Environmental Development 24 (2017) 179–186

Contents lists available at ScienceDirect

Environmental Development

journal homepage: www.elsevier.com/locate/envdev

# Paradoxical environmental conservation: Failure of an unplanned urban development as a driver of passive ecological restoration

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ARTICLE INFO

*Keywords:*
Project cycle
Plant assemblages
Birds
Historical applied ecology
Civic ecology

ABSTRACT

The recent discipline of historical applied ecology has suggested that casual and context-specific circumstances may play a role in driving socio-ecosystems towards unpredictable changes. Here, we report a case study from Rome (Italy) where a recent history of unplanned stochastic events, beginning with illegal development of an abandoned factory, has unexpectedly turned a degraded industrial area into a site worth of conservation (about 300 plant species, 11 plant communities, 3 EU priority habitats, 62 bird species including 3 taxa of conservation concern at continental scale). Such a paradoxical history is discussed in the light of (i) the complexity arising from organizational, social and ecological systems occurring in this context and, (ii) the role of civic ecology, as a new approach in environmental conservation.

## 1. Introduction

Environmental strategies need to be carefully planned (Margoluis and Salafsky, 1998; Margoluis et al., 2009). According to the IUCN project management cycle (Hockings et al., 2000) and the problem solving approach in environmental and conservation planning (Primack, 2002), all strategies should provide an analysis of the context (or 'situation analysis'), a definition of the objectives, a selection of priorities following a decision-making process, a planning of activities, a monitoring of project action outputs and outcomes. Nevertheless, in systems embedded in the 'full world' development arena (sensu Farina et al., 2003) as, for example, the urban areas of the Mediterranean context, the role of contingent circumstances may be very important and should be considered as a driver of unpredictable historical events (Swetnam et al., 1999). In particular, it should be taken into consideration that the ecological systems may be driven to new conditions by the counter-intuitive effects of anthropogenic activities. Depending on the different types and regimes of disturbances (sensu Sousa, 1984; White and Pickett, 1985), these novel and unpredictable systems (sensu Hobbs et al., 2009) may be characterized by a high level of habitat degradation but they may also host unexpected new ecological systems.

Recently, we have had the opportunity of analyzing a history of unplanned stochastic events inside Rome, one of the largest metropolitan areas in the Mediterranean region. In such an area, the illegal alteration of an abandoned factory has turned a degraded industrial area into a site worth of conservation. In the present article, this paradoxical history is discussed and a causal model of the chain of events which can occur in contexts where planning is poor or absent is suggested. The case might be considered a paradigm of the recently developed approach of (contemporary) historical applied ecology as defined by Swetnam et al. (1999).

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http://dx.doi.org/10.1016/j.envdev.2017.05.003
Received 11 March 2017; Received in revised form 19 May 2017; Accepted 22 May 2017
2211-4645/ 

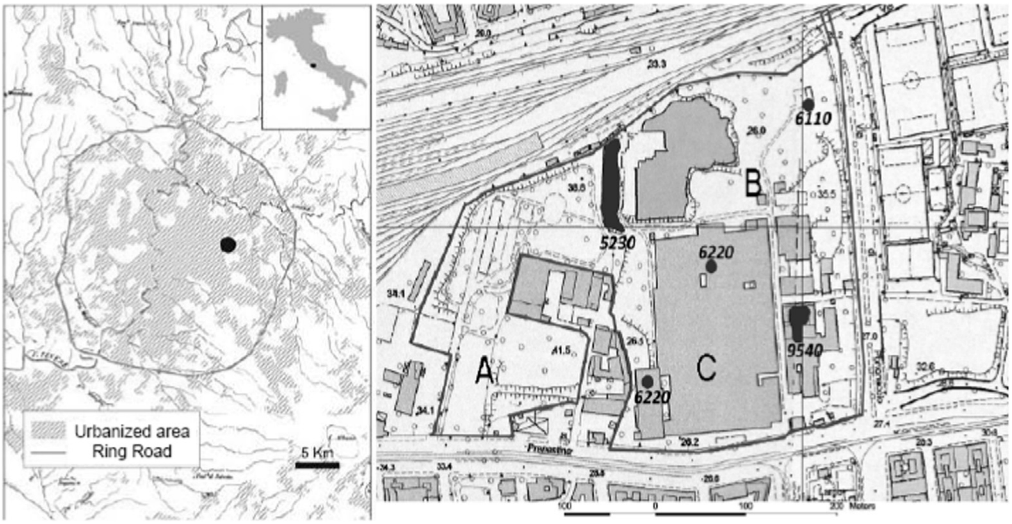


**Fig. 1.** Study area (SNIA Viscosa, Rome, Italy). Left: Location inside the urbanized area of Rome; Right: Detail of the study area (A: pinewood; B: grasslands and lake; C: degraded industrial area). Numbers indicate the prioritary habitat type (92/43 European Directive; see text for details).

