Ecosemiotics: A new field of competence for ecology to overcome the frontier between environmental complexity and human culture in the Mediterranean

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Abstract

The Mediterranean region shows unique environmental and ecological characters. The observed ecological complexity is the result of a long-lasting and intense co-evolutionary process between human and non-human organisms.

Most of valuable landscapes at present time are under serious threats from agricultural intensification, land abandonment and forestation, urban sprawl and mass tourism. The urgency of conservation clashes against permanent land use conflicts.

Such complexity of human-nature interactions is best represented by the "full and empty" world ecological model. Cultural landscape and niche construction theories belong to this framework. In turn, perception and cognition are central themes in the definition of such paradigms. This leads ecological research into the field of the eco-

semiotics, a new scientific perspective that can provide powerful tools for the study of the Mediterranean ecological complexity, as it addresses the interpretation of signs that human and other evolutionary drivers leave in the environment. Such signs are the expression of mutual interactions that shaped patterns and processes in the region. The eco-field paradigm, derived from the eco-semiotic approach, is a theoretical tool that allows to intercept a portion of such signals to model the relationship between any species and its environment.

Key words: Mediterranean region, eco-complexity, full and empty world, eco-field, eco-semiotics

Introduction

The Mediterranean region is one of the most peculiar places of our planet due to the overlap of historical heritage, long-term human dwelling, strong and fine-grained environmental gradients, species diversity and speciation across the temperate climatic belt (see for a detailed description of the main characters of the Mediterranean region Blondel and Aronson 1999; Grove and Rackham, 2001 and Farina and Naveh 1993, on the perspective for the future of this region). Actually, in the Mediterranean region human-induced processes deeply change structures and functioning of the majority of the natural components (Myers et al. 2000).

We have two ways to interpret human intervention in this region: the first is to consider human activity in terms of persistent negative impacts (always and

everywhere), the second is to distinguish positive and negative interactions of human activity according to the different conditions in which such activities interact with ecosystem dynamics. We believe that the first option can not be reasonably considered in this study while the second perspective finds a strong linkage with the "full and empty" world model (Farina et al. 2002). According to this last model the Mediterranean is the expression of the "full" world concept in which human dwelling is intimately connected with the natural processes by co-evolutionary mechanisms. The "empty" world is a typical "frontier" vision of untouched environment still free from human intervention. But nowadays this world persists only in the more remote parts of the planet like polar zones or deep sea.

The aim of this contribution is to discuss under a broad perspective the peculiar characters of the Mediterranean region and to advance new ideas useful to improve the understanding of how to preserve the ecological functioning of this region and to reduce the risks of an unprecedented environmental crisis. At the same time, another goal is to actively foster the enlargement of knowledge and the enhancement of management efficiency reformulating theories and paradigms like the eco-semiotic perspective that will be discussed at the end of this contribution.

Relevant and peculiar characters of the Mediterranean region

The Mediterranean region is heterogeneous for geological, morphological, and climatic characters, and this heterogeneity is reflected in the biological components that have created a mosaic of vegetation and animal populations as well.

After the last glacial crisis, the Mediterranean has deeply changed type and composition of the biological communities several times and human intervention has been important during this process (Yll et al. 1997).

Mediterranean represents a bridge between Africa, Middle East and Europe, functioning like a social and economic buffer, but it also functions like an ecotone, a tension zone both in anthropological terms, and under a biogeographical perspective. A comparison between the European side and the North-African side shows an evident asymmetry in social organization, welfare distribution, and scientific knowledge.

For long time, the entire region has experienced impressive land manipulations by human populations that were continuously moving (at a historical scale) through the region to self maintain the access to resources. For instance, in the present time human settlements have been reshaped by a short-range migration from mountains and internal regions to lowlands and coastal ranges.

The human development and persistence across the Mediterranean has significantly modified dynamism of many abiotic processes, affecting in turn composition and coalescence in several biological communities (f.i. Plieninger et al. 2004a,b).

Major threats and their dynamics

Intensive agriculture, land abandonment, urbanization, coastal development, and mass tourism associated to energy facilities and transportation infrastructures are the main sources of environmental disturbances and threats across the Mediterranean

landscapes (f.i. see Rundel (1998) for a synthesis and Vos and Stortelder (1992) for a case description located in central Tuscany (Italy)).

