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Relationship Between Greenways and Ecological Network: A Case Study in Italy

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ABSTRACT: Linear green infrastructures along rivers and canals serve different functions: Green corridors, or ecological network, maintain biological diversity, improve water quality, and provide areas for fauna and flora to grow and thrive. Greenways connect people with landscape resources and serve as recreational areas that are easy to use and accessible to the greatest number of potential human users. Both ecological networks and greenways are linear structures crossing the landscape, both perform a connecting function in that they are elements created for migration and movement (in one case of flora and fauna and in the other of humans), and both generally contain vegetation. Greenways can be divided into three major categories: ecological greenways, recreational greenways, and greenways with historical/cultural value. When an ecological greenway is planned and designed, human-wildlife conflicts must be minimised.

Key words: Planning, Waterfront, Landscape, Environment

INTRODUCTION

All over the world, humans have profoundly modified the landscape in which they live, qualitatively (e.g., subtracting land from natural areas and converting it for different uses: agricultural, residential, industrial, and so on) and structurally (e.g., changing the relationship between diverse components) (Collinge, 1996; Kopnina, 2011; Odindi and Mhangara, 2012; Saffarnia *et al.,* 2012). Aerial photographs reveal that the structure of the landscape is frequently composed of a predominant element: human presence. Consequently, residual natural and semi-natural areas are dispersed and fragmented (Baschak & Brown, 1995; Jongman, 2008; Kong *et al.*, 2010; Seifollahi and Faryadi, 2011; Faizi *et al.,* 2011; Basso *et al.*, 2012; Rasouli *et al.,* 2012; Salehi *et al.,* 2012). Various studies, beginning with MacArthur and Wilson's theory of biogeographical islands (1967), have demonstrated that biodiversity and stability, two important ecological values, are significantly influenced not only by the dimensions of the natural areas but also by their distribution and, in particular, by the possibility for species to move from one area to another. Therefore, we must create and maintain ecological corridors and networks (Belisle, 2005), or "natural and linear ecological structures that permit ecosystems and populations to survive and move within a territory dominated by the presence of [humans]" (Jongman & Pungetti, 2004). In a landscape heavily influenced by humans and poorly suited not only to the settlement but also to the movement of diverse natural species, guaranteeing them corridors along which they can move requires the provision of a means of survival in the face of, for example, changing climatic, environmental, or nutritional conditions or demands. At the same time, creating or maintaining such corridors increases the probability of encounters between different populations, an important factor in determining genetic exchange and, as a consequence, variability (Zonneveld, 1994; Dinetti, 2000; Goodwin & Fahrig, 2002).

We are witnessing growing interest in "greenways", to use an expression coined in the United States (White, 1959) that has given rise to a widespread movement, initially on the American continent (1980s) and subsequently, from the 1990s onward, in Europe, too (Flink & Searn, 1993). The term greenways indicates "a system of interconnected linear territories that are protected, managed and developed so as to obtain ecological, recreational, historical and cultural benefits", or a "system of routes dedicated to non-motorized traffic connecting people with landscape resources (natural, agricultural, historical-cultural) and the centres of life (public offices, sport and recreational facilities, etc.) both in the urban areas and in the countryside" (Toccolini *et al.,* 2006). Therefore, greenways serve different functions and offer different values: recreational, historical-cultural, or ecological value (Ahern, 1995; Fabos, 1995). On the basis of this premise, the

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objective of this study was to identify a means of combining the functions performed by greenways and ecological networks in a single structure or, rather, ascertaining whether greenways may also perform a role similar to that of ecological networks (Bueno *et al.*, 1995; Linehan *et al.*, 1995).

These two concepts (ecological networks and greenways) overlap somewhat (Konkoly-Gyuró & Nagy, 2010). For example, both ecological networks and greenways are linear structures crossing the landscape, both perform a connecting function in that they are elements created for migration and movement (in one case of flora and fauna and in the other of humans), and both generally contain vegetation. Regarding this last point, noteworthy is that ecological corridors contain vegetation that is natural, semi-natural, or restored, while greenways are not necessarily composed of natural flora, and flora may actually be absent (as in the case, for example, of certain urban corridors or those crossing historic town centres) (Turner, 1998; Toccolini *et al.*, 2004). Additionally, the concept of greenways may take on a different tone depending on the context: In North America, greenways frequently play an important ecological-environmental role (in many cases they are, in fact, long natural corridors crossing, for example, forests, mountains, or prairies, integrated in the course of rivers or canals). Hence, they assume the role of ecological corridors, thanks in part to the low density of users and their dispersion along the route (Benedict & McMahon, 2006). The European situation is very different (Jongman & Pungetti, 2004). In Europe, the percentage of anthropised land is significantly greater: Here, the greenways are more frequently corridors within an urban, suburban, or rural context, slotted into an artificial landscape. Few are set in completely natural environments. In any case, greenways generally develop along linear structures or elements already present in the surrounding landscape, such as natural corridors (rivers, valleys, and ridges), disused railways, canals and embankments, and panoramic roads or minor rural roads (Little, 1990). Therefore, they offer the advantage of being easily established even in areas that are critical in terms of of competition for space (Weber *et al.*, 2006).

MATERIALS & METHODS

Existing studies (see the bibliography) demonstrate that the ecological stability of natural areas is influenced by a number of factors, such as the number, type, form, dimension, and connectivity of patches, the presence of linking corridors, and the structure, composition, and characteristics of the existing network. For an analysis of the ecological resources of the landscape, the bibliography offers a number of indices capable of measuring these parameters (Forman & Godron, 1986, 1996; Farina, 2001; Cook, 2002). They are, however, methods appropriate for natural areas of a reasonable size and therefore ill suited to application when the number and dimensions of the areas in question are less significant, as in the case, for example, of the Po Valley. Hence, during the present study, we needed to develop a method for the design of greenways with an ecological function and one that was capable of estimating the environmental valence of the landscape and of highlighting those areas of greatest ecological significance to be connected via ecological corridors. The evaluation of ecological value should be simple and appropriate to the situation: In the context analysed, in fact, the use of the indices proposed by Forman and Godron for estimating the value of individual natural or semi-natural elements proved to be relatively unproductive and of little significance; it appeared to be more appropriate for evaluating the ecological quality of the entire landscape system in order to identify the most important areas and those in which an ecological network could be developed. On the basis of the consolidated design methods and the analysis of a number of Italian and foreign case studies, we were able to define a new planning model suitable for the design of a greenway with ecological value (see Fig. 1). At the conceptual level, the method developed involves working on two parallel strands, one deriving from the method of designing for greenways and the other from the method of designing an ecological network, structured along the lines of the classic approach to design.