## 2. Study area

The study area is located close to the historical center of Rome (Fig. 1, left), in a highly urbanized area (15.600 inhabitats/km$^2$, one of the most densely populated area in Italy), with a very low number of green areas (public green area per person is 4 m$^2$; the lowest in Rome: WWF Lazio, 2016). The site includes an abandoned factory of artificial silk, the SNIA Viscosa, which was active from 1923 to 1954. The industrial plant was located in an area rich in groundwater springs along the Marranella ditch, which descended from the Alban hills and flowed into the Aniene river. The plant withdrew water from the ditch and used it in the production process. The rapid and uncontrolled city growth and the presence of an important industrial plant determined the strong urbanization of the neighborhood, which in a few years saw a great increase in its population (Severino, 2005; Frondoni et al., 2011). In 1934, the ditch was channeled and covered, although the SNIA Viscosa continued to use its water. It was for many years one of the largest industrial establishments in Rome, employing more than 2500 workers (Nerbini, 1925). Also the area owned by the factory was very large, and spread over almost 15.5 ha. Approximately half of it (about 7 ha) was built and included a small hill adjacent to the plant, on which housing for the workers and other service facilities were built and a small pine forest (*Pinus pinea*) was planted. When the factory was closed, the area was abandoned for many years. In 1968 - in order to protect endangered landscape features from the urban dynamic of the neighborhood - what remained of the pine forest was subjected to protective restriction; the hill area was expropriated and established as a public garden. The rest of the area, including the old industrial buildings and the surrounding areas, was purchased in 1990 by a builder. In 1992 the property unlawfully began to build a shopping center. The illegal excavations for the construction of a car park caused a leakage of groundwater (with a depth of up to- 5 m) which created a small lake (about 10,000 m$^2$). Due to the citizen protests, the works were immediately blocked and the whole area, including the lake and the surrounding unbuilt land, was expropriated. However, the area holding the ancient buildings of the industrial plant remained in private property and, in the following years, became the subject of some proposals for transformation. These included the construction of other buildings or private sporting facilities which the citizens of the neighborhood have always opposed. Locally, there is intense awareness of the importance of green areas, especially for nature-disconnected generations who live in almost completely urbanized neighbourhoods (see Levi and Kocher (1999), Miller (2005) and Louv (2005)). Consequently, the area, which is still closed to the public, has not suffered anthropogenic transformations and is slowly re-naturalizing.

Presently the study area comprises three sectors (Fig. 1, right):

- public garden A (called “Parco delle Energie”) on the small hill, an area of 6.5 ha which includes lawns, public vegetable gardens and old trees (*Pinus pinea*) planted for ornamental purposes;
- the state-owned area B (about 4 ha), closed to the public, which includes a lake, fallows and a small hill covered with bushland. The lake is approximately 1 ha large and 5 m deep. Microbiological tests have shown that the water quality is good (Passatore, 2014). Around the lake a thick belt of hygrophilous vegetation developed.
- the private area C (5 ha), containing the ruins of the old factory and now included in the Industrial Archeology Heritage of Rome.

## 3. Methods

In order to assess the value of the natural and semi-natural ecosystems occurring in our study area, we carried out a pilot study on two focal targets of biodiversity (plants and birds), largely considered as good indicators of the general state of an ecosystem (Battisti and Fanelli, 2011, 2015).

The local distribution and frequency of plant species were assessed by dividing the area into squares of 2500 $m^2$ each, for a total of 63 squares, 35 of which were comprised in the "Parco delle Energie" and 28 in the dismissed abandoned area. Identification of plant species was carried out according to Pignatti (1982). Nomenclature followed Conti et al. (2005).