Agriculture is shifting from locally climate-adapted crops to generalist and water demanding cultivations. In the arid portions of the Mediterranean deeper ploughings simplify soil structure and composition (f.i. Yaalon 1997) and increase dramatically the occurrence of ephemeral gullies (Vandekerckhove et al. 1998). For instance, the recent development of vineyards has been recognized by Kosmas et al. (1997) as a factor that increases runoff and soil erosion. Agriculture changes in the Mediterranean require new procedures to maintain the character of local sustainability as argued by Tanrivermis (2003).

Especially on Mediterranean mountains, the shift from sheep rearing toward cattle ranching and the more recent complete disappearance of such practices, have deeply modified the structure of the land mosaic as argued by Lasanta-Martinez et al. (2005).

Locally land abandonment decreases the diversity and favours wild fires that recursively increase the homogeneity of areas favouring fire hazards (f.i. Naveh 1974; Giovannini et al. 2001; Badia et al. 2002; Perez et al. 2003). Fires are concentrated in specific areas as discussed by Vasquez and Moreno (2001) and this seems like a "self-organising" process in which fire frequency increases in already burned areas.

Modern forestry based on pine and eucalyptus plantations depresses diversity and increases the risk of wild-fire. In the Mediterranean forests need to be managed to maintain biodiversity for the future (f.i. Zavala and Oria 1995). On the other side the

historical fragmentation of natural forests reduces the complexity of forest bird assemblages (Santos et al. 2002).

Urban cover develops everywhere along the coasts and also in valuable natural parts. Infrastructures like ports and highways are permanently modifying the shape and functioning of the landscapes; and wind farms along mountain ridges are the last generation of environmental mortgage.

Urbanisation has received a great impulse by tourism attractiveness with an increase of urban settlements like, for instance, along the Turkish coast in which the growth has been of 62% after 2000 (Burak et al. 2004). In fact, mass tourism from a valuable resource is becoming a serious problem in terms of cultural and habitat destruction, especially in the more remote areas of the Mediterranean where the land heritage is better conserved (Bougeant 2002), although appreciable attempts for maintaining a multiple use of land are present (see f.i. Makhzoumi 1997). The economic value of the environment, composed by materials, services, and functions may be considered as the totality of all the ecosystems services (Freeman 1993). An increase in the use of land and water is associated to the urban sprawl, and both resources are of limited availability across the Mediterranean. In particular water demand is a major concern along the Mediterranean coasts extensively transformed into metropolitan areas to meet the mass tourism demand. Plans of effluent reuse introduced as recommendations have been turned into forced choices (f.i. Tselentis and Alexopoulou 1996 for the Athens metropolitan area).

Tourism in Mediterranean needs an increase in social sustainability, that means increased interactions between foreign tour operators, hotel managers and local people (Godfrey 1995; Alipour 1996).

Political instability, especially in the Balkans and in Eastern Mediterranean has created sudden changes in tourism preferences with an unpredictable shift of large masses of tourists from one region to another (f.i. Clements and Georgiou 1998).

Conservation challenges and conflicts in the Mediterranean

A multitude of related drivers act as main constraints in the ecological and socio-economical dynamics. Human niche strongly interacts with several other niches. A great part of principles developed in the framework of nature conservation are the result of observations and experimentations carried out in temperate and tropical biomes, and most parks and natural areas are conceived to exclude human intervention (see f.i. Sayer and Campbell 2004).

The natural history of the Mediterranean is greatly different from the common belief that we have of the relationships between people and ecosystemic processes. There are several examples in which it is the human intrusion and the related transformation of the land that allows the presence of some peculiar species (Farina 1995). For instance in Alantejo (southern Portugal) the survivorship of Great and Lesser Bustards (*Otis tarda, O. tetrax*) largely depends on non-irrigated agriculture. In Spain the over-wintering success of common cranes (*Grus grus*) in dehesa, largely depends on the number of livestock that compete for *Quercus ilex* acorn as argued by Diaz et al. (1996). Distribution and abundance of many waterfowl

species are also related to the fishing coastal ponds actively managed and continuously re-shaped by people but with negative effects on the distribution of vegetation and on water quality (Boldreghini and Santolini 1997).

In Israel Kaplan (1994) recognises that the impact of mountain gazelles *(Gazella gazella*) on green crops represents a problem, but the necessary fences increase the fragmentation of such population. The management of large and medium size mammals (f.i. roe deer, bear, wolf, otter, etc.) poses serious challenges to the maintenance of viable populations. This is the case of Iberian lynx *(Lynx pardinus*), one of the most rare mammal of southern Europe at risk of extinction by the habitat insulation and fragmentation (f.i. Rodriguez and Delibes 2003).