RESULTS & DISCUSSION

The methodology proposed above was applied to the area crossed by the Naviglio di Bereguardo (Naviglio is the name of historical canals surrounding the city of Milan built in the XII century for irrigation and transportation), a rural area on the borders of the provinces of Milan and Pavia, in the north of Italy, characterised by human pressure of a certain significance though the predominantly agricultural use of the land but offering considerable opportunities for the recovery of an ecological-environmental function, thanks to the low level of urbanisation (see Fig. 2). This canal is well suited to the objectives set for the study, as there is already a cycle path along the towpath that is under the jurisdiction of the Ticino Park authorities and that already performs to a number of the functions performed by greenways. The goal of the project is to improve the existing greenway characteristics and identify the area's ecological functions. On the basis of the diagram shown in Fig. 1, the case study is structured using the following phases:

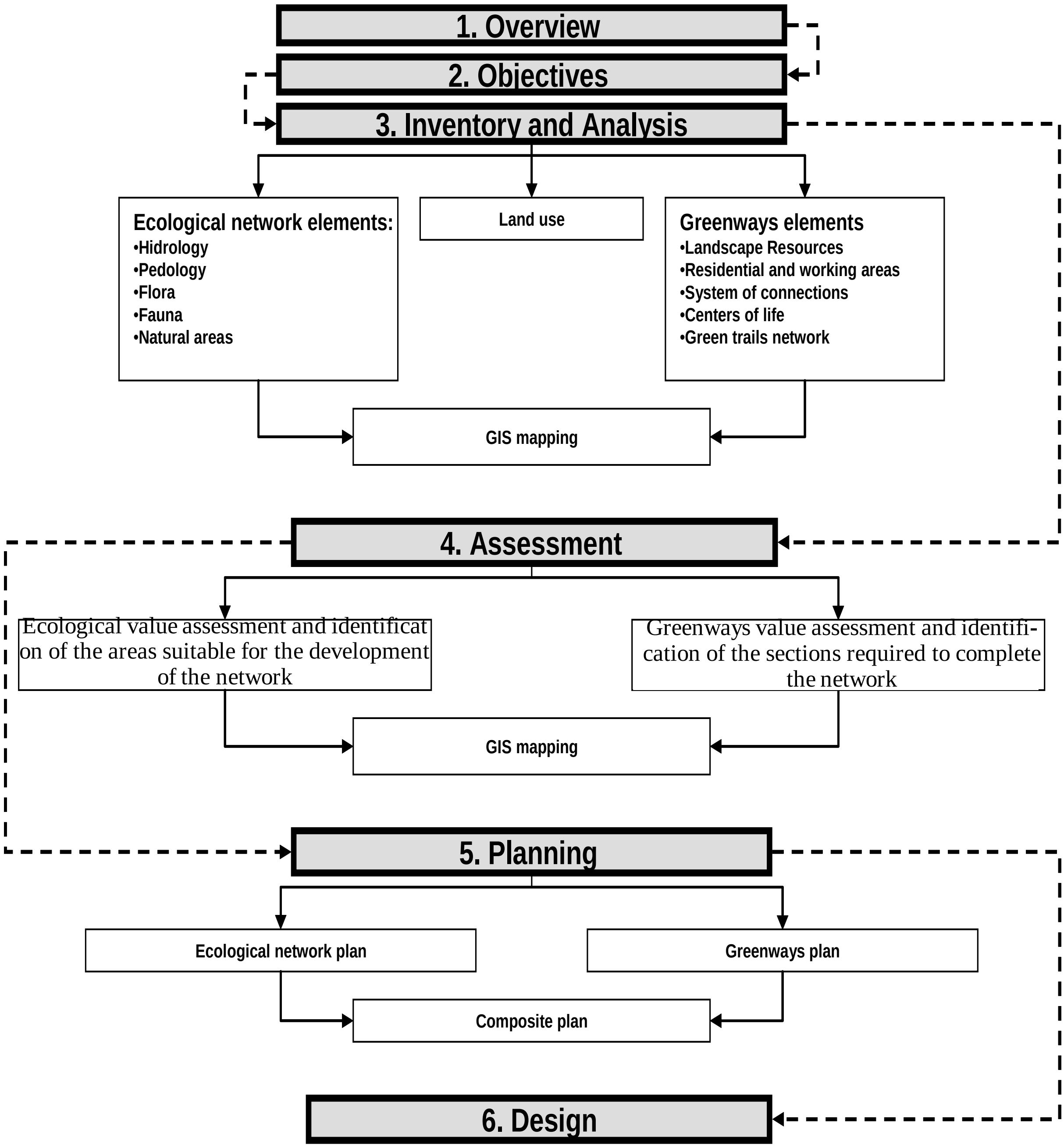

Fig. 1. Diagram of the methodology used

Overview: This was necessary for contextualising the study area within the surrounding district and identifying which elements outside the area may exercise a certain influence or to which the greenway or the ecological network in question could be linked. For the purposes of this territorial overview, the following were performed:

-a physical survey: chorographic and climatic overview, land use and existing infrastructures;

-a social survey: existing population;

-a survey of productive factors: agriculture, industry, and commercial sector;

-an historical survey; and

-an analysis of the existing plans (in order to identify any existing proposals, territorial plans, or development plans with a bearing on the area in question).

The study area is situated between the provinces of Milan and Pavia in a district to the south west of the Lombardy region. The municipalities traversed by the canal largely fall within the boundaries of the Ticino Valley Lombard Park and to the east border the South Milan Agricultural Park. The population density is 339 inhabitants per km^2; the settlements are prevalently

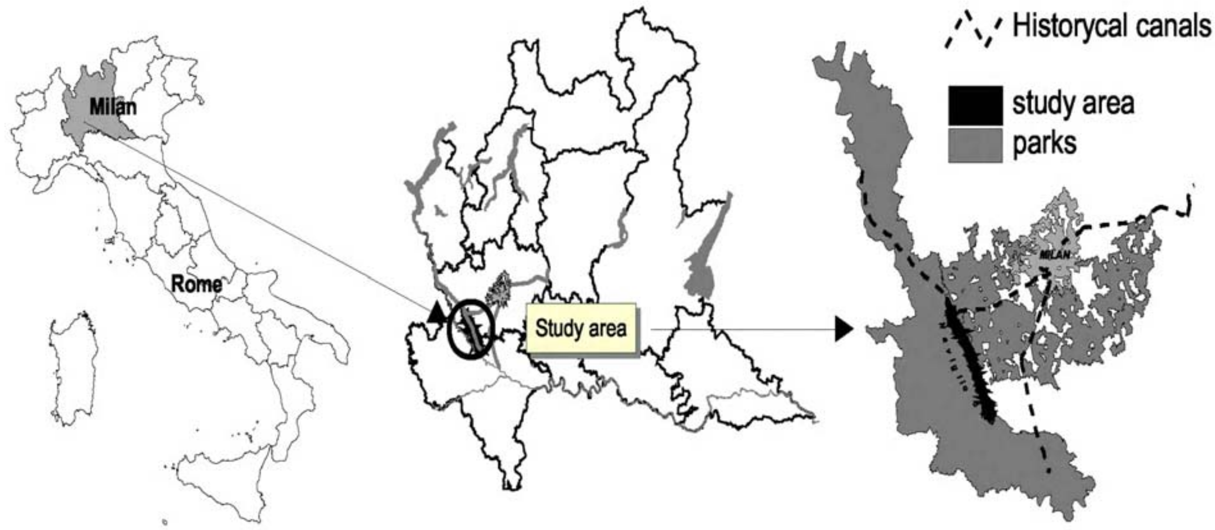

Fig. 2. Case study area

concentrated in the municipality of Abbiategrasso and along the SS526 main road traversing the area from north to south.