The vegetation was surveyed by mapping the area at a scale of 1:2000. The different vegetation types (see Supplementary materials 1) were identified with reference to the phyto-sociological literature and the vegetation types of European interest according to the "Habitats" Directive 92/43/EEC (Mücher et al., 2009). The identification of the habitats follows the European and Italian Interpretation handbook (European Commission, 2013) while the phytosociological nomenclature follows Rodwell et al. (2002) and the Prodromus of Italian vegetation (http://www.prodromo-vegetazione-italia.org/).

With regard to the evaluation of the environmental status of the flora, we calculated a set of ecological indicators for the flora (Ellenberg et al., 1991; Landolt et al., 2009; Guarino et al., 2012): L (light), T (temperature), K (continentality of climate), F (moisture of the soil), N (nutrients in the soil), R (pH of the soil), D (aeration of the soil) and H (degree of disturbance). The indicators are based on a 10-point scale, and the values for single species are taken from an unpublished database on the indicators of the Mediterranean flora (G. Fanelli, unpublished data). These indicators have already been applied in urban ecosystems (e.g. Pyšek and Pyšek, 1991; Pyšek et al., 2004; for Rome see Bianco et al., 2003).

In order to study the bird fauna, we carried out replicated and stratified point counts covering all the study area (Bibby et al., 2000). We located three sampling points for each day, and, from November 2014 to May 2015, repeated the surveys every month (n = 107 sampling surveys). Moreover, to obtain qualitative data on the occurrence of more rare species, we carried out a non-standardized survey walking periodically around the study area (total research effort: 50 h). The local check-list of species was selected from the data output, (Supplementary materials 2), with emphasis on the species included in the Annex I of the "Bird" Directive 2009/147/EC. Nomenclature followed Fracasso et al. (2009).

For the local bird fauna, we calculated the mean hemerobiotic score (HS) and hemerobiotic enthropy (HH) as a proxy respectively of the averaged level of generalism of the species and of the level of disturbance of the system based on bird ecology (Fanelli and Battisti, 2015). These indices were obtained for each species. The HS was calculated using the following equation:

$$HSi = \Sigma_j Fij \times Hj / \Sigma_j Fij,$$

where Fij is the frequency of occurrence of bird species i in habitat j and Hj is the hemeroby of jth habitat; subscripts j refer to summation over habitats. This formula is widely used in plant ecology, and represents the weighted average or barycentre of the distribution of the species along the hemerobiotic gradient (Ter Braak and Barendregt, 1986). The higher the HSi, the more numerous the species which are linked to progressively more disturbed habitats.

Since each species occurs with different frequencies in different habitat types the HH index can also be calculated by means of the Shannon's formula:

$$HHi = -\Sigma\ Hik\ \ln\ Hij.$$

This index may indicate the level of generalism/specialization of a species with regard to the frequency of differently disturbed (hemerobiotic) habitat types (higher HH expressing a higher generalism of the species). Both HS and HH may be useful for the assessment and monitoring of habitats and communities of conservation relevance. A particularly useful feature of these indices is that they allow to take into account both common species and less frequent ones which often play a key role in ecosystems (Battisti et al., 2017).

Since not all species of the ex SNIA Viscosa area were present in the list, we calculated the values by averaging the values for the 45 species present in the list of Battisti and Fanelli (2015). In Battisti and Fanelli the values are based on a 5-point scale, thus we converted them into a 10-point scale for comparison with the plant values.

## 4. Results

The flora of the entire area includes 358 spontaneous and 133 cultivated species. Among the spontaneous species, 38 are exotic (11% of the total flora). Inside the area of the dismissed factory (B + C in Fig. 1, right) 225 species occur, 35 of which, are exotic (15% of the flora).

The vegetation of the state owned and private area can be framed into 11 plant communities (Supplementary material 1). Although a few communities are dominated by exotic species (e.g. *Robinia pseudoacacia*), overall the vegetation can be considered natural or semi natural. Four communities can be ascribed to habitats listed in the Annex I of "Habitats" Directive (among them three – marked with asterisk – are priority habitat types of conservation concern at European scale): (i) 6110*: Rupicolous calcareous or basophilic grasslands of the *Alysso-Sedion albi*; (ii): 6220*: Pseudo-steppe with grasses and annuals of the *Thero-Brachypodietea*; (iii) 9540: Mediterranean pine forests with endemic Mesogean pines; (iv) 5230*: Arborescent matorral with *Laurus nobilis*. Although these habitats are rather fragmentary and occupy small areas (from a few $dm^2$ for 6220* to a few $dam^2$ for 5230*) they were nonetheless easily recognizable in the field survey.