Pond landscape dynamic is very important to amphibian ecology (Boothby et al. 1996), and protecting ephemeral processes like temporal ponds seems an important strategy to preserve biodiversity. In fact permanent ponds are not the key to assure amphibian recruitment, in the Mediterranean it is temporal ponds with a different hydroperiods that allow amphibians escaping the predator pressure thanks to the unpredictability of their spatial distribution (Beja and Alcazar 2003). But the principles that we have just presented are not applicable to all the organisms and the maintenance of the biodiversity for some groups of species largely depends on the permanence of specific suitable habitats. It is the case discussed by Brotons et al. (2005) on the steppe of Crau (Provence, France). The presence of larks in this restricted habitat largely depends by the surrounding context. Improved pasturelands enhance the lark diversity in the area, but non-herbaceous habitat in the vicinity of the steppe habitat reduces the attractiveness of the steppe habitat.

Changing the ecological paradigms

Comparative studies of different Mediterranean climate regions (Central Chile, South-Western Australia, Central California, South Africa Cape Region, Mediterranean Basin) emphasise evolutive affinities of plants in terms of adaptive mechanisms (f.i. Deacon 1983). The unicity of human history in these regions has had a strong impact on the land mosaic ontogenesis and on population dynamics. As argued by Blondel and Aronson (1999) "the exceptional richness of annual, or even ephemeral plant species in the Mediterranean flora is also to a large extent the result of long-standing human activities". Plants show an evident adaptation to ploughing, fire-setting, clear-cutting, heavy browsing and grazing by domestic livestock.

It seems that many centuries of uninterrupted human occupation of the Mediterranean has not produced catastrophic consequences on the natural systems, but a deep and continuous turnover in biodiversity composition and ecosystem functioning at local scale. It is evident that Mediterranean region so deeply shaped by human intervention is better described according to a landscape perspective than using an ecosystemic approach. The mosaic-like landscape is dominated by gradients and surfaces of discontinuities and the effects of such configurations are very important for several processes. Interfaces are part of our perception and their aesthetic must enter into the necessary consideration (Lynch 1976).

Since the middle of 1980s the concept of cultural landscape is used to describe environmental patterns produced by the result of the interactions between human culture and all other natural processes (Van Droste et al. 1995). Moreover, as well described by Naveh (1998) the cultural landscape is the result of solar powered activity. On the contrary the fossil oil powered landscape represents exactly the opposite result in resource utilisation. The concept of cultural landscape can be

applied to every agricultural landscape maintained in a"traditional" way, although often it is impossible to establish a coherent classification (Farina 2000).

What theories can be grounded in the Mediterranean? Proposals and suggestions

Despite the unicity of Mediterranean natural and socio-economical history, very few attempts have been made to arrange the results of ecological research into the framework of the large-scale ecology (Blondel and Aronson 1999; Grove and Rackham 2001).

The Mediterranean system is a fine-grained cosmo in which several highly differentiated processes occur close to each other and contemporarily in complete independence and self-organisation.

The complexity of the Mediterranean region represents on the one hand a true barrier to the ecological ecosystemic studies for the lack of great extensions of homogeneous natural environment (lack of typicity over large areas) and on the other hand, an extraordinary laboratory to investigate processes and to experiment new ideas and theories.

In the Mediterranean the process of the human niche construction sensu Odling-Smee et al. (2003) is evident. These authors declare that the niche construction occurs when "an organism modifies the feature-factor relationship between itself and its environment by actively changing one or more of the factors in its environment, either by physically perturbing factors at its current location in space and time, or by relocating to a different space-time address, thereby exposing itself to different

factors". This paradigm is perfectly applicable to the description the processes that occur between humans and Mediterranean features and it is coherent with the "full world" model (see Farina et al. 2002). The Mediterranean ecosystems and landscapes have been deeply modified by human intervention and represent the product of the human niche construction process. It seems reasonable to consider the concept of niche construction very close to the Naveh's idea of the "Total human ecosystem" (Naveh 2000), but also in line with the idea presented by Kalevi Kull (1998) in which the relationship between nature and people is mediated by culture and a "second nature" is the product of this first relationship.

Mediterranean ecology urgently requires new ways to investigate, to document and to transfer into the practice a plethora of processes that result from natural and human driven processes (see also the comments of Yov-Tov 2001).

To support our reasoning we suggest that ecological research in every man-dominated landscapes should take into consideration the Complexity Theory (f.i. Lewin 1992; Merry 1995; Cilliers 1998; Levin 1999; Bossomaier and Green 2000; Manson 2001; Taylor 2001).

