URBAN PRESSURE AND PLANNING MANAGEMENT FOR ITALIAN COASTAL AREAS

Riassunto - La piastra costiera italiana è un'area geografica sede di notevoli contraddizioni: negli ultimi 50 anni le attrezzature e le infrastrutture hanno quasi interamente sostituito gli ambienti originari, lasciando relativamente integro meno del 10% del perimetro peninsulare, ma nonostante ciò è ancor oggi diffusamente riscontrabile una ricchezza di valori ambientali ed ecologici che giustificano più di 100 parchi e riserve, e oltre 200 siti Natura 2000 per una dotazione complessiva che supera i 500.000 ettari. Si tratta di una area altamente attrattiva per il turismo, l'industria e la residenza permanente grazie alle favorevoli condizioni morfologiche e dei trasporti. E' ancora oggi soggetta a forti pressioni trasformative che minacciano le risorse ambientali residuali. Utilizzando un set di indicatori di pressione e di pregio il presente lavoro ha classificato le condizioni ambientali attuali e i margini di recupero e di conservazione.

Abstract *– Italian peninsular coastal areas including over 500,000 ha of protected areas, and interest all coastal regions and urban development registered over the past half century has caused important consequences on ecosystems. This geographical area is highly attractive for tourism and for permanent residence, thanks to the good conditions of mobility and transport. Many proposals for productive interventions still have the land as preferential localization and, in many cases, the presence of natural values, is neglected. A goal of this work is to highlight the conditions of presence of high pressures and high transformative environmental values. It will be particularly used comparing indicators to highlight conflicts between the phenomena of urbanization and protection, obtaining a classification of models for the settlement and residual values.*

Introduction

The research described in the article involved the coastline of the Italian peninsula, excluding the two large islands of Sicily and Sardinia. The purpose was to highlight the elements involved in the phenomenon of urban conversion of land, the presence of natural lands, and institutional policies for environmental protection.

Indeed, the geographic area studied is the site of striking contradictions: over the past 50 years, man-made development has led to the near total replacement of the original coastal environments. Currently, less than 10% of the peninsular perimeter is relatively intact and free of construction. It is estimated that the transformation of the coastline through building and urbanization has occurred at a rate of 10 km per year since the end of World War II (Romano and Zullo, 2014; Zullo *et al*, 2015; Tagliapietra *et al*, 2014). Despite this, today the peninsular coastline is still rich with environmental and ecological value, with more

than 100 parks and reserves and more than 200 Natura 2000 sites, covering more than 500,000 hectares.

Multiple studies attest to the importance of coastal environments, even if besieged by intensely constructed areas, infrastructure, and continual threats of further degradation (Acosta *et al*, 2003; Carboni *et al*., 2009; Sargolini, 2010; Buffa *et al*, 2012; Ercole *et al*, 2014; ISPRA, 2015). Indications of these phenomena, then, are decidedly numerous, considering the other Mediterranean coasts as well (Le Houérou, 1990; Saliba, 1990; Hill *et al*, 1995; Esbah *et al*, 2010; Vimal *et al*., 2012; Salvati *et al*., 2012; Cigdem *et al*, 2013; Finkl *et al*, 2015).

The Italian continental Mediterranean coast extends for 3,970 km and is made up of three distinct geographic sectors: Adriatic 1,470 km (37%), Tyrrhenian 1,760 (44%), Ionic 740 (19%). These sectors are very geomorphologically diverse, with development that has also heavily influenced by the economic differences between the relevant regions. In particular, the Adriatic and Tyrrhenian sectors include all national latitudinal development from north to south. This coastline includes northern regions that have been heavily industrialized for some time, such as Liguria, Tuscany, Veneto, and Emilia Romagna, and southern regions that are chronically slower economies, such as Campania and Calabria. The Ionic sector, on the other hand, is completely contained within the south, and includes only Puglia, Basilicata, and Calabria.

The research carried out has highlighted the urban/environmental contradictions using five municipality-based statistical indicators. The methodology has illustrated in point 2 below, providing indications on the data and techniques applied as well. Point 3 shows the results and identifies the models for territorial organization. Also presented are some proposals for management policies for various cases corresponding to the resulting models, to try to curb the processes of irreversible alteration of Italian coastal ecosystems.

Study area

The study area was identified as a 1 km strip of coastal perimeter, divided by municipality, obtaining 430 statistical sections. From a sampling of the entire coastal development, it could be seen that the 1 km strip intercepts most of the development phenomena most directly influenced by the presence of the coast (tourism and trade) and the adjacent transportation infrastructure (streets, railways, and highways), with a reduced flow of other economic dynamics more closely associated with inland areas.