The values of the indicators (Table 1) point to a Mediterranean climate (T and F), with light values typical of a fringe habitat (L), high nutrient availability (N), sub-acid, clay soil (N and D) and a degree of disturbance typical of suburban areas (H).

The bird community is rich when compared to other green areas of Rome (Arca et al., 2012) (Table 2) and include 62 species (among them three included in Annex I of 'Bird' Directive 2009/147/EC).

The HH indicator, which is related to disturbance, is 2.5 on a 5-point scale (5.0 on a 10-point scale); the HS indicator, reflecting the generalism of species with respect to the gradient of disturbance, is 0.8.

**Table 1**
Value of Ellenberg indicators for the flora (Ellenberg et al., 1991). Only the species of the dismissed factory (public area and private area) are considered. L = light, T = temperature, K = continentality, F = moisture, R = pH, H = hemeroby.

| | L | T | K | F | N | R | H |
|---|---|---|---|---|---|---|---|
| Unweighted average (mean value and s.d.) | 7.6 (1.3) | 9.1 (0.8) | 5.1 (1.1) | 4.9 (1.4) | 8.8 (1) | 6.5 (0.8) | 6.5 (1) |
| Average weighted with frequency (mean value and s.d.) | 5.8 (8.3) | 8.8 (12.5) | 3.8 (5.5) | 5.8 (8.3) | 9.2 (13.1) | 7 (9.9) | 5.8 (8.4) |

## 5. Discussion

The high number of plant species sampled (> 200 species) is striking for an heavily urbanized area, even when considering that the flora of Rome is very diverse (Celesti-Grapow et al., 2013). Although rare species are absent, the quality of the flora is nonetheless high, as indicated by two lines of evidence. First, the Ellenberg indicators (Table 1), in particular the indicator of disturbance (H), are similar to those of the flora of scrubs and grassland mosaics, which are typical of the non urbanized landscapes surrounding Rome (Fanelli, 1998). Secondly, many genera are present with a large number of species (e.g. *Trifolium* 12 species, *Bromus* 8, *Medicago* 7), a pattern which is uncommon in heavily urbanized areas and more typical of semi-natural areas. Although the meaning of high species-to-genus ratios is controversial (Järvinen, 1982; Gotelli and Colwell, 2001), this tool can undoubtedly be considered a good indicator of diversity.

The main vegetation units of the area are grasslands (with high diversity; Fanelli and Lucchese, 1998), aquatic vegetation patches and riparian woodlands surrounding the anthropogenic lake, and the vegetation growing on the walls of the abandoned factory. The habitats of ex SNIA Viscosa are very recent; although the factory was abandoned more than 50 years ago, recovery of vegetation begun only in the 1990s. The abandonment led to a slow successional process, which passively restored the original plant communities of the Campagna Romana (Celesti-Grapow and Fanelli, 1993), i.e. the landscape mosaic which surrounded Rome until the beginning of the dramatic urban development at the end of the 19th century, when Rome became the capital of Italy (Salvati and Sabbi, 2011; Salvati, 2013).

The presence of a few habitats of conservation concern under the EU Directive should be stressed, representing an unique feature at urban landscape scale. On the abandoned building behind the lake there is a community with *Sedum album* and *Cerastium semidecandrum,* which can be referred to the 6110* EU prioritary habitat. A calcicolous community referable to 6220* EU prioritary habitat, relatively common on limestone in the mountains surrounding Rome (Fanelli and Lucchese, 1998; Fanelli et al., 2010), has a very limited extension.

Two woody communities are present: a population of *Pinus halepensis* (9540 EU habitat) thrives on the walls of the abandoned factory, whereas a community dominated by *Laurus nobilis* (5230* prioritary habitat) can be observed on the western slope of the lake. Both are secondary and related to the naturalization of cultivated nearby individuals; however, in floristic composition, physiognomy and ecology they closely match analogous communities scattered in Central Italy (e.g. Filibeck, 2006). Urban forest plays a key role in ecosystem functioning (Bryant, 2006), particularly in relation to the fauna (Dobbs et al., 2011).