Land use in this area is primarily agricultural because the area is characterised by an abundance of water, thereby permitting irrigation. The main crops are maize and rice. With the exception of the extensive wooded area along the Ticino River, the land adjacent to the canal is of little interest. It contains a few hedges and rows and small wooded bands along irrigation dykes. The landscape structure is therefore composed of agricultural plots of small and medium dimensions throughout which small wooded bands and a number of hedges and rows are dispersed (see Fig. 3). Regarding the historical background, construction of the Bereguardo Canal began in 1457 and was promoted by Francesco Sforza. The canal was probably intended as a link between the castles of Milan and Abbiategrasso (already linked by the Naviglio Grande or Grand Canal) and Bereguardo. The Bereguardo Canal draws its water from the Naviglio Grande (which in turn carries water from the Ticino River into the heart of Milan), is 19 km long, and overcomes a height difference of 25 metres thanks to the construction of 11 locks. This high number of locks in such a relatively small stretch has always meant that navigation is laborious and the canal is essentially used for irrigation.

The Bereguardo Canal is subject to the planning rules and regulations in force in the area at the various territorial levels:

- The Regional Territorial Landscape Plan of the Regione Lombardia identifies the Bereguardo Canal as a *principal feature of the landscape*;
- The Provincial Territorial Coordination Plan classifies the Bereguardo Canal as a minor watercourse, *useful in the creation of a secondary local ecological network*; and
- The Lombard Canals Master Plan assigns a *rural environment recreational function* to the Bereguardo Canal.

Objectives: In relation to the territorial context in which they are inserted, greenways and ecological networks may perform different functions. These functions are summarised in Fig. 4. For the evaluation of the study area's ecological function, we must distinguish between the form of the existing elements and, on this basis, the various roles they may play: The patches may serve as habitats and biodiversity reserves or as stepping stones. In relation to their breadth, the linear elements may act as habitats or corridors, and when located close to watercourses, they may perform a filtering function or a mechanical action, for example, stabilising the banks (Saunders & Hobbs, 1991; Malanson, 1993; Bennett, 2003; Micarelli *et al.*, 2007).

Taking into account both the territorial context in which the Naviglio di Bereguardo lies and its classification in the existing plans mentioned above, the following objectives can be defined:

- Serving as a *greenway*, the canal could take on a primarily recreational and sporting function, largely associated with minor local tourism. The canal possesses negligible potential as infrastructure for daily transport as the land crossed is primarily agricultural with a low population density (Tzolova, 1995);
- Serving as an *ecological network*, the study area is characterised by primarily agricultural land use and a heavily modified landscape with a restricted number of natural and semi-natural areas. Thus, it cannot serve as a principal ecological network. The canal itself represents a linear element with a very restricted breadth, as is the case with the majority of the natural