Due to the geomorphological characteristics of the peninsula near the coasts, the nation's major transportation infrastructures (highways, streets, and railways) and many of the largest cities (Rome, Naples, Genoa, Bari, Venice) are concentrated there. In the strip under study, the density of urbanization has doubled from the 1950s to 2000, rising from 10% to 21% (from just under 30,000 to the current 61,500). Most of the facilities for beach tourism and vacation homes are concentrated within the study area, and are a very consistent part of the country's building heritage. Therefore, it is a very important geographical district, both demographically and economically, and has always been subject to strong development pressure. This pressure reached its height between the 1960s and the 1980s, but even today continues with significant momentum.

However, the research data was processed for only 285 out of the 430 total sections, as the Basilicata and Calabria regions are not yet equipped with post-2000 digital land use cartography as the other Italian regions are. Therefore, the sectors analyzed involved only 11 regions, with the following coastal lengths: Adriatic - all (1470 km), Tyrrhenian - Liguria/Tuscany/Lazio/ Campania (1460 km out of 1760 km), and Ionic - none, as the coast is located completely within Basilicata and Calabria. The total area studied therefore covers approximately 2,930 km^2, or 74% of the entire developed coastline. For this reason, even given the absence of the Ionic and southern portion of the Tyrrhenian coastlines, the results can be considered statistically significant.

Data and methods

As previously noted, the study was conducted using digital land use maps from the Italian regions, available with varying updates from 2000 to 2008, except for Basilicata and Calabria. The CORINE Land Cover datasets were not used, as they are known to have little dimensional reliability for Italy with respect to the measurements of urbanized areas. Other countries with more compact urbanization can effectively make use of this EU-managed remote sensing using nominal scales of 1:100,000 (Thomson *et al*, 2007). But this is not possible for Italy due to the extremely small sizes of some urban centers, which are not detectable by a satellite reading with a minimum mappable unit of 25 hectares and a minimum width of 100 meter polygons. Out of the 16 regions tested, the accuracy of satellite detection was 60% less on average than detailed scale photographic detection, at some points more than 80% when developed centers are very small, at the level of the individual residential building set in an agricultural context. Five indicators were identified (Fig. 1) to measure territorial density, where the denominator of the expression is always the surface of the relevant municipal section (S_m). The first of these (I_{URB}) is urban density and it is connected to development pressure. There are two indices for the types of environmental protection (I_{PA} = density of protected areas and I_{SCIS}= density of Natura 2000 sites - Sites of EU interest). The final two indices refer to the ecological quality of topsoils (I_{FOR}= density of forestation and I_{EVL}= density of other lands of ecological value).

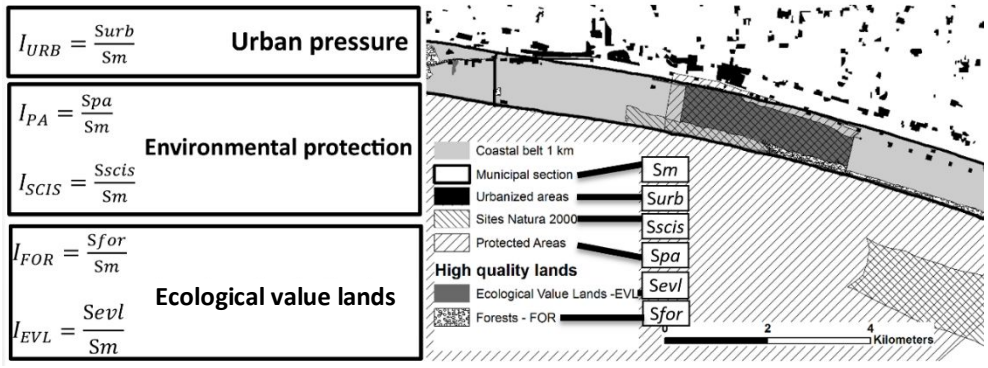


Figure 1 - Detail of the study area and formulation of indicators used

Development pressure could have also used other indicators, such as demographic load, but the forms in which municipal data is available in Italy do not make it possible to extract the resident population in randomly chosen geographic sections (such as the coastal strip or urbanized areas).

Some clarifications are warranted for the I_{FOR} and I_{EVL} indices and the definitions of forest lands and lands of ecological value. The land use categories of the various regional land use maps (LUM), though with a certain variability, can be tracked to the Corine Land Cover (CLC) land coverage classes.

