Landscape ecomosaics evolution and land use change in south-Sicilian coastal area

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Introduction

Intensive agriculture, urbanisation and neglected land-country often entail rapid landscape changes, losses of ecological capacity (Feranec, J., 2006) biodiversity and cultural landscape degradation (Farina, A., 1998). Sicily's countryside is characterised by a rich diversity of cultural landscapes and was shaped by traditional land-uses. The case study covers the middle-south part of Sicily (Agrigento), the so-called Temple's Valley, a literary territory passed through by many writers like Diodoro (I sec. a. C.), Goethe (1787). In last fifty years, the rural–urban fringe of Agrigento city have become the setting of the intense suburb growth and considerable land use change. One consequence of this development is the loss of traditional landscapes. The traditional landscape of Temple's Valley is Almond-Olive dry culture (Barbera et al., 2000), with trees scattered in croplands and pastures. Unfortunately, neglect and inappropriate development threaten this irreplaceable landscape legacy. Too often the long-term environmental and cultural ramifications of short-term decisions are not understood and as a result we lose a unique portion of our cultural heritage. The traditional social structures embodied in the local history of rural areas have dissolved. During the last 30 years, different trends have dramatically changed this production driven development of our cultural landscapes. This disappearance risk is due to transport technology, the economy resulting in urbanisation and urban sprawl and tourism pressure. Landscape ecomosaics evolution analysis has undertaken by determining the meaning of objects in aerial photographs and then by landscape metrics use, highlighting a strong land-use change. This changes causes the network connectivity complete loss, that is why this paper discusses the concept of ecological connectivity and proposes to improve riparian vegetation as a priority, which will achieve the multiple benefits of improving river health while contributing to network connectivity.

Background

Hobbs and Saunders (1991) developed the concept of 'reintegration of landscapes', based on ecosystem restoration at a landscape scale. In situations where human activities have caused major disturbance and fragmentation, this can be applied for re-establishing ecosystem connectivity, such as wildlife corridors across multiple habitats, and in restoring the flow of ecosystem goods and services. Consequently, a new approach to landscape restoration is suggested within the scope of the European Landscape Convention (Council of Europe, 2000). These landscapes provide multiple values and functions, including natural resources, wildlife habitats, economic benefits in the form of goods and services, recreation (Merlo & Croitoru, 2005), and, last but not least, cultural heritage (EEA, 1995). For example, rural areas are losing their traditional landscapes, characterised by a small spatial scale, mixed cultures, limited technology, low use of fertilisers and pesticides, and high biodiversity. These areas are also losing their environmental complexity and ecological connectivity. A riparian buffer restoring project (Aronson et al., 1993) can replace the benefits or services provided by the buffer.

Goals and objectives

With the accelerating pace of urbanization in the 20th century, the development that resulted from urbanization had an increasingly impact on rural environments (Pedroli et al., 2006). The growth of discontinuous urban fabric areas in to the rural fringe has led to the high fragmentation of the agricultural landscape. The purpose of the analysis is to assess the landscape ecomosaics evolution and to develop a management plan. In order to understand the integrity evolution and the stability of the historical and archaeological site is necessary to carry out studies specifically focused on the landscape change detection and the long term development descriptive. The landscape evolution dynamics was analyzed by comparison of land use change and ecosystem services change (Millennium Ecosystem Assessment, 2003) in two temporal scales. The cartographic elaborations and landscape metrics use reveals that the transformations occurring in the last 50 years in this area are considerable and the landscape results considerably fragmented. A landscape fragmentation process (Forman, 1995) influences its biodiversity causing grave environmental imbalance. In this situation, like other many case (Farina, 2000), the river system became the only way to connect ecosystems (Marino, E., 2009).For this reason we have proposed to restore the riparian vegetation along the river to create a green corridor and, in this way, to improve the biodiversity conservation and genetic exchanges (Green, 1994). This restoration could also decrease hydro-geologic risks. A linear system enhancement (Farina, 2002) and traditional landscapes protection seem the only way to connect this landscape system and increase its complexity. Many studies have shown that by installing or restoring riparian buffers where they have been previously removed improve network connectivity (Farina, 2000; Bennett, 1998; Mander, 2007). The goal of the project is to inform of the benefits of programs designed to restore riparian habitat and to improve the vegetated buffer zone.

