

AN ONTOLOGY OF THE APPROPRIATE ASSESSMENT OF MUNICIPAL
MASTERPLANS: A CASE STUDY CONCERNING SARDINIA, ITALY

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ABSTRACT

Following a discussion on the semantics of the term “ontology”, this paper discusses some key points related to the ontology of the “Appropriate assessment” (under the Directive 92/43/EEC of 21 May 1992, the so-called *Habitats Directive*) procedure concerning plans significantly affecting Natura 2000 sites.³ We study this ontology by discussing its implementation into the adjustment process of the Masterplans of the regional municipalities of Sardinia (Italy) to the Regional Landscape Plan (RLP), and put in evidence some important general observations, coming from the case study, concerning the utility and effectiveness of the ontological conceptual framework in order to help planners and decision makers understand and structure the assessment process of plans.

KEYWORDS: ontology; ontologies; municipal Masterplans; Appropriate Assessment; Habitats Directive

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³ Natura 2000 is a European coherent network of areas to be protected for their ecological importance, and it presently consists of Sites of Community Importance and Special Protection Areas.

1 Introduction

With its approximately 24,000 square meters, Sardinia is the second-largest island in the Mediterranean Sea; its population density is rather low, as it counts less than 1.7 million inhabitants according to the 2011 National Census. The vast majority of Sardinians live close to the sea, and especially in the two densely urbanized areas around the two major cities (Cagliari and Sassari), while the inner areas of the island, hilly and mostly badly connected to the rest of the island, are sparsely populated. This uneven concentration of population parallels the island's unbalanced economic development, as in coastal areas the majority of economic activities takes place. The peculiar combination of Sardinia's insularity, geographical distance from the mainland, culture and history, completely different to those of the rest of Italy, has to be taken into account to explain the special status of "Autonomous Region" granted to the island soon after the birth of the Italian republic. This means that, together with three other regions and two provinces, Sardinia exerts a more robust legislative power than the majority of the rest of Italian regions.

It is therefore not surprising, given this context, that the Regional Landscape Plan of Sardinia (RLP) was the first statutory landscape plan with regional dimensions produced in Italy under the new legislation. Its statutory character stems from both a national law (National Code of Cultural Heritage and Landscape), which required that each regional executive committee should approve a landscape plan, and from regional law no. 8 of November 25, 2004, which required that the Sardinian RLP for the coastal areas be approved within one year since the approval of the law itself. The Regional Administration of Sardinia initially focused on the coastal zone because of the complexity of development conflicts arising from tourism (on which a large part of the economy of the island relies) and other development, and owing to the fact that thirteen out of the fourteen previous landscape plans covering coastal areas, which contained some restrictions on coastal development, had been quashed in 2003 in a court decision.

Following approval of the plan in 2006, restrictions and prohibitions (on development of land and on certain changes in land uses) stemming from the plan are currently in force, in order to protect a part of the island considered economically strategic and environmentally sensitive. Restrictions and prohibitions are set out by the plan by means of a system of rules.

The planning activity of the regional administration of Sardinia has undergone a deep change after the approval of the Regional Landscape Plan (RLP), which establishes the directions for nearly any future planning activity in Sardinia, and requires that actual sectoral and local plans, as well as plans for protected areas, be changed to comply with its directions.

The process of adjustment of the Masterplans (MMP) of the cities of the coastal strip to the RLP is quite complicated. The MMP have to conform themselves to the descriptive, prescriptive and propositive contents of the RLP, to the general planning rules and directives

established by the RLP for the coastal zones, and to the strategic policies for the “conservation and protection, maintenance, improvement or restoration of the landscape values identified in the landscape units.” (Planning implementation code of the RLP (PIC), article 7, paragraph 1). The relationships between landscape values, characteristics of the zones and categories of strategic actions are described in the Annex 1 of the PIC.

The question of the adaptation process of the actual MMP to the RLP is of paramount importance for the effectiveness of the new planning policies of the Sardinian regional administration, and for the definition of a general model for the strategic assessment of city planning based on the analysis of perceived needs and expectations of local communities, through sustainable-development-oriented governance processes (Cau and Zoppi, 2008).