Table 1 - Conformity between the CLC and regional CUS categories on the allocation of FOR and EVL classes

CLC			FOR CUS	REGIONS												
II/III	IV	V		Friuli	Veneto	Emilia Romagna	Marche	Abruzzo	Molise	Puglia	Basilicata	Calabria	Campania	Lazio	Tuscany	Liguria
			Forests				x									
			Broad-leaved forest	x						x			x	x	x	
	3111		Broad-leaved forest with continuous canopy						x							
	3113		Broad-leaved forest with discontinuous canopy						x							
			Deciduous forest					x								
	3111		Xerophilous forest		x											x
	3112		Thermophile mixed woods		x											x
	3113		Mesophile mixed woods		x											x
	3115		Beechwood			x										
311			Hornbeam oak and chestnut			x										
			Willows and poplars			x										
			Plains woods with oaks and ash trees			x										
	3115		Wood with chestnut			x										x
			Chestnut			x										
			Riparian vegetation					x								
	3117		Hygrophilous woodlands													x
			Recent reforestation			x										
			Riparian forests											x		
			Coniferous forest	x	x	x		x		x			x	x	x	x
312	3121		Coniferous forest with continuous canopy						x							
	3123		Coniferous forest with discontinuous canopy						x							
			Mixed forest	x	x	x		x		x			x	x	x	x
313			Unclassifiable area mostly wooded				x									
			Bushy woods						x							
			EVL CUS													
321			Natural grasslands	x				x		x			x	x		x
322			Moors and heathland	x				x							x	x
						x				x			x	x		
		32211			x											
323			Sclerophyllous vegetation							x			x	x		x
324			Transitional woodland-shrub	x											x	x
							x									
										x				x		
			River wetlands		x											
			Willow and brackish water		x											
331			Beaches, dunes, sands		x	x		x		x			x	x	x	x
							x		x							
									x							
			Natural grasslands with trees and shrubs		x											
			"Valli da pesca"		x											
			Shrubby riparian vegetation											x		
	3312		Dunes		x											
			Riparian vegetation						x							
			Riverbeds and streams with abundant vegetation			x										x
			Riverbeds and streams with limited vegetation			x										x
(333)			Gullies			x										
			Meadows and high-altitude moors			x										
332			Bare rocks			x				x			x			x
							x									
333			Sparsely vegetated areas													x
41			Inland wetlands			x										
411			Inland marshes							x				x	x	
412			Peat bogs			x										
			Uncultivated land				x									
			Natural grasslands						x							
			Grasslands with tree and shrubs						x							
	4112		Fresh water marshes with reeds (river wetlands)		x											
	4124		Fresh water marshes with reeds (coastal wetlands)		x											
42			Maritime wetlands										x			
421			Salt marshes		x					x				x	x	
(421)			Salt marshes			x										
423			Intertidal flats							x					x	
	4231		Lagoon marshes		x											
	5111		Rivers							x				x		
521			Coastal lagoons	x											x	
522			Estuaries					x	x	x					x	x

The overall entries have been reorganized over the years, where possible, according to CLC directives, implementing levels IV and V in the best cases, and maintaining level III in other cases. Some regions have instead adopted their own classification. In the context of the Image & Corine Land Cover 2000 (I&CLC2000) project in Italy (Maricchiolo et al, 2004), it was decided to implement a level IV thematic search of the CLC2000 database for a more detailed mapping of the land use/coverage classes considered to be of greatest interest for the inventory and management of forest and semi-natural resources (Bologna et al, 2004).

The model used in this study required the inclusion of various land use categories into one of the two classes: FOR (Forest Areas) and EVL (Ecological Value Lands). For this purpose, the LUM categories referring (explicitly or not) to the CLC level III indicated in Table 1 were selected from the regional legends.

Categories 3 and 4 represent predominantly natural or semi-natural lands, where human manipulation has been very limited, or in any case does not alter the high environmental quality. FOR includes all the forest categories, while EVL includes all the various natural categories of the first (Table 1).

Results

The diagrams in Figure 2 and 3 show, along the two Adriatic and Tyrrhenian coastlines, the pattern of average values for the indicators used, expressed using trend lines. The municipal statistics sections are in both cases geographically ordered from north to south. As explained previously, the Adriatic coast is complete, while the Tyrrhenian lacks data for the Basilicata and Calabria regions.

In both cases, we see a notable oscillation of values, but the aspect that appears to be common to the two geographical areas is the substantial dominance of urbanization, which can clearly be seen nearly everywhere. However, in assessing the relative weights of the indicators, there are important differences along the two coastlines.