Methods

The land use maps have made by using interpretation of air photo (black and white photo- 1955, 1:33.000 and in color). The black and white photos were rectified and georeferenced using a topographic map (1:10,000) and aerial photographs (1:10,000) produced in 2003. Categorical land usewere created by manual interpretation using ESRI's ArcMap software. The cases were surveyed on the field at two different times (1955 – 2003).The land use categories identified with the photo-interpretation are several, concerning urban spreading (Continuous and Discontinuous urban fabric; Industrial or commercial area; Green urban areas; Archaeological area; Tree-lines), agricultural spreading (Abandoned olive groves; Agro-forestry areas; Almond groves; Complex cultivation Fruit trees; Intensive arable land; Non-irrigated arable; Olive groves; Traditional Olive - Almond groves; Pastures; Trees-Pastures; Vineyards;) and natural – geomorphologic spreading (Bare rock/Gully erosion; Riparian zone). Developing ecological networks requires improvement of the spatial pattern of urban- rural space. To identify potential improvements, we compared the landscape ecomosaics on two temporal scale, 1955 and 2003, using five spatial indices (Table 1), which are usually used for landscape pattern interpretation and to predict habitat connectivity (Tischendorf, 2001). The landscape metric analysis have made by using Patch Analyst extension (Elkie et al. 1999).

Table 1: Configuration Index temporal variation (2003–1955): NP: Number of Patches, PD: Patch density, MPS: Mean Patch Size, MPP: Mean Patch Edge, ED: Edge density.

	2003					**1955**				
Classes	**NP**	**PD**	**MPS** (ha)	**MPP** (m)	**ED**	**NP**	**PD**	**MPS** (ha)	**MPP** (m)	**ED**
Agro forestry areas	12	0.83	3.29	955.30	0.66	18	1.26	3.17	865.62	0.60
Almonds groves	3	0.21	2.36	663.14	0.46	1	0.07	1.71	600.18	0.42
Archaeological areas	9	0.62	1.59	598.55	0.41	4	0.28	3.01	1217.91	0.85
Bare rock/Gully erosion	13	0.90	1.16	584.11	0.40	15	1.05	0.76	562.33	0.39
Beaches	3	0.21	6.20	2571.81	1.77	2	0.14	4.71	4054.50	2.83
Complex cultivation	11	0.76	2.39	733.06	0.50	9	0.63	1.24	669.50	0.47
Continuous urban fabric	2	0.14	82.87	7555.86	5.20	1	0.07	2.38	716.38	0.50
Discontinuous urban fabric	128	8.81	1.79	524.38	0.36	144	10.05	0.26	165.22	0.12
Green urban areas	7	0.48	11.04	1900.14	1.31	5	0.35	2.34	954.14	0.67
Historical Garden (*Kolymbetra*)	1	0.07	3.40	1650.00	1.14	1	0.07	2.71	1235.09	0.86
Non-irrigated arable	49	3.37	7.65	1659.46	1.14	25	1.75	29.97	4044.79	2.82
Olive groves	27	1.86	2.29	690.95	0.48	23	1.61	2.40	704.42	0.49
Traditional Olive-Almond groves	10	0.69	15.23	2318.56	1.60	16	1.12	22.40	2827.82	1.97
Pastures	15	1.03	6.04	1650.88	1.14	3	0.21	11.20	2527.96	1.76
Tree-Pastures	11	0.76	8.20	1749.36	1.20	1	0.07	4.01	1058.06	0.74
Riparian zones	4	0.28	3.02	1623.26	1.12	11	0.77	2.85	3102.11	2.17
Tree-lines	3	0.21	1.78	1492.47	1.03	2	0.14	0.64	1184.35	0.83
Vineyards	6	0.41	1.34	566.67	0.39	8	0.56	5.38	1210.46	0.85
Grand Total	344	23.69	4.22	984.68	0.68	289	20.18	4.96	1008.72	0.70

Landscape ecology uses the metric index to quantitatively study the rural landscape in order to provide reference for landscape structure and ecological process. For example edge attributes can provide critical information for quantifying and understanding landscape fragmentation, and yet, in fragmentation studies, compositional and patch-based landscape metrics are most often used for qualifying landscape changes (Hargis et al., 1998). Developing networks connectivity begins with identifying potential corridors; in this case high landscape fragmentation process allow to get better ecosystem connectivity through linear systems as hydrographic network. The riparian zone restoring project was made on the landscape class maps in 1955 and 2004 from the urban centre to the sea with a width of 30 m along the river and 10 m along canals and watershed.

Results

Landscape ecomosaics analysis has highlighted outstanding landscape's transformations. This research has produced two temporal ecomosaic maps in vector format: one map of the 1955 and another of the 2003 (fig.1).

