persicaria																							X		X
Populus alba																	X								
Populus nigra		X		X		X	X																		
Pseudognaphalium luteo-album									X																
Pteridium aquilinum									X	X	X				X								X	X	
Quercus robur								X												X					
Ranunculus muricatus																				X					X
Raphanus raphanistrum								X																	
Reichardia intermedia																			X						
Robinia pseudoacacia																			X						

Table 4: (Cont.) List of the species distributed in the survey points where they were found, for the east corridor.

Species	Survey points																								
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
Rubus sp.								X		X															

Rubus ulmifolius		X					X		X		X			X			X	X					X		X
Rumex sp.				X	X																				
Rumex conglomeratus															X										
Rumex crispus								X												X					
Rumex obtusifolius								X							X										
Salix atrocinerea							X																		
Sagina procumbens						X																			
Sambucus nigra				X											X										
Saxifraga sp.				X																					
Senecio vulgaris						X	X						X				X						X		
Setaria parviflora						X																			
Setaria pumila											X														
Sherardia arvensis												X													
Sisymbrium officinale									X																X
Solanum nigrum		X		X																					
Solanum sublobatum																			X						X
Soliva pterosperma												X								X					
Sonchus oleraceus		X	X			X	X	X	X		X	X	X		X		X	X	X	X			X	X	X
Spergularia sp.				X																					
Stellaria media												X			X										
Taraxacum sp.				X																					
Taraxacum ekmanii																									X
Teucrium scorodonia														X											
Thuja plicata		X	X	X																					
Tilia americana				X										X											
Torilis arvensis																									X
Tradescantia fluminensis				X											X		X								
Trifolium arvense														X											
Trifolium campestre																				X					
Trifolium pratense		X				X		X	X		X									X				X	
Trifolium repens			X	X				X	X	X	X		X	X											X
Ulex europaeus subsp. latebracteatus						X	X																		
Ulex minor										X															
Urtica dioica							X																		
Urtica membranacea				X											X										
Verbascum simplex																								X	
Verbena bonariensis						X			X																
Verbena officinalis							X		X																
Veronica arvensis					X												X								
Veronica officinalis									X				X												
Viburnum tinus																	X								
Vicia disperma														X											
Vicia hirsuta									X						X				X						
Vicia sativa							X				X								X	X					X
Vitis vinifera																							X		
Vulpia myuros			X										X												
x Cuprocyparis leylandii																	X								

In table 4, the species found were more disperse in the different points surveyed. A few species only appeared once, some species appeared a couple of times but very spaced within the east corridor. The species *Sonchus oleraceus, Plantago lanceolata, Parietaria judaica, Geranium purpureum, Foeniculum vulgare* were the ones present in the higher number of points across the east corridor. In this corridor a total of 187 species were surveyed.

Both sides of the highway seem to shelter a high number of plant species but a larger species number is present in the east side. Also, several of the species present in this embankment have a larger distribution range on this side of VCI, being possible to observe some of them along almost all the embankment.

Most of the species present in the west corridor (table 3) seem also to be present in the east corridor (table 4).

In these corridors the species that was found more often was *Sonchus oleraceus*. It could be found on both sides of the highway and for almost its entire width.

6. Discussion and Conclusions

Porto's city is a developed and urbanized metropolis and as well as others urbanized towns it show several problems related to noise and air pollution as well as landscape fragmentation. As the city grew, the connectivity inside it had to be improved, increasing the number of accesses such as highways and roads. These connections posed many problems to natural life blocking animal and plant species from spreading across the territory.

VCI surrounds Porto inner city and along its entire length there are embankments that could provide habitat for animals and plants.

In this work, embankments were studied and it has been found that most of the VCI's margins don't have a high slope and present a constant sun exposure. No actual use for these spaces is known and most of them are narrow, with an average width around 7-9 m although some have more than 10m (to a maximum of 100m).

The variables analysed - distance from the river, distance from the sea and distance to the nearby green zones - seems to have some influence in vegetation when analysed isolated, but there are so many factors conjugated that a influence/distribution pattern barely can be observed.

According to Bryant (2006) nature found in urbanized context is very different from that within the urban fringe (gardens, exotic and invasive plants, etc.). Although Porto is a developed city, small rural patches which may affect embankments' fauna and flora, still can be seen. Therefore, a larger number of species can be located further away from the river and in that case proximity to gardens and fields could actually be acting as stepping stones.

Most of the surveyed points had at least 9 different species, even the ones with shortest width. No clear vegetation distribution patterns were found throughout the highway corridor. In these corridors flora is trapped in an early successional stage, maintained through mowing applied for aesthetical and traffic safety reason as well by urban by-laws (Ranta, 2008).

Despite the destruction caused by maintenance, a high number of different species was found during the survey. This fact has been seen in other studies; the number of species tend to increase when there is a frequent mowing regime, but when this regime goes for a long period of time the number of species decrease (Yang, 2012; Kolos, 2013) . The VCI embankments mowing regime is not going on for a long time yet and it only seem to occurs twice a year (at least in most of VCI's extension) so the number of species present could decrease in a few years and so it would be better adapt the mowing regime to the species found in these embankments as proposed by Ranta (2008). However, the growing use of herbicides in several places along this structure can change the floristic data presented in this work, rather quickly.