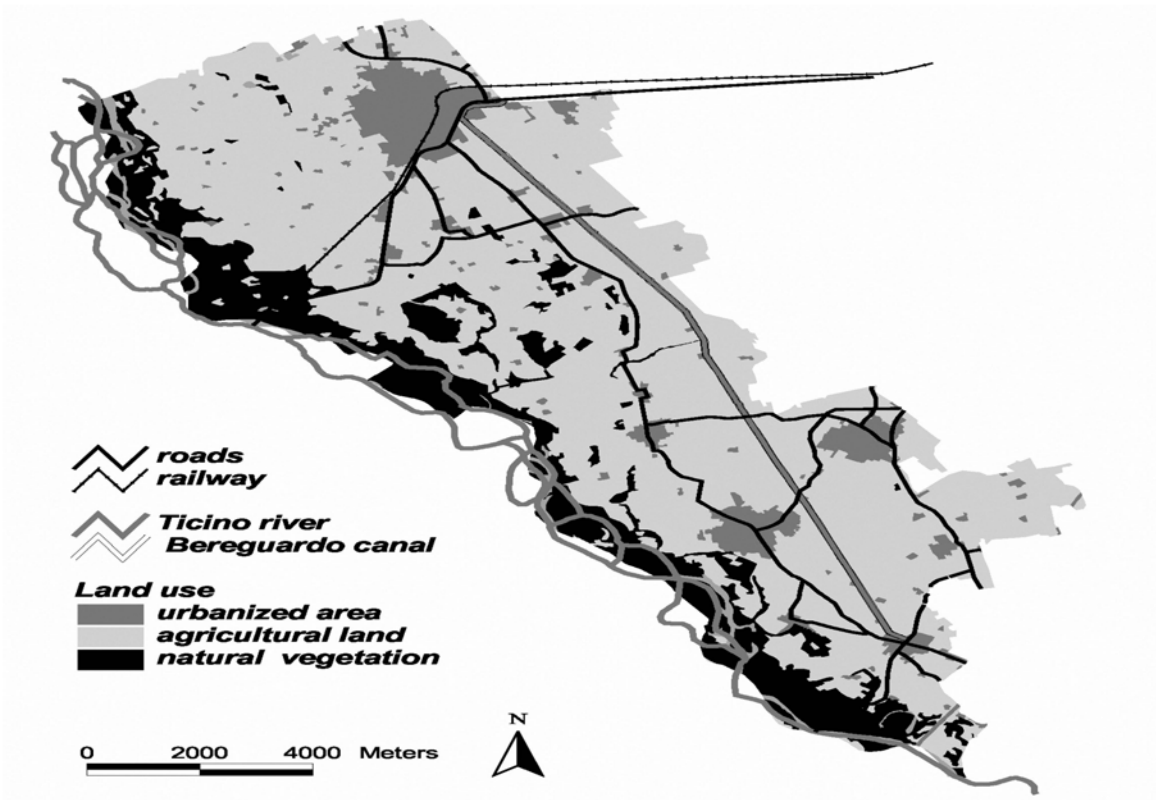

Fig. 3. Land use and transport system of the study area

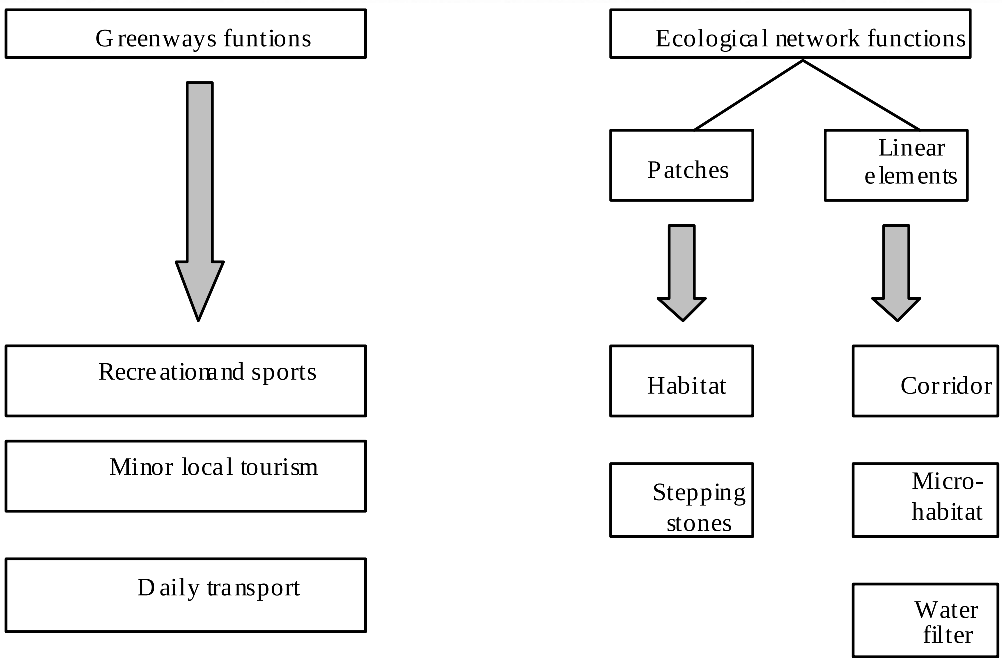

Fig. 4. Diagram of the functions of Naviglio di Bereguardo greenway

elements closest to it. For this reason, a minor ecological function may be hypothesised, associated with the presence of more or less natural microzones: This “system” may perform a buffer role for the water and act as a microhabitat and microcorridor for small animals and bird species (Cook, 2000; Najafpour, 2008).

Analysis: An ecological network or corridor has significance when it is connected to other natural elements and is therefore part of a broader structure. For this reason, the natural elements present in the landscape (natural areas, parks, reserves, wooded areas, wetlands, hedges, rows, wooded strips, and so on) and their characteristics have to be identified, along with any existing ecological networks (Aminzadeh, 2010). The same is true in the case of greenways: Their value increases significantly if they are part of a broader system of interconnected routes. The territorial analysis phase therefore involves the assembling of all the information and data necessary to identify the resources present in the area that concern both the greenways system and the ecological network.

Regarding the study area's potential as a greenway, the territorial analysis phase takes into consideration the existing green trails (subdivided according to type and characteristics) and the elements of interest in the area that the trails should connect. In the study area, the following elements were surveyed and mapped: landscape resources (that is, elements of naturalistic, historical-architectural, and archaeological interest, or evidence of the relationship between humans and the territory), the population and residential and working areas, centres of social activity and congregation, and interconnections with other means of transport (Senes *et al.*, 2010; see Fig. 5).

Regarding the study area's potential function as an *ecological network*, during the analysis phase, gathering information relating to hydrology, pedology, existing protected/natural areas, vegetation, and fauna seemed appropriate. In particular, regarding natural areas and vegetation, a survey of the landscape of the eight municipalities traversed by the Bereguardo Canal was conducted, along with an in-depth study of the vegetation in the band adjacent to the canal. In this buffer, the average width of which – a function of the breadth of the plots bordering the canal – is around 500-600 metres, direct surveys were made of both the land use classes and the types of vegetation, subdivided by form (patches, rows, and hedges) and composition (autochthonous, allochthonous, and mixed, with the identification of the prevalent species; see Fig. 6).

The analysis and survey of the water system involved characteristics with the greatest influence on the canal's ecological value: the type of banks and the presence of "lentic zones" in conjunction with locks and spurs (see Fig. 7). Lastly, the analysis of the fauna, conducted at a less detailed level without the production of general cartography, had the aim of identifying the species normally present in the area and capable of benefiting from the presence of an ecological network.

The fourth part of the methodology, assessment of all these elements, was conducted in two parts. Regarding the study area's potential as a greenway, the evaluation phase brought to light those elements of the landscape to be connected to one another and the planned network, the existing green trails to be incorporated, the stretches found lacking or those where maintenance work is required, and critical points and junctions with the ordinary road network (Toccolini *et al.*, 2006). During this phase, the links with the inhabited centres and with other existing green trails were highlighted. The most critical points to emerge were the study area's junctions with local roads and the lack of comfort facilities along the towpath. In relation to the theme of ecological valence, following the identification of the elements of stability, a qualitative and quantitative study of the natural elements was conducted in order to produce an overall estimate of the ecological valence of the landscape deriving from the unification of the results of the first two points (Vos *et al.*, 2001; Xiang, 2001). Regarding the evaluation of the quality of the elements, two