A very important issue concerning the adjustment process of a municipal Masterplan to the RLP is represented by the *Appropriate Assessment* (AA) of the impacts of the Masterplan on Natura 2000 sites. The discussion proposed in this paper focuses on the implementation of AA’s within Masterplans’ processes.

There are three main normative points of reference for the assessment of the impact of the adjustment process of the Masterplans of Sardinian municipalities to the RLP on the Natura 2000 sites: i. the *Methodological guidance on the provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC* “Assessment of plans and projects significantly affecting Natura 2000 sites” (European Commission, DG Environment, 2001); ii. the *Guidance document on Article 6(4) of the “Habitats Directive” 92/43/EEC* “Clarification of the concepts of: alternative solutions, imperative reasons of overriding public interest, compensatory measures, overall coherence, opinion of the commission” (European Commission, DG Environment, 2012); iii. the provisions of Annex D of the Annex to the Deliberation of the Regional Government of Sardinia Autonomous Region no. 44/51, 14 December 2010, which is entirely related to the assessment of the impacts of Masterplans on Natura 2000 sites.

We develop the ontology on the basis of these normative standpoints, and implement its construction through Protégé, a software program developed by the Stanford Center for Biomedical Informatics Research of Stanford University and freely available at: <http://protege.stanford.edu>.

This paper discusses some key points concerning the ontology of the AA procedure applied to Masterplans, using sustainability as a reference point (third section), after a discussion on the semantics of the term “ontology” (second section). This discussion regards the implementation process defined by the methodological guidance of the European Commission as an experimental context, with the objective of proposing the AA ontology as an important contribution to the improvement of AA effectiveness (fourth section).

2 The semantics of the term “ontology”

A generally-accepted meaning of the term “ontology” in contemporary theoretical debates of urban and regional planning is “discussion of the substance of an object”, that is a discussion of the most important characteristics of its essence, especially in epistemological debates. For instance, Hillier (2010) points out that, according to some contemporary scholars, “ontology” indicates the paradigm of “relational ontology”, that is a discussion of the substance of the relations between agents and structures (capital, social classes, agreed-upon semantics, etc.) which do not possess their own essence, formed only through their being in relation. Moreover, Hillier stresses, with reference to DeLanda (2006), that the reference point of planning practice should be the observation and analysis of the relations between the elements which constitute the empirical reality (e.g., agents and structures), whose existence does not depend on the fact that human beings perceive it.

These relations generate emergences, that is unexpected phenomena, for those who are familiar with the single elements but who are not aware of their mutual relations as well: the ontology of agents, structures and relations is a “realistic ontology” of the scientific paradigm of the (planning) disciplinary paradigm, which is based on the empirical analysis of the relation. These emergences have an autonomous existence with respect to agents and structures.

The realistic ontology (the ontology of relations) is an ontology of the reality (Hillier, 2010), and a scholar’s disciplinary role is to be aware of and to describe this reality, by identifying and analyzing its relational substance.

The “substantial” attribute of the term “ontology” leads to an effective comprehensive view of the contemporary debate concerning ontology and ontologies. In this context, ontology is not referred to, according to the meaning described so far, as one or a set of conditions which define the substance of a concept (reality–agents, structures, relations) as much as the substance of its agreed-upon representation, that is its formal definition. Ontology is the identification of a concept, of a domain—in other words, the cognitive contents that a set of agents identify as the particular characteristics of a domain. Therefore, ontology is not connected to substance, that is the essence of an object, as much as to the agreed-upon available knowledge (scientific, technical, based on traditions and on common sense, etc.) concerning an object.

Formal ontologies are not connected to substance or to essence, but to the essence of representations, or definitions; that is, they propose an agreement on cognitive contents, rather than the substance analysis of an object. According to Smith (2003), ontologies are descriptions of domains of objects as closed data models whose nodes define concepts. These concepts are strategically identified and make sense only in the context of the universe they try to model. Moreover, Smith illustrates that, historically, the use of formal ontologies comes

from the fact that several disciplines are experiencing a dramatic Tower of Babel syndrome which needs to be addressed somehow. Those who deal with complex systems of data and knowledge have peculiar and often idiosyncratic frameworks for representing information. The semantics used for the same term may vary, or the semantics for different terms could take the same meanings. Formal ontologies could make it easier to deal with this syndrome. Also according to Guarino (1998), as quoted by Pretorius (2004), a formal ontology is a projected representation which consists of a specific agreed-upon set of words which describe concepts belonging to a knowledge domain and a set of agreed-upon propositions concerning the meanings of these word as well. Pretorius agrees with Smith since, in his view, the concept of ontology originated in the field of artificial intelligence.