Despite the limited extent of the area, the bird community is rich (> 60 species) and rather well structured when compared to other urban green areas of Rome, with many generalist and synanthropic species (Arca et al., 2012). Over the past 25 years these species, both allochtonous and native, increased their density in Italian towns, significantly changing the species richness and composition in urban assemblages (Sorace and Gustin, 2008). Overall the bird community may be considered a sub-assemblage of a larger meta-community living in an 'patchy archipelago' (i.e. a set of green areas, historical parks and remnant natural fragments embedded in a transformed landscape matrix; Lorenzetti and Battisti, 2006), spanning the entire Eastern area of Rome (Arca et al., 2012). Nonetheless, species of ecological interest are also present (for example listed in the Annex I of 147/2009/Bird EC Directive).

This high diversity is related to a set of particular features of the study sites. First, the unintentional restoring of a new ecosystem made available food resources and refuge sites, helping to mitigate the negative effects of the disappearance of the rural and semi-natural habitats due to urbanization (Kennedy et al., 2013; Kowarick, 2011). The emergence of novel ecosystems allowed the presence of characteristic species (Frank and Battisti, 2005; Lorenzetti and Battisti, 2006; Ukmar et al., 2006), locally declining at regional scale (Brunelli et al., 2011). In this sense, our area may be considered a key-patch at landscape scale (see Tews et al. (2004)), where a crowding effect might occur (Debinski and Holt, 2000). Secondly, although the area is located in the inner core of Rome, the

**Table 2**
Number and percentages of phenological groups of birds.

| | Number of species | % |
|---|---|---|
| Migratory | 6 | 9.7 |
| Migratory Breeding | 6 | 9.7 |
| Migratory Wintering | 1 | 1.6 |
| Summering | 1 | 1.6 |
| Sedentary Breeding | 34 | 54.8 |
| Wintering | 13 | 21.0 |
| Winter Breeding | 1 | 1.6 |

scattered fragments of green areas dispersed in the urban matrix surrounding the study area, probably had a positive effect on diversity, allowing a high dispersal rate from surrounding areas (Driscoll et al., 2013), in particular for vagile species which can "jump" among patches and "stepping-stones" (patchy population structure; Wiens, 1976; Thomas et al., 2000). Thirdly, a factor affecting species richness is the diversity of ecosystems and the balanced proportion of the different vegetation units (Paker et al., 2014). This heterogeneity makes many resources and habitats suitable for different species (such as the lake and the mature trees useful respectively for waterbirds and cavity nesters; Dodaro and Battisti, 2014). The restored habitats and communities resemble those of the "Campagna Romana" (Celesti-Grapow and Fanelli, 1993), a landscape with surprisingly high α and β- diversity (sensu Magurran and McGill, 2011), both for plants and animals (Celesti-Grapow et al., 2013; Zapparoli, 1997; Fattorini, 2014). In this sense, the HH and HS values indicate a fauna typical of moderately disturbed open woodlands and scrubland-grassland mosaics, like those that can be found in the undeveloped surroundings of Rome (Fanelli and Battisti, 2015).

The number of priority habitats and the presence of threatened bird species (listed in Annex I of the "Birds" Directive) mean that it would be compulsory, under the prescription of the Directives, to preserve the study site as a Site of Conservation Interest. This is paradoxical in an abandoned factory embedded in a heavily urbanized area. Nonetheless, paradoxes are often the road to rethinking longstanding habits of mind (e.g. Westenholtz, 1993), stimulating new approaches for planning.

Environmental restoration projects are extremely complex to plan and carry out in the medium- and long-terms from both the ecological and socio-organizational point of view (Hockings et al., 2000; Bullock et al., 2011). Moreover, a long time is required for their fulfillment and for the proper assessment of costs and benefits (Holl and Howarth, 2000). Another problem is represented by the scarcity of financial resources whose availability is also increasingly limited. In some European countries, the main support for the realization of these projects is the 'Environment' sub-programme of LIFE, the European Union's fund for environment and climate action. EU Projects submitted under 'Nature and Biodiversity' priority area have to undergo a long evaluation process and a rigorous selection- of the 289 proposals received under the call for proposals in 2014, only 39 LIFE Nature and Biodiversity projects were selected for funding by the Commission, corresponding to 13.5% (the 2004–2014 average is 28,4%; European Commission, 2014). Moreover, once approved, many dynamics may affect these complex projects during the operational process due to internal weaknesses, difficulty to create partnerships between stakeholders, and other behaviours related to the human dimension arena (a synthetic review is in Battisti (2017); for case studies on EU projects see Enengel et al. (2011), Enengel et al. (2014) and Nita et al. (2016)).