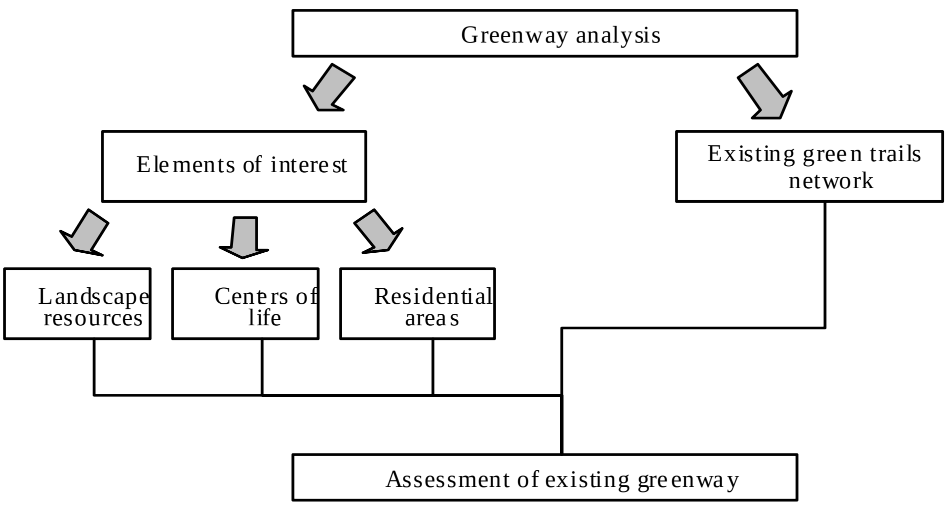

Fig. 5. Diagram of greenway analysis

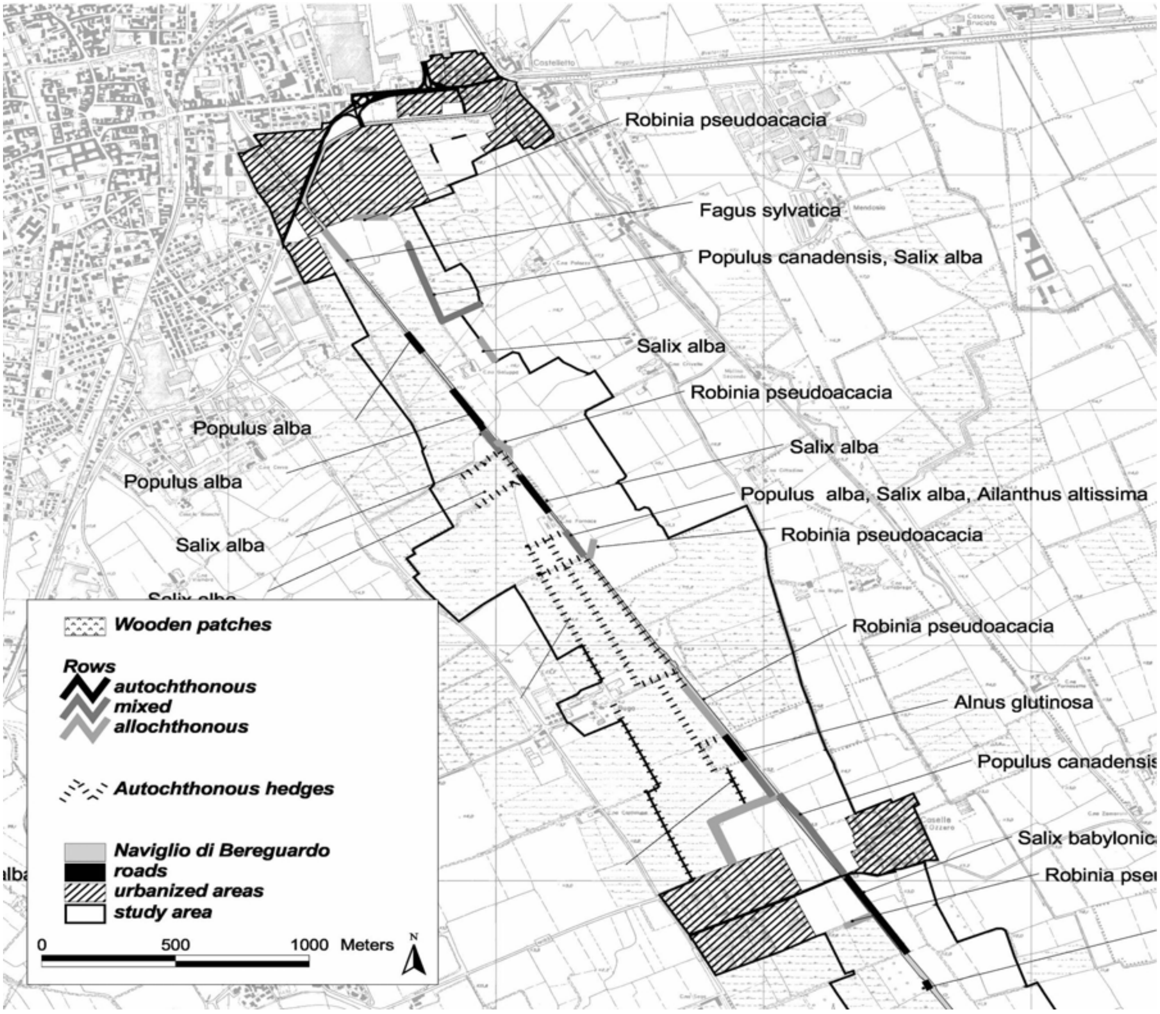

Fig. 6. An example of natural vegetation map

Fig. 7. Artificial and vegetated (in a lentic zone) banks of Naviglio di Bereguardo

principal characteristics were taken into consideration: the type of vegetation (increasing and passing from allochthonous elements to mixed and through to autochthonous) and the **s**tructure of the element (increasing and passing from hedges to rows and wooded patches); both characteristics were surveyed via direct observation in the field. The quality of the elements was evaluated by cross-referencing these two factors through the assignation of a points score (on a scale of 0 to 10): The combination of type and structure was neither automatic nor unequivocal. Greater weight was given to the type of vegetation (autochthonous, allochthonous, or mixed). Meadows and poplar stands were also taken into consideration as they guarantee ground cover throughout the year on a medium- to long-term basis, thus offering greater opportunities for shelter and/or nutrition. The cultivation of orchards was excluded, as it involves more frequent phytosanitary treatment. The score assigned to these zones was in any case low, as they are characterised by minimal levels of naturalness and biodiversity (see Table 1).

Table 1. Scores of natural and semi-natural elements quality ecological value

	Autochthonous	Mixed	allochthonous
Wooden patches	10	9	5
Rows	8	7	4
Hedges	8	6	3
Meadows, poplar plantations			2

Regarding the measurement of "**quantity**", the density of the natural and semi-natural elements distributed across the landscape was considered to be significant. In particular, it was decided to subdivide the study area into 20m x 20m cells, a factor indicated as significant in similar studies (Smith & Hellmund, 1993). In the case of each cell, first the density of linear elements (hedges and rows) was considered and then the density of polygonal elements (wooded patches, meadows, and poplar stands). The following formulas were used to calculate density:

$$D_L = \frac{L}{A}$$

where D_L (linear density) is the density of the linear elements, L the total length of the linear elements present in a cell, and A the surface area of a single cell.

$$D_L = \frac{L}{A}$$

where D_p (polygonal density) is the density of the polygonal elements, A_p the total area of the polygonal elements present in the cell, and A the total surface area of the cell (400 m^2).

Lastly, the ecological valence of the landscape was calculated on the basis of both the quantitative and qualitative characteristics of the natural and semi-natural elements present. The synthesis of the information relating to these two parameters was obtained in the following manner:

A) Every element considered was attributed a "virtual" value in terms of its dimensions; this virtual value was to be significant in terms of both quality and quantity. Here, too, separate approaches were used for the linear and polygonal elements: In the first case, a virtual value was obtained relating to the length of the element (virtual length L_v). In the case of the two-dimensional elements, a virtual surface area (S_v) was instead calculated. This value was obtained by multiplying the real dimensions (length L or surface S) of every element by an index of quality (I_Q)—a function of the quality score (Q) previously assigned, see Table 1—a variable between 1 and 2.

Summarising in formulas:

Virtual Length (for the linear elements)

$L_V = L * I_Q$

Virtual Surface Area (for the polygonal elements)

$S_V = S * I_Q$

with

$I_Q = f(Q)$

In this way, the initial dimensional parameter (that is, the quantified nature of the element) was transformed into a virtual dimensional parameter that is also indicative of quality, obtained by weighting the former on the basis of the qualitative value of each individual element. This step represented the synthesis of the two strands of information: quality and quantity.

B) For each of the study area's cells, a "virtual density" was calculated for linear and polygonal elements using GIS. The term virtual density is used because, as explained above, the lengths and surface areas of each element are not the actual dimensions. Rather, they are increased in proportion to the quality of the elements:

$D_{VL} = L_V/A$

where V_L is the virtual density of the linear elements, Lv the virtual total length of the elements present in a cell, and A the surface area of a single cell. In other words, V_L represents the ecological valence of the linear elements of a cell.