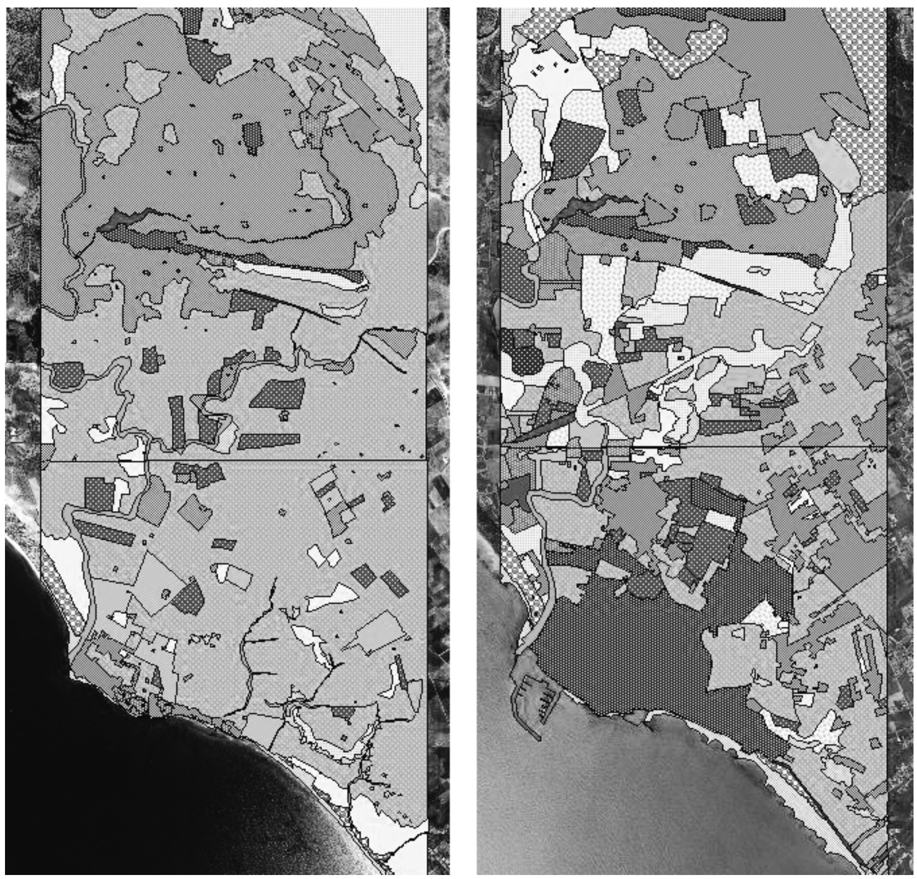

Figure 1. Ecomosaic maps (1955 on the left, 2003 on the right).

The landscape's present status of study area is a result of dynamical factors that has modified the rural and urban area in the last 50 years. Agrigento's perimeter has increased dramatically. The northern border has expanding, but of greater concern is the expansion eastward, taking place since the 1960's, the urban sprawl between sea and countryside. Between the temples' Valley and the sea many houses have been build scattered throughout the countryside that have transformed the traditional rural environment into a urban agglomerate.

The rural landscape has deeply transformed by increasing of intensive farming to the detriment of agroforestry area and riparian zones. In area suitable for fruit and vegetable cultivation (flat and close communication network area), the cultural landscape has been progressively replaced by more profitable uses, has had a decrease of arable land, above all wheat extensive cultivation, increasing new specialized- intensive culture such as new olive groves, orchards and plastic-tunnel cultivation. In this way, nowadays traditional manual techniques of land management have been replaced by mechanisation and chemical fertilisation.

Landscape composition and configuration is still characterised by a small-scale land use mosaic of several patch (Non-irrigated arable land, Pastures and Olive-Almond groves, a traditional dry culture). However, the traditional landscape composition has been decreasing and Continuous and Discontinuous urban fabric increasing due to urbanization and land abandonment. It is a productive landscape of dry-arboriculture (Barbera et al., 2000), managed by dry farming techniques. All that remainsis, at the moment, is attributable to bonds imposed by the Park on this area. For the same reason, we can found in the midst of the Valley, the Kolymbetra Garden (5 hectares); an historic, naturalist and landscape site. An authentic archaeological and agricultural jewel, returned to light after decades of abandonment.

Furthermore, the cultural landscape has been progressively replaced by more profitable uses, such as modern crop fields, new olive groves, orchards or vineyards.

The landscape metric analysis has highlighted the ecomosaic heterogeneity change. Making a comparison between indexes temporal variation is possible to note a number of patches (NP) decrement and on the other hand, a mean patch size (MPS) increase, that means landscape complexity decrease.

Patch density (PD) increases with a greater number of patches within a reference area, increasing mosaic heterogeneity. For example marginal lands ('Pastures', 'Tree-pastures') have increased their PD, on the contrary of other classes as 'Riparian zones' and 'Traditional olive-almond groves'. Whenever the mean patch size increase, mosaic uniformity also increase as the case is of 'Continuous urban fabric' and 'Green urban areas'. In the end, Edge density (ED) takes the shape and the complexity of the patches into account. ED is a measurement of the complexity of the shapes of patches and, expressing the spatial heterogeneity of a landscape mosaic. 'Discontinuous urban fabric' and 'Continuous urban fabric' are classes that much more then other have modified landscape mosaic.