The vegetation found, especially communities of shrubs-grassland plants can be able to provide habitat for some species of animals. Although not studied it's an interesting reference for future works.

Accessibility and fencing (50% and 46% respectively in VCI slopes) are important factors in a greenway; although fencing is a necessity in questions of safety, also creates serious barriers to access. Probably fencing is one of the main reasons why VCI embankments don't have cultural or recreational functions.

Samways (2010) propose that a greenway need to be at least 200m wide to be an actual greenway, this condition is not satisfied by the embankments of VCI who present widths estimated between 1 and 100m.

Taking into account the findings described previously, it can be said that the embankments of VCI constitute *a linear green structure* with only one or two functions: the ecological one and possibly the social one. It doesn't have a cultural or a recreational function or even an educational one. So, it is possible to say that those corridors could be ecological corridors but not a greenway due to lack of the multi-function characteristic.

The first designs for the VCI highway had a more cultural and recreational characteristic that was excluded from the original plan. However, it is still possible to find some remnants of those projects that could be explored and used to improve the quality of life for those who live in the highway surroundings and for its users.

It is possible that the entire highway couldn't be altered to become an actual greenway, but it could be possible to do it in some areas of the highway because 46% of its width has no fences and 36% has difficult, but not impossible, access that could be improved to allow public admission.

The educational asset could also be introduced in the VCI by allowing the students to see and study the pollution effects, caused by exhaust fumes released by cars or garbage thrown into the embankments.

To become a greenway, VCI's embankments need to have their access improved and some of the fences removed which means that some of the green areas need to be acquired from its owners. It is necessary to promote the greenway concept among the future greenway nearby habitants. This promotion will help to increase the interest in the project and it may facilitate the collaboration between the different stakeholders (Viles, 2001; Bryant, 2006; Frischenbruder, 2006).

The intervention in a greenway in general and in VCI in particular, would be better if made at a local or regional scale taking in account the ideas and opinions of the people that will be affect by the greenway outcome (Bryant, 2006).

A coordinated effort between landscape ecologists, landscape architects, city planners is also needed to improve the quality of life around the VCI corridor and to improve the VCI embankment so it will became an actual greenway.

In this work, it wasn't possible to obtain data from all the points surveyed for the reasons stated before (impossibility of access according to the Portuguese law or just physical impossibility mainly caused by obstacles).

In forthcoming works or future research, would be interesting to determine if the VCI embankments actually act as a sink for pollution and/or how can be used to control water fluxes.

To ascertain the ecological efficiency of VCI's embankments, it would be necessary monitoring and execute interdisciplinary studies in the area in a regular basis over a large amount of time.

In conclusion VCI embankments' are not a “greenway”, even though it shows some ecological features, but lack the multifunctional characteristic and therefore doesn't allow for the application of the present concept. As a summary of the principal conclusions it can be said:

- It was observed that almost all the embankments were constantly exposed to the sun. Most of the points studied had no previous use but the majority of the points can be public accessed. The high number of fenced points poses as a problem for the application of greenways multifunctional characteristic.
- In the 47 points surveyed, 219 different species and 57 different families were found. Several potential invasive species were identified throughout the corridor. Also, a high number of species found were exotic.
- As distance to the river increases seems to produce a rising effect in the number of species. However this effect can be associated to the fact that rural patches are to be found also far away from the river.
- An inverse effect can be observed when distance to the sea declines. This behaviour can be probably associated with the effects of salt spray although no causes for that behaviour were found, except for a decreasing in the width of

the embankment, due to use of land for construction purposes, number of highway exits and population density.

- Embankments width also seems to play an important role in the number of species present. A relation between slope size and number of species couldn't be draw. But intuitively seems to exist. However, embankments with less than 10m are the easiest to maintain and therefore treatments (mowing, herbicide applications, etc.) can be easily applied and more intense.
- The importance of embankment "**width**" can also be masked by the fact that many times narrow slopes have been planted with gymnosperms which will influence the number of species present due to soil acidification, shadow and other factors. Moreover, in some surveyed points, where gymnosperms weren't present, it was observed many times, that vegetation cover was composed almost by one or two Poaceae species, clearly chosen and applied by the municipality services. In some places the lack of treatments or/and the difficulty of access allowed some particular species, as *Rubus* sp., to develop and becoming dominant preventing the developing of other vegetation types. Thus, again results could mask not only the "width" effect but also other variables such as proximity to green areas.
- Most of the points studied have a green structure near them. This particular factor seems to improve the number of species present in the embankments and acting as possible stepping stones (but see previous points).

The results of this work could aid to increase the knowledge of the studied area but a complete and multidisciplinary survey should be made to help improve the condition of life for the surrounding habitants and increase biodiversity.

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