The case of ex SNIA Viscosa is a serendipitous example of unintended restoration where no financial resources have been used. It demonstrates how, in an uncertain real world, where policy is inadequate, money is lacking and illegal practices widespread, ecosystem processes may start thanks to their intrinsic resilience (e.g. dispersal and colonization capacity; see Alberti and Marzluff (2004)) in the absence of any active deterministic planning. It should be pointed out that passive restoration, occurring when a secondary succession is allowed to develop spontaneously in abandoned or degraded areas, is widely accepted as an alternative to active restoration (Scott et al., 2001; Morrison and Lindell, 2011; Smith and Gehrt, 2010; Zahawi et al., 2014).

In cases like that of SNIA, a flexible framework (adaptive governance: Ollson et al., 2006) is needed (Fig. 2), capable of adapting

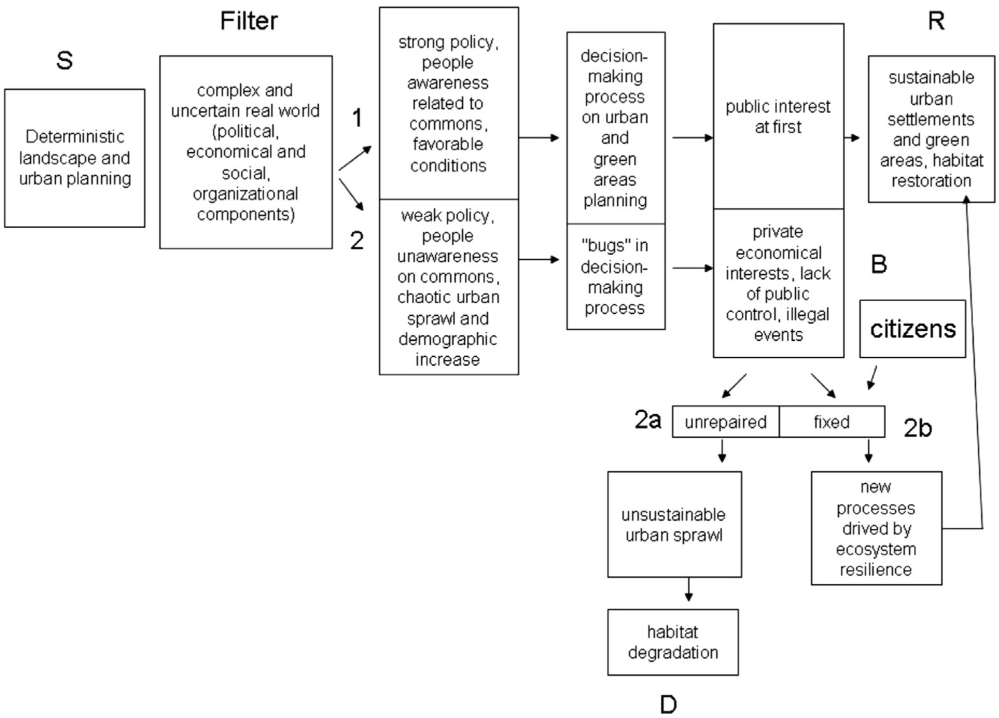


**Fig. 2.** A conceptual model for causal or deterministic adaptive management of critical urban contexts (see text for explanations).