Along the Adriatic there emerges a notable limitation of the forest component (with I_{FOR} always less than 10% on average) and a decided impoverishment of all environmental characteristics of the territory in the geographical sector that runs from the center-north Emilia-Romagna through all of Marche and ends in central Abruzzo. In this part of the coast, there is extremely high geographical selectivity of land, with average densities of up to 60% for construction and infrastructure, which have largely replaced any other topsoil of ecological value (with a density of not more than 10%). The remaining 30% of land is made of up agricultural areas. Where the coast presents morphological and environmental characteristics other than sandy expanses (swamps and lagoons, headlands, rocky slopes), the values of the other indicators overtake those of the urbanized indicators (I_{URB} <= 30%) and we see attention given to protection, expressed by the presence of Natura 2000 protected areas and sites which also center on values of 30%. This is the phenomenon produced, with rather different levels, in the north Adriatic area (Friuli V.G., Veneto, and north Emilia Romagna regions) and to the south of Abruzzo up to Puglia, accentuated at the height of the Gargano headlands. It is precisely in this last sector that the action of the protection policies stabilizes, with I_{AP} and I_{SCIS} values between 20% and 30%; we also see a significant remainder of lands of ecological value around 20%, which for the I_{EVL} represents, in any case, the maximum length along the coastline. It should be noted that the I_{PA} values are always rather

close to the I_{SCIS} and I_{EVL} values, testifying to a close adherence between perimeters protected by parks and perimeters of the territories occupied by habitat and natural resources.

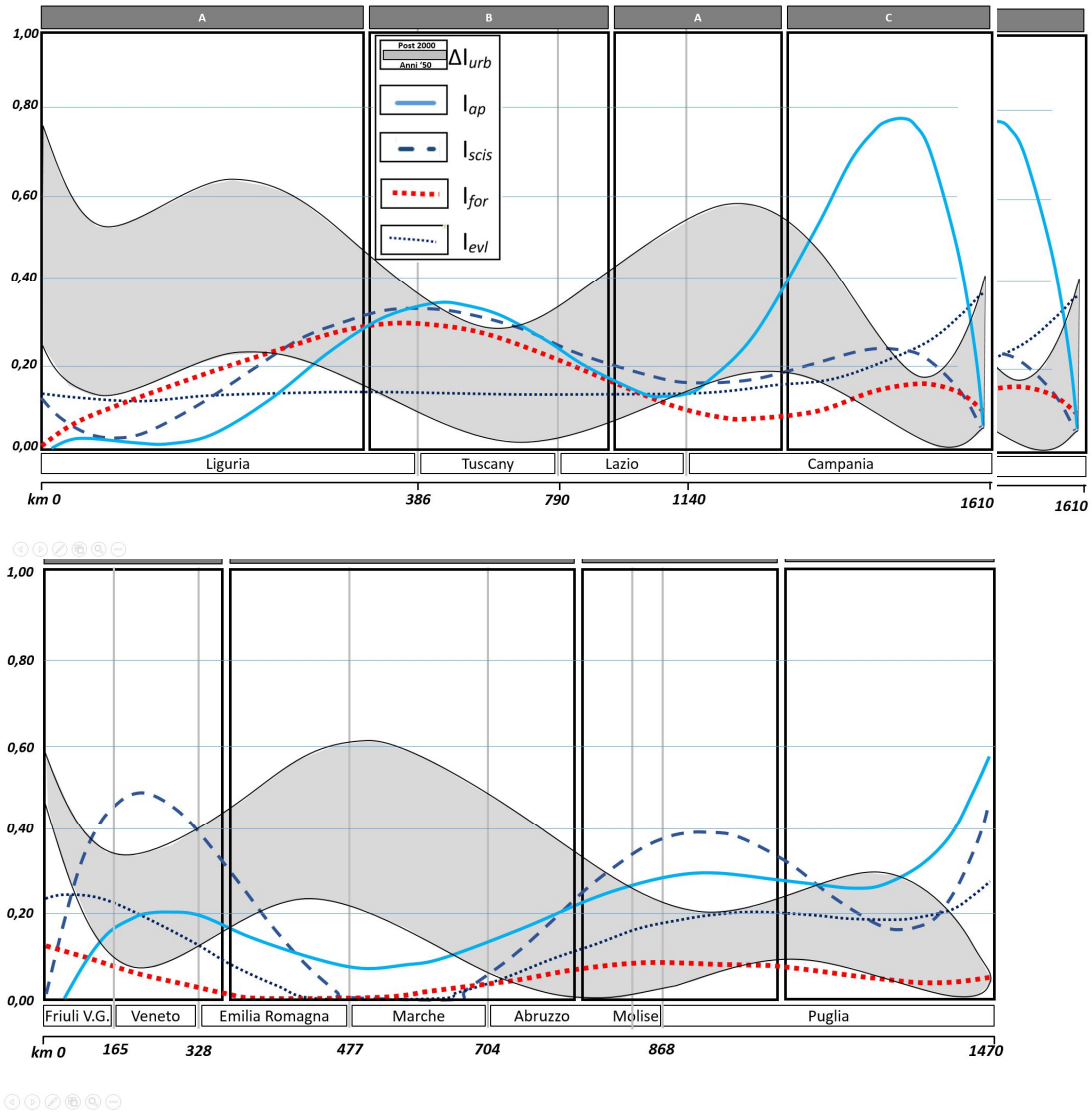


Figure 2 - Values of indicators along the Tyrrhenian (above) and Adriatic coastlines (below)