3 The Appropriate Assessment of municipal Masterplans

We discuss the AA of the municipal Masterplans of Sardinia on the basis of the provisions of the *Methodological Guidance* (MG) quoted above (European Commission, DG Environment, 2001). The MG is essentially related to articles 6.3 and 6.4 of the Habitats Directive. The methodology for the AA implementation is described in the third section of the MG, even though only paragraph 2 defines the assessment phases, while the others concern the screening procedure (paragraph 1), the issues of alternatives to the proposed plan or project that might possibly generate negative impacts on a Natura 2000 site (paragraph 3), and of how to deal with situations characterized by lack of alternative solutions and important negative impacts (paragraph 4).

The AA of a municipal Masterplan (MMP) on the Natura 2000 site(s) located in the area ruled by the municipal administration (“Site” hereafter) is based on an information set related to the Site and to the rules of the MMP concerning the municipal area which overlaps the Site (Site overlapping area, SOVLA).

According to the MG a Site can be characterized through the following information set: i. habitats; ii. species; iii. conservation objectives; iv. ecological requirements; v. threats, pressures and activities with impacts on the Site; vi. relevant conservation issues. This set contains information which, on the one hand, comes from the characterization of habitats, species and impacts contained in the Site’s *Natura 2000 - Standard Data Forms* (SDF’s) available, for each Site, on the Internet site of the European Environment Agency concerning the Natura 2000 network (EEA, 2013).⁴ On the other hand, supplemental information is required, which is related to conservation objectives, ecological requirements and relevant conservation issues. This information can be collected from several sources such as scientific studies concerning site-specific historical, natural and environmental issues, on-site surveys

⁴ See the Commission Implementing Decision of 11 July 2011 concerning a site information format for Natura 2000 sites (notified under document C(2011) 4892).

related to the conditions of habitats and species, and on the local factors which may generate negative impacts, etc..

The SDF's contain detailed information on habitats and species, in compliance with the classification of the Habitats Directive. Habitats are classified into *natural habitat types of Community interest* and *priority natural habitat types* (paragraphs 1 (c) and 1 (d) and Annex I of the Habitats Directive). Species of Community interest are drawn from those listed in Annexes II and IV of the Habitats Directive and in Annex I of the Directive 2009/147/EC of 30 November 2009, the so-called *Birds Directive*. The informative content of the SDF's concerning habitats and species is defined as follows (Commission Implementing Decision C(2011) 4892).

Information on habitats includes:

- i. representativity, that is criterion A.(a) of Annex III of the Habitats Directive: the representativity of an habitat for a Site is related to how a habitat is typical for the Site, and either for groups or for combinations of groups of habitats; the assessment of representativity should be implemented taking account of the provisions of the Interpretation Manual issued by the DG Environment of the European Commission (2007);
- ii. relative surface, that is ratio of the area of the habitat in the Site to the total area covered by that habitat type within national territory, that is criterion A.(b) of Annex III;
- iii. state of conservation in terms of structure and functions, and restoration possibilities, that is criterion A.(c) of Annex III;
- iv. global assessment of the habitats, with reference to the three criteria indicated above, that is criterion A.(d) of Annex III.

Information on species includes:

- i. population of the species in terms of the ratio of number of individuals with respect to the total population within national territory, that is criterion B.(a) of Annex III;
- ii. conservation of the species, in terms of the state of conservation of the Site's habitats elements relevant for the species, which is related to the elements' state of conservation and to the restoration possibilities, that is criterion B.(b) of Annex III;
- iii. isolation of the species, which indicates the species' potential contribution to biological diversity, that is criterion B.(c) of Annex III;
- iv. global assessment of the species, with reference to the three criteria indicated above, that is criterion B.(d) of Annex III.

Moreover, the SDF's contain precise information, which could possibly be expanded within the AA, on threats, pressures and activities with impacts on the Site.