For instance the following points make the Complexity Theory fit the Mediterranean characters:

. A plethora of different conditions.

. The strict relationships between contiguous parts.

. The local effects that expand the unicity of phenomena across scales as recently argued by Farina (2005a,b).

Under the Complexity Theory perception and cognition approaches, usually restricted to human domain, should be enlarged to many other organisms and processes. Perception and cognition approaches are a constellation of principles that address the different perception by which humans interact with the environment and more specifically with the landscape. These approaches can be applied to every condition which humans experience but it seems particularly useful to describe natural and man-made values of Mediterranean.

Prospect and refuge (Appleton 1975), affordance (Gibson 1979), and aesthetic (Bourassa 1990, 1991) are some of the principles that can be used to face the Mediterranean complexity.

In particular, the recent eco-field hypothesis (Farina and Belgrano 2004, 2005) seems a very efficient approach to describe the relationships between organisms and the Mediterranean landscape.

The eco-field hypothesis argues that for every function an organism (animal, human) needs to perform a specific spatial configuration of the interacting context is requested. For instance the foraging eco-field of a fox is the spatial configuration required to locate preys. As previously shown some birds need specific natural habitats, but also the surroundings of such habitat can increase or decrease their abundance. This is an example of reproductive and foraging eco-fields (f.i. Broton et al. 2005).

If for every function a spatial configuration of objects (f.i. trees, shrubs, or houses) is necessary, the landscape can be seen as the totality of all the eco-fields of the entire organism collection. This simple idea opens up the road to new argumentation about the ecological complexity as the result of several eco-fields overlappings.

The eco-field based on the cognitive processes and cognitive ecology, sensu Allen and Bekoff (1997) can be successfully applied into the Mediterranean landscape (Farina et al. 2005).

Often the complexity of Mediterranean landscapes has been approached according to an ecosystemic perspective or a historical vision that maintained ecology, economy, culture, perception and cognition separate. It is time to reconcile these different visions in a unique paradigm. The niche construction hypothesis coupled with the perception theories can be blended together by the eco-field hypothesis.

For instance the anthropological analysis of the settlements in Mediterranean can be explained in terms of the safety eco-field for the hilly villages, religious eco-field for the mountain church and abbey, therapeutic eco-field for the coastal second houses and camp-ground facilities, etc.

According to this vision it is possible to describe the history of the human Mediterranean landscape in terms of accomplishment of different functions, ranked in terms of priorities along the different periods of history. When the Roman Empire assured safety conditions to the populations, a great expansion of agriculture in lowland was achieved and the centuriation design was applied every where in agriculture (Caravello and Giacomin 1993).

The eco-field hypothesis applied to animal populations finds a very useful application in conservation ecology. The maintenance of endangered species like the Iberian lynx is an example. This species requires extensive ranges to perform mating or territorial defence functions. These functions in turn require spatial configurations of the landscape that are difficult to be preserved under the present human pressure. For instance, an unprecedented spread of man-made barriers reduce connectivity between sub-populations preventing the explorative behaviour of such

large organisms. The survivorship of the lynx is not a simple matter of prey biomass availability (f.i. see the allometric constraints by Carbone and Gittleman 2002), but is the result of the low score of different eco-fields that become rare in the Iberian region.

Conservation policies often focus only on direct threats to individuals, and sometimes fail to address fundamental functional needs. For instance, agri-environmental schemes in the Netherlands included the delay of mowing time as a measure of prevention of nest destruction for ground nesting birds. An increase in bird diversity and abundance was expected in the areas where the measure was taken up. Kleijn et al. (2001) showed that this led to an "ecological trap" for some species: food availability may be the cue that these bird species use to locate suitable areas for nesting, and as in unmowed fields food is less available, they tend to nest in the fields not subject to the measure, despite their breeding success being lower.

In this vision, although landscape is the result of the stratification of several eco-fields, negative interaction between these eco-fields commonly occurs and often it results in the local extinction of some species or the non accomplishment of some functions. For instance in industrial district amenity and naturalness are rare or are not sufficient to guarantee such recreational service to people. But industrial districts assure job opportunities and economic welfare. The increase of one function can depress others in a continuous dynamic that often forces to geographical displacement.

Using this perspective it is possible to trace a balance of human eco-fields and to introduce new ways to evaluate our surroundings. Often the eco-field's trade-off is the final result of such complex processes.