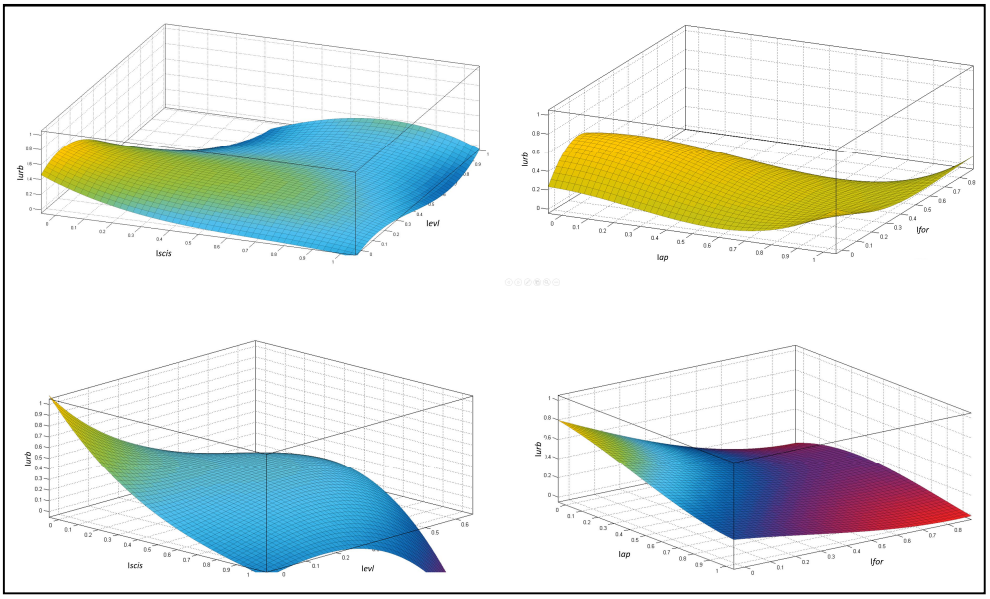


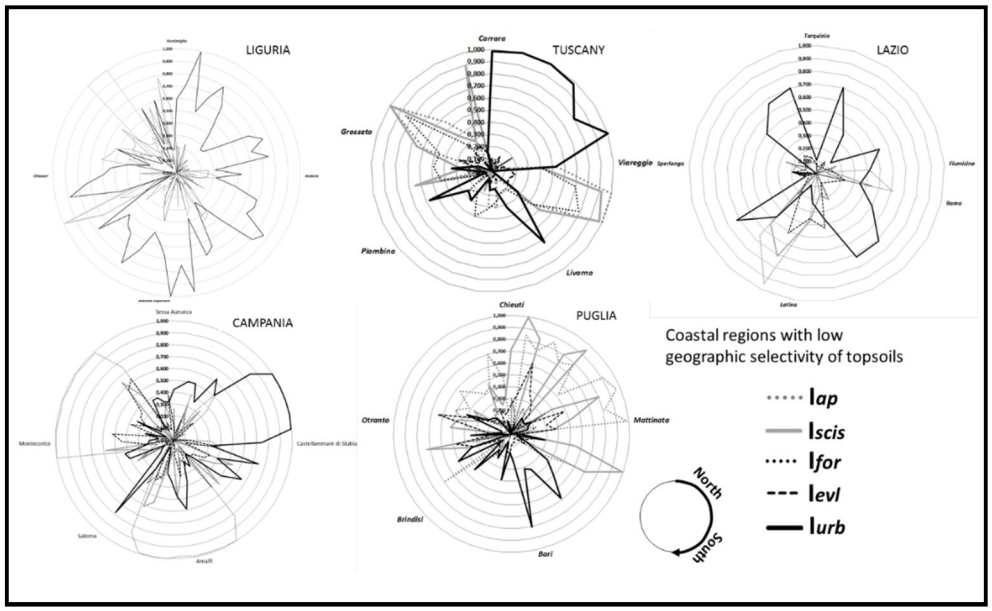
Figure 3 – Correlations I_{URB} - I_{SCIS} - I_{EVL} and I_{URB} - I_{PA} - I_{FOR} along the Adriatic (above) and Tyrrhenian (below) line

The maximum I_{EVL} value is always lower than 20% on average, a characteristic that is also found along the Tyrrhenian coast, although in this case the total situation is clearly better for the forest areas (I_{FOR} always varying between 10% and 30%). The very densely urbanized Tyrrhenian coastal sectors, however, are extremely extensive, with average I_{URB} values oscillating between 50% and 60%. This happens along nearly all the Ligurian coast and between center-south Lazio and center-north Campania. All of Tuscany and the areas where it borders with Liguria and Lazio present a very special condition: all the indicators, with the exception of I_{EVL}, center on the same value of 30%. This indicates a section of the territory where the urbanized parts are distributed in a rather significant environmental mosaic (low geographical selectivity of land), always with a high correspondence between the dimensions of the protected areas and the areas of ecological-habitat value.