The other three elements of the information set on the Site need particular attention in terms of Site-specific scientific research and direct observation and surveys. The most part of this

information should be included in the management plans of the Site, if available.⁵ The most part of Sardinian Sites of Community Interest are ruled by management plans, which received huge financial support from the Sardinian regional administration during the 2000-2006 European Union Structural Funds programming period; the preparation of a series of management plans also concerning Special Protection Areas, funded through the 2007-2013 Rural Development Program (measure 323, action 1, subaction 1), is currently in progress. As a consequence, the information set could be made almost complete for the most part of the Sardinian Sites with little supplemental effort.

The SOVLA of the MMP concerning a Site is characterized by the following information: i. zone-type according to the planning implementation code (PIC) of the MMP; habitats included in the SOVLA. If the provisions of the PIC imply possible future residential, service or infrastructure-related development in the SOVLA, negative impacts on habitats and species can eventually take place as a result of the interaction between planning rules, conservation objectives and ecological requirements.

The AA, according to the MG (subparagraph 5 of paragraph 3.2., and paragraphs 3.3. and 3.4.), has to define and make available to planners, public officers, decision-makers and local communities a set of possible policies to: i. mitigate negative impacts of the on-going land-use developments and transformations; ii. delineate possible future scenarios alternative to the present which is generating negative impacts on habitats and species; and, iii. address situations characterized by lack of alternatives and persistence of negative impacts.

From this perspective, the AA is quite similar to an environmental report of the Strategic Environmental Assessment of a MMP, which should include measures which in some way address the issue of negative impacts on environmental resources (Lai and Zoppi, 2011). As in the case of the environmental report, the fundamental question to be analyzed is how and by how much the implemented MMP affects and impacts both ecological requirements and conservation objectives of the Site. Hence, not only is it fundamental to understand and design a proper framework concerning the Site and its characteristics, requirements and objectives, but it is also decisive to build a proper conceptual model of the interaction between the plan implementation, particularly in the SOVLA, and the habitats and species of the Site.

The fundamentals of the ontology of AA processes concerning MMP should entail: i. analysis and interpretation of the Site, that is the characterization of the Site in terms of habitats, species, ecological requirements and conservation objectives; ii. definition of the implementation code of the MMP concerning the SOVLA; and, iii. conceptualization of the

⁵ According to paragraph 1 of article 6 of the Habitats Directive: “For special areas of conservation, Member States shall establish the necessary conservation measures involving, if need be, appropriate management plans specifically designed for the sites or integrated into other development plans, and appropriate statutory, administrative or contractual measures which correspond to the ecological requirements of the natural habitat types in Annex I and the species in Annex II present on the sites.”

interaction between MMP and Site. In the following section, we propose tentatively an ontology having these features.

4 An ontology of the appropriate assessment of city Masterplans

Within the context of spatial planning, ontologies have generally been proposed as a means to share and reuse existing information and data (Noy and McGuinness, 2007), to homogenize data and solve semantic conflicts (Mizen, Dolbear and Hart, 2005), to support the modeling of spatial datasets (Schuurman, 2006), and therefore as a possible solution to the issue of making interoperability and integration possible in spite of the proliferation of data and data sets built in the absence of common standards (Murgante and Scorza, 2011). One of the most challenging and promising field of research concerning the use of ontologies in spatial planning deals with allowing for a better understanding and awareness of programming and planning processes (Scorza et al., 2010). Ontologies, in this context, do not deal with “the specification of what exists and what does not exist, but rather with the creation of a data set that contains concepts related to the domain under inquiry” (Las Casas and Scardaccione, 2008); in other words, they tackle the problem of describing a given domain of interest by identifying key concepts that define the domain, relations that connect the concepts, and existing constraints, thus making formalization and knowledge sharing within the given domain possible.