to the complex interactions among the ecosystem, the local community and the stakeholders, and to take into account the high uncertainty and unpredictability of such systems (Folke et al., 2005; Wilson et al., 2005). Starting from ideal, hypothetical deterministic urban planning (S), the 'real world' acts as a selective filter, which opens two scenarios: (1) if public policies are strong, citizens are aware of the socio-ecological role of green areas (Bryant, 2006) and other demographic and economic conditions are satisfied, it is possible to start a decision-making process leading to habitat restoration and sustainable urban settlements (R); (2) conversely, if public policies are weak, demographic trends are uncontrolled (with urban sprawl and "self-made urbanism"), lack of regulation encourages illegal events and the decision-making process may suffer from a planning 'bug' (B). In this last case we have again two possibilities: (2a) if the 'bug' is unrepaired i.e., illegal settlements appear, uncontrolled land use change follows and habitat degradation (D) occurs; (2b) if the illegal 'bug' is fixed, ecosystem resilience and passive restoration (e.g. Bullock et al., 2011) may drive the transformed site towards an unexpectedly restored system (D). In this scenario, citizens play a pivotal role, supplementing the inadequacy of public policy (Backstrand, 2003; Chiesura, 2004) and helping fixing the planning "bug". The dynamics of events involved in our case study area shifted from ecosystem collapse (D in Fig. 2) to restoration (R in Fig. 2) largely because of the involvement of the local community.

## 6. Conclusions

Traditionally the field of nature conservation deals with landscapes, where nature reigns and humans play a subordinate, although determinant role (Angermeier, 2000). Conversely, in our case study, and generally in urbanized areas, the natural ecosystem is a subsystem of the human socio-sphere. This socio-human ecosystem shows sign of self-organization that are reminiscent of the self-organizing properties of natural ecosystems (Folke et al., 2005). The system of the ex SNIA Viscosa, put in a broader context, has elements linked to three different levels of complexities: (i) the organizational level of complexity represented by both the Public Agency and by the private property, which owns the abandoned factory; (ii) the social level of complexity here represented by the local human community, which enjoys the ecosystem services (in particular recreation and experience) of the local green area (Chiesura, 2004); (iii) the ecological level of complexity corresponding to the "novel" nature itself. The unpredictable interactions of these three levels of complexity and their related actors and processes (particularly, the failure both of public planning and of the illegal actions carried out by the property) shaped a fragment of nature of high value. It is perfectly reasonable to hypothesize that a planned management would not have been effective here in creating this unexpected novel ecosystem (see Ollson et al., 2006).

Worldwide urbanization is a rapidly spreading process (Elmqvist et al., 2013). Human population is now concentrated more in urbanized contexts than in rural areas, and the influence of society, production and exploitation affects every corner of the biosphere (Steffen et al., 2007; Ellis et al., 2010). In this sense, case studies such as the one conducted in the ex-SNIA Viscosa area, where high biodiversity is embedded in a strongly anthropized matrix, force us to rethink our conservation practices. Recently, ecological thinking has been focusing on Earth stewardship (Chapin et al., 2011; Rozzi et al., 2015), and urbanized areas play a leading role in this framework (Krasny and Tidball, 2012). Tools are already being developed for the management of this type of systems (Lovell and Taylor, 2013). Nonetheless, the field is still in its infancy, and the ex SNIA Viscosa is a perfect case study to be used as a paradigm for developing and refining the methods of civic ecology as a key factor in urban planning (Backstrand, 2003; Randolph, 2003; De Wit and Verheye, 2009; Krasny and Tidball, 2012; Krasny et al., 2014). When applied to areas subjected to uncontrolled urban development it can play a determinant role, particularly in the case of the explosively growing cities of the Southern Mediterranean basin, Africa, Asia and Latin America (McHale et al., 2013).

## Acknowledgments

All the authors conceived and designed the research; performed the field sampling, analyzed the data; wrote and edited the manuscript. We wish to thank Fulvio Cerfolli (University of Tuscia), Luca Scarnati and Fabio Attorre (University of Rome Sapienza); Giovanni Salerno who censused the flora together with one of us (G.F.); the "Forum Territoriale Permanente del Parco delle Energie" for information about the history of the factory (and, above all, for the strong commitment to the defense of the lake and for saving the archive of SNIA Viscosa); WWF Italy – "Pigneto-Prenestino" section; Alessandro Fiorillo, Mario Paloni and Flavia Sicuriello for their support in collecting data on birds. Alessandro Zocchi and Simona Petruzzi carried out English proof reading. Special thanks is given to Michele De Sanctis for helping us elaborate Fig. 2. Two anonymous reviewers greatly improved a first draft of the manuscript with useful comments and suggestions.

## Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.envdev.2017.05.003.

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