This last correspondence is decidedly skewed, however, on the center-south Campania coast, where the presence of two large national parks (Pollino and Cilento-Vallo di Diano) bring the I_{PA} values over 70%. However, these protected areas clearly include many territories of largely cultural/scenic rather than ecological/natural importance, given that the I_{FOR}, I_{SCIS} and I_{EVL} values are only around 20%. This is a well-known phenomenon for these two protected areas, whose dimensions approach and exceed 200,000 hectares, and whose perimeters enclose many landscapes of monumental, historical, and cultural/rural value.

Figure 4 expresses the considerations just presented at the scale of the individual regions. The diagrams of geographical selectivity reveal the dominance of some characteristics or the strong co-mingling of others: the Puglia coast is a special case, where the artificial parts of the territory are strongly mixed with the residual natural parts in a mostly

non-selective geographical manner. Conversely, geographical selectivity is notable in the three cases of Emilia Romagna, Abruzzo, and Marche, where the urban concentration excludes any other form of residual nature. Intermediate models of selectivity are found in Campania and Liguria, where the dominance of the urbanized areas does not exclude all the natural features.



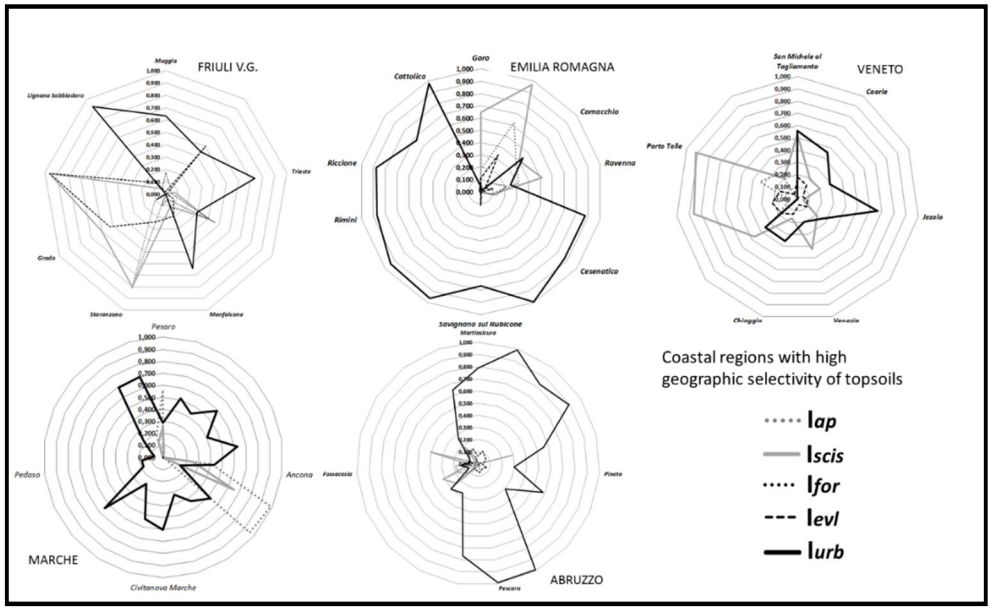


Figure 4 - Diagrams of geographic selectivity of topsoils (stands) for the coastal regions

Discussion

The considerations that emerged from analysis of the diagrams in Figures 2 and 3 with the values of the proposed indicators led to a type classification of the coastal sectors, indicated as follows, and providing some policy management guidelines (Table 2).

On the Tyrrhenian coastal strip analyzed, 16 coastal segments longer than 5 km were identified (Figure 5), with elevated I_{FOR} and I_{EVL} (> 80%) indices, free of urbanization (I_{URB} < 1%) for a total of 144 km (less than 10% of coast analyzed). The longest tracts are located in Tuscany (15 km between Viareggio and Pisa, 20 km between Grosseto and Orbetello), in Lazio (15 km between Latina and Sabaudia), and in Campania (12 km between Camerota and S. Giovanni a Piro). Of the 144 km total, nearly 20% (28 km) lacks conservation protection (protected areas and Natura 2000 sites), and instead exerts pressure on the remaining segments (Figure 6).