$D_{VP} = S_V/A$

where V_P is the virtual density of the polygonal elements, S_V the total virtual surface area of the polygonal elements present in the cell, and A the total surface area of the cell (400m^2). In other words, V_P represents the ecological valence of the polygonal elements of a cell.

C) On the basis of the virtual density values obtained, it was possible to subdivide the study area into various classes: It was in fact possible to attribute a value relating to the linear valence and the polygonal valence of each cell. The classes defined are shown in Table 2.

D) The overall *ecological valence* of the landscape was then calculated: The total ecological valence of each cell was calculated on the basis of the ecological valences of the linear and polygonal elements. Regarding the calculation of the total ecological valence, it was decided to assign the greatest weight to the polygonal elements; the overall valence is shown in Table 3.

A diagram of the entire procedure is shown in Fig. 8 with the final map of the Bereguardo Canal's ecological valence.

The ecological evaluation phase was completed with the evaluation of the resistance of the landscape to the movement of species and, as a consequence, the realisation of an ecological network. The diverse land uses were grouped, on the basis of the existing bibliography, into five classes of resistance:

- no resistance: woods or wooded patches and meadow;
- almost no resistance: orchards and poplar stands;
- low resistance: arable and uncultivated land;
- high resistance: stables and agricultural farm nuclei, horticultural areas, urban green areas, and roads; and
- very high resistance: built-up residential, commercial, and industrial areas.

A point score (from 0 for no resistance to 4 for very high resistance) was assigned to each class to obtain a territorial resistance map that would be useful in the following planning phase (Fig. 9).

On the basis of the analyses and the evaluations of the previous phases, it is possible to plan a greenway with ecological value.

A *greenway plan* was defined that identified:

- a principal axis, coinciding with the Bereguardo Canal towpath (used above all for open-air recreational purposes, sports, excursions, and local tourism);
- a number of primary green trails; and
- a number of secondary green trails.

A number of interventions are necessary along the principal axis: the creation of rest areas to improve comfort, the planting of vegetation along the towpath to increase the level of shade along the trail, the positioning of information panels to make the greenway more easily identifiable and usable, and the regulation of junctions with the local roads to improve the level of safety (see Fig. 10).

Regarding the *ecological network plan*, as the area in question is characterised by intensive

Table 2. Density classes used

Virtual Linear Density score D_{VL} ($m/400m^2$)	Linear value classes (V_L)
> 25.	High
15 – 25	Medium
0.1 – 15	Low
0 – 0.1	Null

Virtual Polygonal Density score D_{VP} ($m^2/400m^2$)	Polygonal value classes (V_p)
> 200	High
75 – 200	Medium
0.1 – 75	Low
0 – 0.1	Nil

Table 3. Diagram of overall ecological valence

Polygonal value classes (V_p)	Linear value classes (V_L)	Overall ecological valence (V_T)
High	High	High
High	Medium	
High	Low	
High	Nil	
Medium	High	
Medium	Medium	Medium
Medium	Low	
Medium	Nil	
Low	High	
Low	Medium	Low
Low	Low	
Low	Nil	
Nil	High	
Nil	Medium	
Nil	Low	Nil
Nil	Nil	