To evaluate the potential improvement, we compared the Riparian zones situation in 1955 with the situation in 2003 (fig 2).

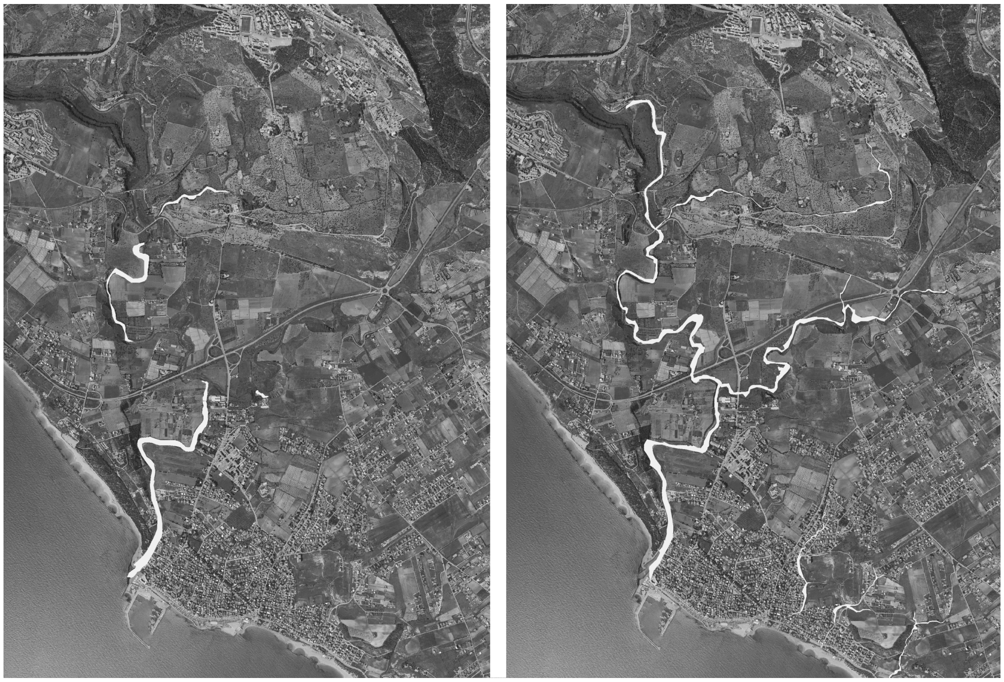

Figure 2. Riparian zones (2003 on the left, 1955 on the right).

The riparian vegetation surfaces, in the space of fifty years, was reduced of 60%. The proposed plan will increase corridor sizes (fig 3), and will help maintain or establish linkages among patches and corridors.

Figure 3. Riparian buffer restoring project

Discussion and conclusion

This study examines industrialization effects that has encouraged the intensification of agriculture in the most productive lands and the abandonment of marginal lands. The urbanizing process is manifested by the enlargement of artificial surfaces. Not only are the rates of urban growth accelerating, but the patterns of urban expansion was become more dispersed. In future, more sustainable approaches must be considered for areas where the agricultural landscape is threatened by urban sprawl and land use change. In this area the rural–urban fringe growth has had a negative impact on ecosystem services (Millennium Ecosystem Assessment, 2003) and on landscape. Although research has examined the land use change and landscape fragmentation, attention has focused on the potential use of riparian buffers and their capacity to improve the connectivity of the rural–urban fringe. After all, there is interest regarding the degree to which the positive changes in the rural landscape, through the employ of buffers, that are able to improve the environmental benefits and aesthetic value and add to character of the rural–urban fringe.

A project planning of a riparian buffer zones could improve and add a lot of ecological functions, without consider all them. The riparian buffer zones can behave as conduits, filters or barriers of energy and species flows in natural, cultural and industrial landscapes. (Mander et al., 2007).

Some of the most important multifunctional elements of the ecological network are riparian biotopes which perform many functions (Lowrance et al., 1997): improve water quality by filtering polluted overland and subsurface flows, reducing the amount of pesticides and fertilizers in the rainfall run-off (Cooper and Gillespie, 2001), from intensively managed adjacent agricultural fields; stabilizes banks of water bodies and reduces erosion, decreasing flood severity; improve the microclimate in adjacent fields and on a broader scale, constitute a carbon sink by sequestering carbon in the soil (Uri et al., 2000); create new habitats, provide food sources, and offering den, and nesting areas that are missing in intensively farmed areas (Naiman et al., 1993); improve connectivity in landscapes due to migration corridors and stepping stones and may also increase the biodiversity of an area (Henry et al., 1999).

From a social aspect, riparian buffer zones may provide important social benefits, they can improve the aesthetic quality of rural–urban fringe and could provide opportunities for recreation by contributing to intangible amenities (Barbera et al., 2003).

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