Table 2 - Type classification of the coastal sectors and some management policies

Type A – Urban-dominant coastal strip (I_{URB}>*40-50%*) and presence of environmental components and restrictions of less than 20% on average. Very limited incidence of protected areas and Natura 2000 sites (I_{AP} and I_{SCIS} of 0 to less than 10%-15%). Environments highly compromised by construction coverage and infrastructure development, with very little natural area remaining.

Management policies:

Potential for ecological restoration is very difficult technically, politically, and socioeconomically.

Type B – Coastal sectors with attenuated development density (I_{URB} also less than 20%-30%), equally present with some environmental restrictions such as protected areas and Natura 2000 sites (I_{AP} and I_{SCIS} between 20% and 40%), with consistent remainders of land with ecological value (I_{EVL} > 20%). Environment still diverse, with widespread urban development, but with still-significant natural spaces.

Management policies:

Potential for ecological restoration medium-high, particularly through application of reticular repair models of interstitial protected areas, or those of naturalistic interest.

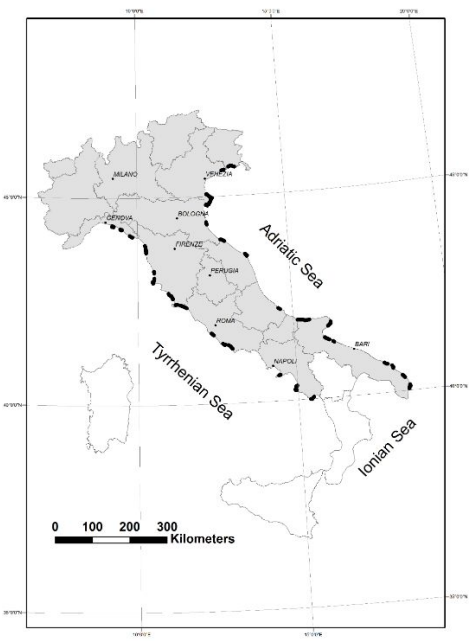
Type C – Predominantly environmental coastal sectors, with urban density (I_{URB}) less than 20% and incidence of conservation restrictions (I_{AP} and I_{SCIS}) varying between 20% and 50-60% and I_{EVL} > 20%. Scarcely-compromised environments, generally for reasons connected to geomorphological conditions that are incompatible with construction. High potential for acquisition of nodal functions of the coastal ecological network and between the coast and interior.

Management policies:

Areas to be subjected to strict development control policies to limit future compromises.

Similar data for the Adriatic coast provides approximately 200 km (13% of the total), but nearly all were identified as Natura 2000 sites (with a few cases of protected areas). The longest segments are found in Friuli V.G. (17 km in Marano Lagunare), Veneto (50 km between Porto Viro and Goro), and in Puglia (14 km along the coast of Lago di Lesina).

Broad sections of free coast are found in Veneto or north Emilia Romagna, including large tracts of lagoon and estuary. The remainder of the free coast exists in some sectors with very steep or rocky headlands (Conero in Marche, Punta d'Erci in Abruzzo, and Gargano in Puglia) or tracts that alternate between sand, raised rocky coasts, and deep seabed (various instances in Puglia). Where the coastline is sandy/dunes, there are extremely few coastal segments still free from construction or other urbanization works within a band of 1,000 meters from the waterline, and development not greater than a few kilometers (Malavasi *et al.*, 2013; Pintó *et al*, 2014; Simeone *et al*, 2014;).



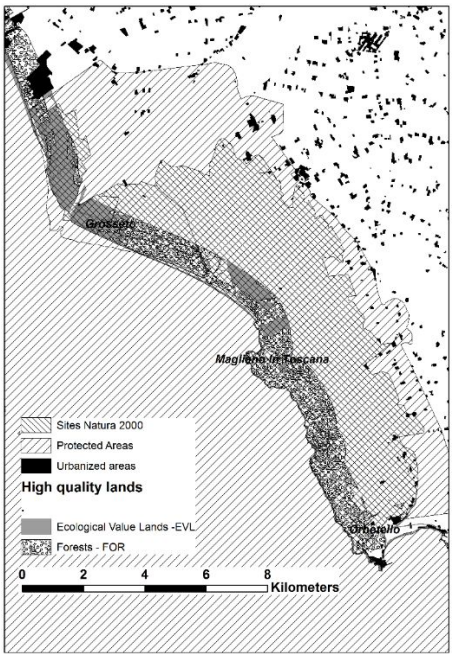


Figure 5 - Peninsular coastal segments longer than 5 km, free of urbanization and with higher density of ecological value (to the left).
Figure 6 - One of the longest coastal segments in Italy free of urbanization and with high density of naturalistic value (to the right)