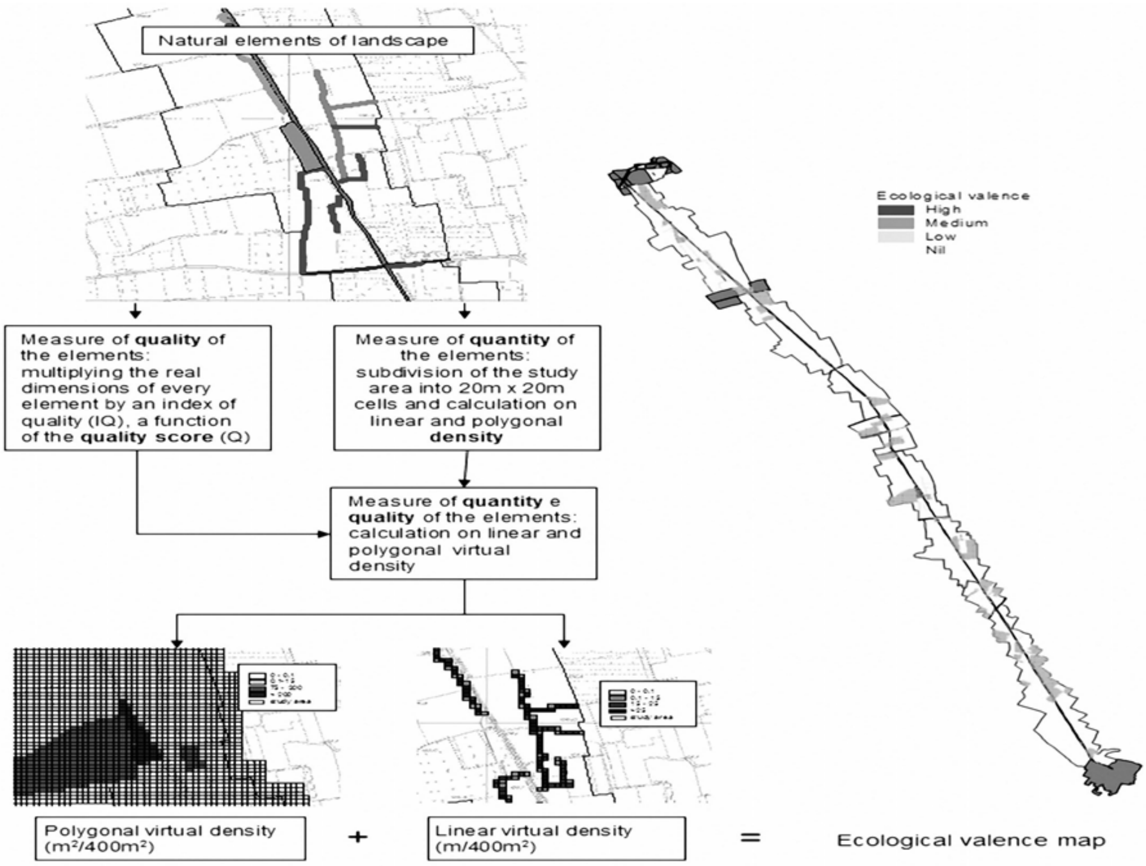

Fig. 8. Diagram of ecological valence estimate methodology

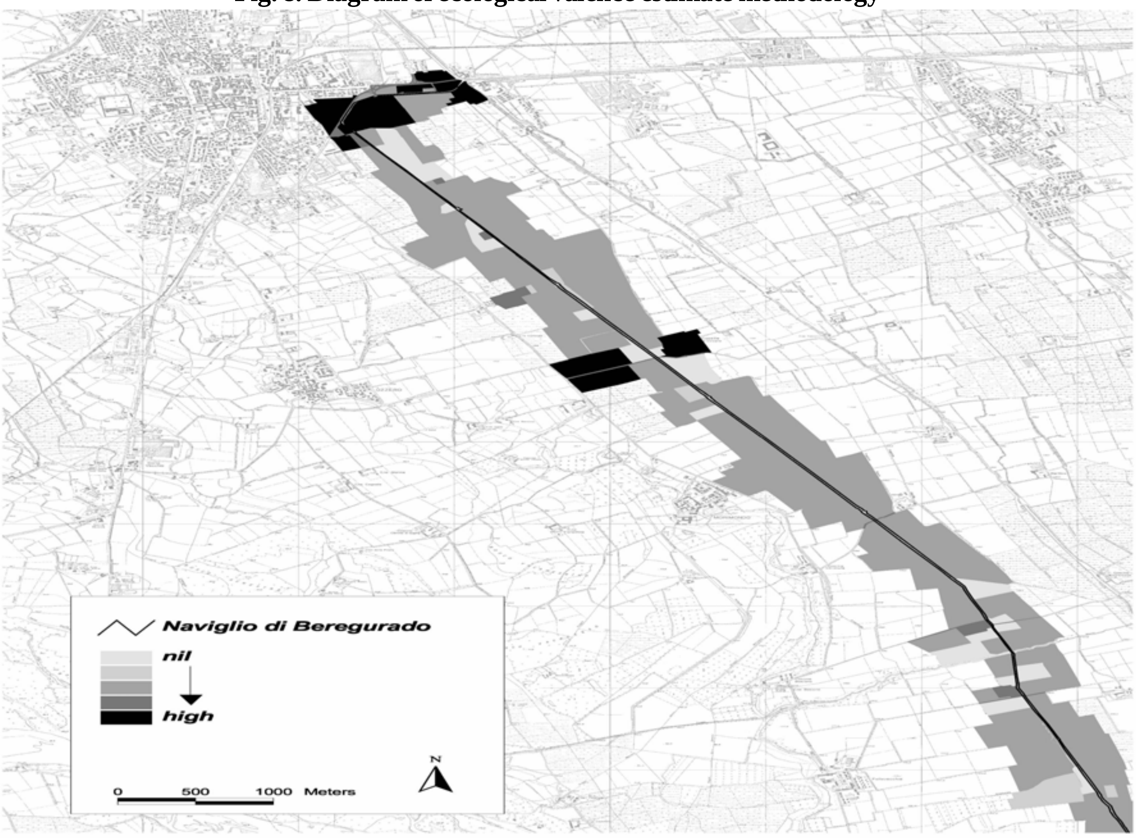

Fig. 9. Map of the evaluation of the resistance of the landscape to the movement of species (based on the land use map)

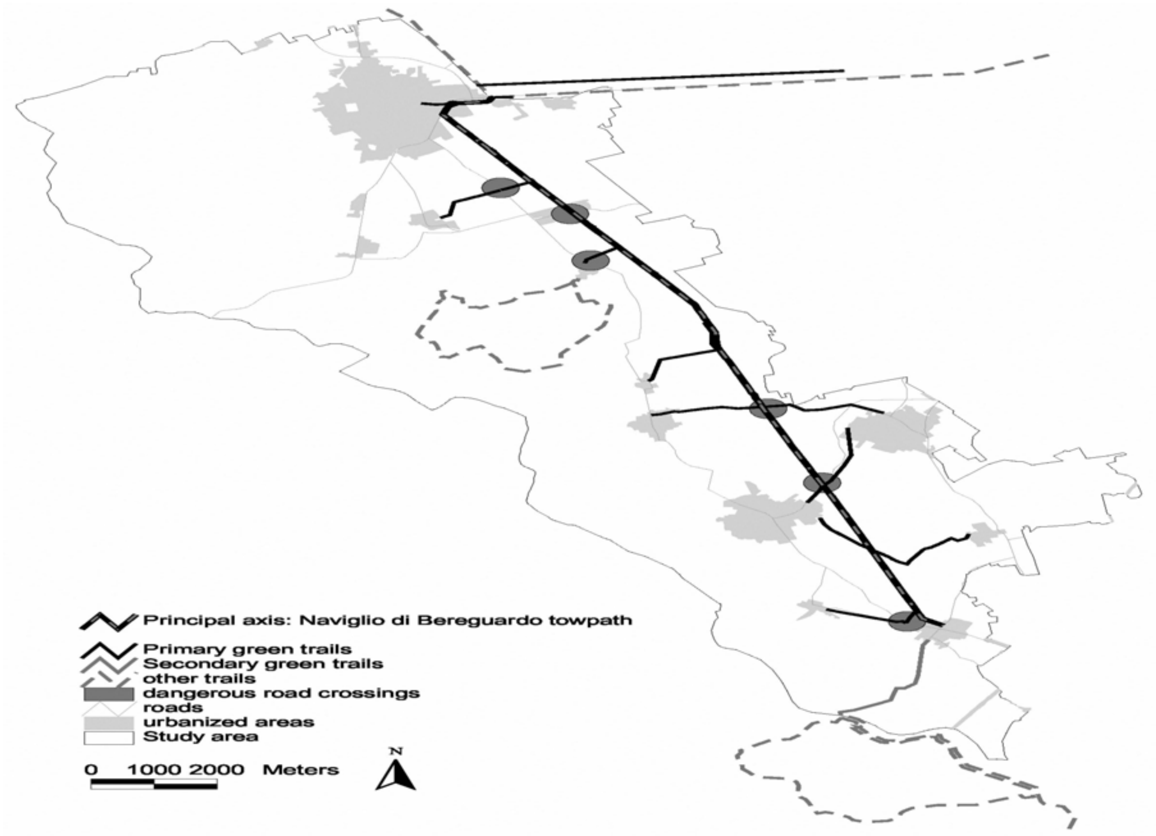

Fig. 10. Greenway plan

agriculture and contains no natural elements of particular value, it is not possible to create a plan for a complex ecological network composed of nuclei, ganglions, and corridors. We have therefore hypothesised:

- the linking of small areas that proved to be more significant and
- the creation of a network of hedges and rows (Malcevschi *et al.,* 1996) composed of autochthonous species extending throughout the area and based on the principal axis represented by the canal.

The objective of a final average hedge and row density of around 150m/hectare was set, as this is a value capable of guaranteeing continuity from an ecological point of view and does not render the landscape excessively homogeneous and therefore visually monotonous for users of the greenway. In order to identify the areas suitable for the development of the network (see Fig. 11), maps of ecological valence and resistance to the movement of species were overlaid so as to highlight those areas with a relatively high ecological valence (medium or high valence classes) and those in which the network could be developed through the creation of links (low or no resistance classes).