Every organism searches for spatial configurations that are carriers of meaning according to the selected function, but in this process the organism modifies its surroundings opening the door to a new configuration (the niche construction principle of Odling-Smee et al. (2003) which assumes a character of the complexity, especially for the uncertainty by which an event appears without a specific project. For instance a pasture, highly grazed by domestic livestock, facilitates the expansion of ruderal and thorny plants depressing the diversity of other native grasslands. The overgrazing is a derivative effect of economic strategy of the shepherds and not a spontaneous behaviour of the grazers.

The eco-semiotic, a new science to develop the Mediterranean ecology

Often scientific papers on conservation offer detailed agendas of the things that decisions makers, stakeholders, and common people have to do in order to improve the environmental context. For instance reasonable recommendations are:

.Mimicking the solar powered development by reducing the fossil or atomic energy.

.Including the perception values into the economic evaluation, or better filling the gap between economic development and ecosystem dynamics, re-evaluating the ecosystem services.

.Reshaping urban development investing in the natural capital.

.Increase size and conservation procedures of marine protected areas (f.i. Juanes 2001).

Such type of "prescription" gives for granted that scientists are able to know enough about the ecological patterns and related processes. The aim of this conclusive part has a different target. Recommendations and suggestions, in our case, are directed to the scientists in order to elicit reactions and opening a debate about type, quality and efficiency of the present ecological sciences to be proactive, anticipatory of the unexpected future environmental crises and to plan adequate remedies. This perennial debate of local versus global crises and temporary versus permanent environmental changes is our principal argumentation.

In the Mediterranean context nature and humanity have created a complex system. Traditional ecology, which usually distinguishes sharply human and natural processes, physical and perceptive cues, genetic and "cultural" memory, can not serve, as such, as a guide in the investigation of strongly multidisciplinary issues. So the Mediterranean complexity represents a constant memento of the need for a new ecological scientific approach. The difficulties to overcome such dualism is evident and at every step the distinction between human and natural attributes appears necessary accordingly. The role of culture on the environmental dynamics appears controversial. Another type of evident dualism emerges between patterns (shape, dimension, surfaces) and processes. This difficulty has been partially removed by landscape ecology, which adopts new paradigms and explores the effects of such patterns on the functioning of the systems (f.i. Naveh and Lieberman 1984; Turner 1989). If the goal of ecology is to study the relation between organisms and their environment the complexity that the *Homo sapiens sapiens* has introduced into the system has been judged in most of the cases as laying outside the competency of

ecology. In fact, as critically argued by O'Neill and Kahn (2000), usually the man is not considered by ecologists a "keystone species" but an external source of disturbance in the natural ecosystems.

To remediate these gaps and to assign a stronger role to the ecological science we believe that the competency of ecology should be expanded toward the biosemiotics, the world of the signs. Biosemiotics is recognized as the discipline that, moving from the traditional semiotics, is exploring the communication between every level of biological organisation (Hoffmeyer 1997; Kull 2005). Recently Noth (1998) has discussed the possibility to distinguish inside the biosemiotic paradigm the eco-semiotic like the study of the semiotic interrelations between organisms and their environment, although Kull (1998) has criticized this vision reducing the eco-semiotic to the relationship between nature and culture. In this case the centre of our attention, argued Noth, is not *Homo semioticus* but an "*Organismus semioticus"*. Krampen (1992) uses the term of phytosemiotics to describe the way plants communicate with each other and with the environment. If scientifically interpreted in the right way, this is another special case of eco-semiotics. This is not the occasion to enter into details about such debate but to move a step onward and to improve the field of action of the eco-semiotic.

Signs, according to Peirce vision (Peirce 1980) are the product of acoustic (sound), chemical (pheromones), visual (shape and colour) and cognitive (behaviour, culture) signals transformed into a meaning by cognitive processes.

Signs and their semiosis can be considered a universal currency in our world and this immediately deletes the dualism between man and nature. Signs come from any biological forms, sign use appears in primitive organisms like bacteria as well as in evolute species. Signs are produced not only by individuals (f.i. language, display)

but also by intra (f.i density) and inter (f.i. diversity) specific aggregations, land mosaics (f.i. heterogeneity, contagion) and ecosystems (f.i. mutual information).

The eco-field hypothesis is a special case of eco-semiotics based on the spatial arrangement of objects which are carriers of meaning when a specific (vital) function has been activated. In this case the signs are based on a spatial configuration of the objects (like trees, shrubs, or other organisms) that is recognized as carrier of meaning for a specific function. In this process a cognitive template (the "search image" in ethology) is mentally compared with the surrounding context, until an overlap occurs.