Table 3 – Type of environmental protection on peninsular coastal segments longer than 5 km, free of urbanization and with higher density of ecological value,

	Municipalities	Length (km)	Type of environmental protection		Regions
			Nature 2000	Protected areas	
Adriatic coast	Marano Lagunare	17	□		Friuli V.G.
	S. Michele Tagliamento-Caorle	7	□		
	Porto Viro-Goro	50	□		Veneto
	Ravenna	6	□		Emilia Romagna
	Gabicce-Pesaro	11	□		
	Sirolo	8	□		Marche
	Torino di Sangro	5	□		Abruzzo
	Chieuti-Serra Capriola	13	□		Puglia
	Lago di Lesina	14	□		
	Vieste-Mattinata	12	□		
	Zapponeta-Margherita di S.	11	□		
	Barletta	6	□	□	
	Carovigno-Brindisi	6	□	□	
	Brindisi-S. Pietro V.	7	□	□	
	Vernote	8	□		
	Otranto-S. Cesarea T.	10	□		
		191	191 km (100%)	19 km (10%)	
Thyrrenian coast	Camogli-S. Margherita L.	8		□	Liguria
	Levante-Momeglia	5			
	Riomaggiore-Portovenere	8		□	
	Viareggio-Pisa	15	□	□	Tuscany
	Bibbona-Castagneto Carducci	5			
	S. Vincenzo-Piombino	7			
	Grosseto-Orbetello	20		□	
	M. Argentario-Orbetello	7			
	Capalbio-Montalto di Castro	7			Lazio
	Roma-Pomezia	7		□	
	Nettuno-Latina	8	□		
	Latina-Sabaudia	15		□	
	Sorrento-Vico Equense	8	□		Campania
	Agropoli	6		□	
	Castellabate	5		□	
	Camerota-S. Giovanni a P.	12		□	
		143	31 km (22%)	96 km (67%)	

Conclusions

The results obtained clearly show the effect that fifty years of relatively uncontrolled development have had on the landscape mosaic and coastal ecosystem, as well as the current condition of "besiegement" of natural spaces and semi-natural remainders, and areas protected for various reasons. It is true that at least 350 km of the coastline analyzed (approximately 12% of nearly 3,000 total) are still relatively unaltered, falling under the type C description, and can constitute the base of a possible restoration under a territorial environmental retrofit policy (Onori, 2009) and adequate coastal management (Suárez de Vivero and Rodríguez Mateos, 2005; Forino *et al*, 2015).

On the other hand, construction dynamics have strongly driven the business market of the Italian coast. This phenomenon, along with the best connections with the rest of the country, has for many years made the coast into a strong attracter of people and services. Due

to a scarcity of data, it is very difficult to correlate the dynamics of the increase of urbanized surfaces with economic components, but some investigations have shown a positive correlation between per capita earnings in the coastal municipalities and the intensity of urbanization phenomena.

The environmental sustainability price paid for these advantages has been undoubtedly high, as are the costs that the community has paid and is still paying to combat many serious phenomena that degrade the same environmental resources that motivated the tourism and consequent real estate interests.

Any plans for retrofit by the government of the territory must now take into account another emergent aspect: the status of the coasts in the Italian regions is very diverse, particularly with regard to past and developing phenomena, administrative sensitivities, and management policy actions. From this perspective as well, some directions for environmental policy can be set out, addressing the most critical situations in light of the information derived from the indicators used (Romano and Zullo, 2015).

As has already been stated in describing the three types A, B, and C, the margins of action for territorial policies (and municipal planning in particular) are very broad in B and in C, but rather restricted in A. In this last situation, the preparation of urban projects aimed at recovering each microsector that is still free, to attempt the difficult work of repairing and connecting, will become increasingly important – and will, however, be predictably blocked by the looming density of the urban fabric and related disturbances, as well as economic interests that are, on average, rather strong.

The most effective actions can therefore be taken in zones B and C. In these zones in particular, the rather determined choices of protection should dominate over all the others. On this subject, we note that today 20% of the Tyrrhenian coastal segments still free from urban density lacks the conservation protection provided by protected areas.

A central, as well as regional, government intervention will likely be necessary, through incentivized tax policies in municipalities for the conservation of remaining coastal passages, using instruments that are already in the experimentation phase in some European countries (Henger and Bizer, 2010). However, it would also be appropriate to systematically carry out environmental restoration projects using, for example, decommissioned areas. Indeed, in these cases, especially when dealing with abandoned manufacturing sites, which are rather numerous, it could proceed with projects to restore original environments between the sea and the interior. This type of action, oriented toward restoration under difficult daily conditions, appears to be the only way to improve technological/environmental conditions and hydrogeological risk to the coasts, which are by now saturated with construction.

Acknowledgment

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