To complete the interventions, the denaturalisation of the stretches of artificial bank (around 20% of the total) is proposed where possible, along with the planting of trees and shrubs along part of the banks so as to enhance the ecological functions of the watercourse (Smith & Hellmund, 1993). On comparing the two plans developed, it is evident that there is significant superimposition coinciding with the course of the Naviglio di Bereguardo: In the next design phase, it is necessary to pay particular attention to the interference that may occur along this axis deriving from the coexistence of ecological and recreational functions. No particular problems were identified elsewhere in the area, as the greenway does not cross zones of particular ecological-environmental value. Particular attention will also have to be paid to the choice of plant species to be used to improve the level of shade along the trail, privileging the use of autochthonous rather than allochthonous species, even though the former are generally characterised by slower rates of growth. The creation of a well-designed ecological network extending throughout the area could also help to improve the visual quality and degree of variety of the landscape, enhancing the landscape value. For this reason, the disposition of the vegetation should be carefully studied to create a degree of

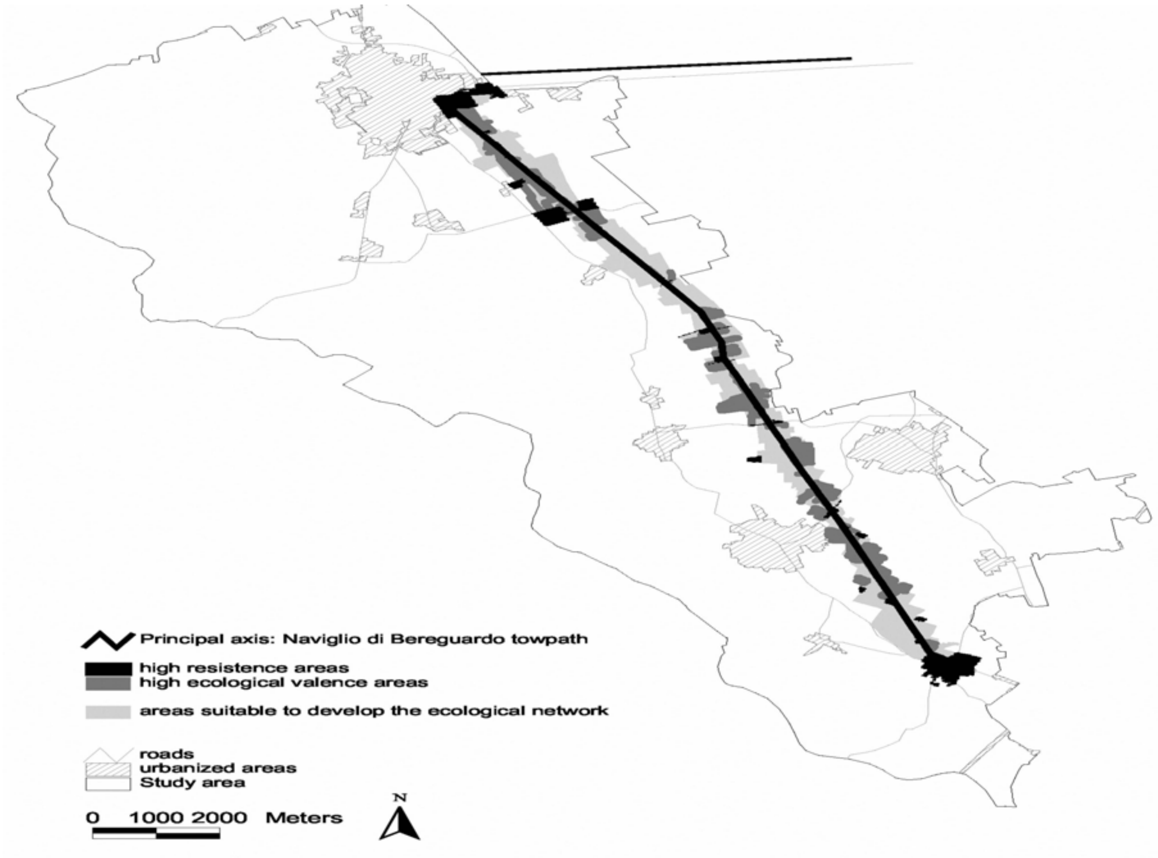

Fig. 11. Ecological network plan

casualness, naturalness, and heterogeneity of form and structure. Design is the final phase of the study, the application of which concerns both the trail itself and the agricultural land it crosses with reference to both the recreational and the ecological function of the greenway. Given the superimposition of functions (ecological and recreational) along the towpath, during this phase, an analysis was performed of the effects that the recreational function and the consequent human presence may have on the ecological valence and design choices were made to minimise these effects. The impact of the impermeabilisation of the ground as a result of the paving of the towpath with bituminous conglomerate could be mitigated (in visual terms, too) with the use of more appropriate self-draining paving. The possible littering by users of the greenway, both unsightly and potentially damaging for the fauna that might feed on it, could be contained through the provision of an adequate number of preferably closed bins that are difficult for animals to access. Disturbance of the fauna by the human presence would appear to be limited by the fact that rather than distributed throughout the area, users will be concentrated along the towpath. Furthermore, the lack of illumination precludes significant use of the route during night hours and therefore disturbance of the nocturnal species (hedgehogs and owls) normally present in the area. The interventions planned for the project concern:

-the installation of rest areas with a frequency of 500-700 meters in the sections adjacent to inhabited centres and 1000-1500 meters along the rest of the trail, for a total of 17 areas;

-the planting of vegetation along the 16 km of towpath in order to increase the shading of the greenway, with the use of autochthonous species and trees and shrubs to increase the structural complexity, the variability of habitats and shelters, and the heterogeneity of the landscape;

-the extension of the system of autochthonous hedges and rows along the confines of the agricultural plots and along the ditches and irrigation channels in such a way as not to interfere with agricultural works;

-the planting of 160,000 m of vegetation to create a secondary ecological network with an average density of around 150 m/ha;

-the implementation of safety measures for the three road crossings; and

-the erection of panels and signs.

The plant species proposed for the various interventions have been subdivided into groups on the basis of their function and characteristics:

hygrophilous trees (*Alnus glutinosa, Populus alba, Populus nigra, Salix alba*), hygrophilous shrubs (*Salix purpurea*), non-hygrophilous trees (*Acer campestre, Carpinus betulus, Fraxinus excelsior, Quercus robur*), and non-hygrophilous shrubs (*Cornus sanguinea, Corylus avellana, Crataegus monogyna, Prunus spinosa*).

CONCLUSION

The study conducted allows us to affirm with confidence that, thanks to the synergies noted between ecological networks and greenways, the latter can – in many situations – act as support for the ecological network. This is particularly true in rural contexts such as the area studied, as they offer greater opportunities for the recovery of natural and semi-natural environments; it should however be emphasised that especially when significant use of the greenway is foreseen, it may be necessary to implement a series of measures to minimise the negative impact of users on the natural resources present (flora, fauna, soil, and water). An approach of this kind, based on the planning and design of multipurpose open spaces, would, for example, permit the diminution of competition for the occupation and use of the land and to overcome the sectorial outlook that has to date frequently characterised land use planning. Its application to the Bereguardo Canal has shown that the method proposed for the estimation of the ecological valence of the landscape permits the efficient identification of areas with different environmental values and has proved to be a foundation for use not only in the planning of ecological networks but also, for example, in traditional land management institutions and instruments. However, the model developed clearly requires adaptations if it is to be applied to projects with different characteristics of land use and/or scale of intervention.

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