We justify this innovative approach in order to understand the relationships between different evolutionary drivers and related constraints that span from virus to *Homo sapiens sapiens.* The common currency of the sign and the theory that describes the rules by which signals are transformed in signs can solve the puzzle of the swift and the church. Common swifts (*Apus apus)* are migratory hole-nesting birds that use human buildings during the reproductive period (June-August). Men and swifts have a quite different perception of a church (!), from a holy site to a nesting site. It is out of doubt that the process that has produced the placement of the church in a specific area is completely independent from the swift decision to breed there, nevertheless religious drivers and reproductive drivers in two so different species have a common point: the church.

The Mediterranean is plenty of examples like this. From olive orchard to chestnut orchard that are adopted like forests by some birds, to hemp tank used by

amphibians to breeding in Spring time, or the lamp pole used by cranes to pose the nest at the crossing of the metal harms.

A world in which human signs are mixed with natural signs is creating the observed complexity and the "eco-diversity" resilience of the Mediterranean region.

Conclusions

The Mediterranean basin is a puzzle of nature and culture strictly set in one other. Modern life style demanding so much more resources represents an unprecedented challenge to the maintenance of such mosaic. The urgency to change human behaviour to reduce this negative impact is evident. Conflicts and competition between the different drivers operating in this scenario reduce the efficiency of conservation practices and poses new challenges to human use of resources in the region. Ecology has demonstrated limits to solve such problems and new paradigms are requested. The elimination of the duality between nature and humanity seems a necessary step. To overpass this threshold we are strongly encouraging to explore the complexity of the Mediterranean region by using an eco-semiotic approach. This approach consists into the extension of the principles of bio-semiotic to the relationships between organisms and the supporting environment. The study of signs, their ontogenesis and signification could assure the maintenance and functionality of the Mediterranean complexity. For instance, ecology and conservation biology are focusing on species, populations and communities. Eco-semiotic deals with diversity of signs and their inventory could be an innovative way to describe the diversity expanding the potentiality of the Mediterranean basin not

only to the biological subjects (plants, animals, etc.) but also to the configuration of non living subjects like cliffs or beaches and their dimensions according a species-specific calibre. Signs in this approach represent the vehicle by which life evolves and grows in complexity, and information (*sensu* Stonier 1990,1996) and cognition can be used as basis to formulate effective metrics.

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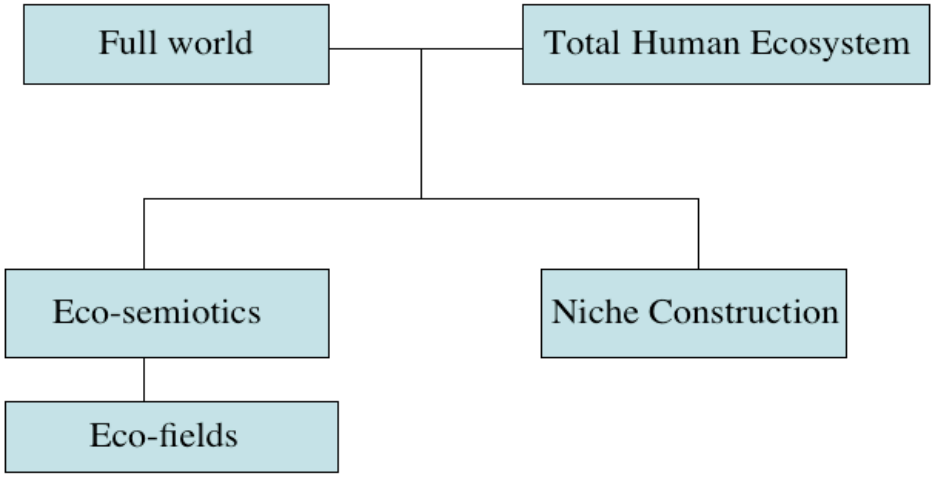
Fig.1 - Relationships between the basic concepts used to reduce the dualism man-nature in the Mediterranean context. The "Full World" model (Farina et al. 2002) is considered largely overlapping with the "Total Human Ecosystem" vision of Naveh paradigm (Naveh 2000). The left side of the branch describes the cognitive approach in which signs are the common currency. In the right side "Niche Construction Theory" explains deterministically the ecological dynamics.


Full world
Total Human Ecosystem
Eco-semiotics
Niche Construction
Eco-fields