There are many definitions of the word “ontology” in the literature regarding the field of artificial intelligence (Winter, 2001). As Caglieni and Rabino (2006) point out, there is no single definition, and conceptual definitions “that regard ontology as a reference system for knowledge” coexist with “others, more operational, which lay the grounds for their actual construction, development and use.” One of the most used and most frequently cited definitions is Gruber’s (1993), for whom an ontology is an “explicit specification of a conceptualization”: this conceptualization, or in other words the construction of an abstract and simplified conceptual model of a given object, or phenomenon, or process represented by the ontology, is explicit because each concept, relationship and constraint is explicitly defined. The subsequent definition by Studer *et al.* (1998: a “formal, explicit specification of a shared conceptualization”), enriches Gruber’s with two additional requirements: first, an ontology should be formal, that is machine-readable; in addition, the conceptual model of the object being represented needs to be agreed by a group of individuals (Agarwal, 2005), and therefore consensus of members of a given community is necessary.

The ontology of the domain “Appropriate Assessment of city Masterplans” was developed according to the phases suggested by guidance documents and methodological reports produced by the Ordnance Survey, according to which the process whereby an ontology is built can be broken down into a series of steps, the first being the identification of the purpose of the

ontology (*i.e.*, the specification of needs and requirements that the ontology should be able to fulfill) and of its scope (*i.e.*, a delimitation of the domain under investigation). These two aspects are crucial for ensuring both that the ontology is correctly formalized and that it is useful, meaning that it contains only those concepts, relationships and constraints that are judged to be relevant, with regard to the possible ways in which the ontology can be used. With reference to the first point (purpose), the ontology here proposed aims to represent the Appropriate Assessment as a process; in particular, it must explain key concepts of the AA in the special context of land-use planning, and, ideally, it should guide plan-making by providing planners with a framework for the identification and understanding of likely impacts of plan contents and provisions on Natura 2000 sites. With reference to the second point (scope), the domain is here confined to the Appropriate Assessment of MMP's.

Once purpose and scope have been established, the following step consists of the construction of a glossary ("*knowledge glossary*"), comprising two tables. The first table ("*table of concepts*") contains a list of core and secondary concepts together with their definition in natural language, the indication of the source of the definition, and of possible synonyms. Concepts can be either *core concepts* or *secondary concepts*, depending on whether or not they are included in the domain under investigation, that is, ultimately, on how purpose and scope have been defined in the previous step. Core concepts are deemed necessary to represent the domain; on the contrary, secondary concepts are not part of the domain; however they belong to the glossary because they need to be defined in order to describe core concepts. The second table ("*table of relations*") lists and defines, again in terms of natural language only, relationships between concepts pertaining to the domain.

The definition of concepts and relationships was based on documentary sources only. These comprised relevant European Directives, as well as national and regional pieces of legislation (e.g., the already mentioned Habitats and Bird Directives, Decree of the President of the Italian Republic no. 357 of 1997, as amended by Decree 120 of 2003, which translates the Habitats Directive into the Italian legislation), and of technical documents, such as the three main points of reference already cited in the introduction to this paper (European Commission, DG Environment, 2001; European Commission, DG Environment, 2012; Annex D to the Annex to the Deliberation of the Regional Government of Sardinia Autonomous Region no. 44/51, 14 December 2010), plus other documents deemed of interest.⁶ The use of

⁶ These include the following:

- "Commission note on setting conservation objectives for Natura 2000 sites", issued by the European Commission in 2012 and available at http://ec.europa.eu/environment/nature/legislation/habitatsdirective/docs/commission_note2.pdf [accessed June 10, 2013].
- "Commission note on the designation of special areas of conservation (SACs) issued by the European Commission in 2012 and available at http://ec.europa.eu/environment/nature/legislation/habitatsdirective/docs/commission_note2.pdf [accessed June 10, 2013].
- "Commission implementing decision of 11 July 2011 concerning a site information format for Natura 2000 sites", available at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:198:0039:0070:EN:PDF> [accessed June 10, 2013].

such sources was an attempt to ensure that definitions are agreed upon by, and shared among, domain experts. Figure 1 illustrates, for instance, a part of the table of concepts. Through a series of checks at internal level of definitions and relations, the two tables were enhanced and modified recursively.

CORE CONCEPT	DEFINITION	SOURCE
Conservation objectives	A conservation objective is the specification of the overall target for the species and/or habitat types for which a site is designated in order for it to contribute to maintaining or reaching favourable conservation status of the habitats and species concerned, at the national, the biogeographical or the European level. Whereas each site contributes to the attainment of favourable conservation status (FCS) this objective can only be defined and achieved at the level of the natural range of a species or a habitat type.	European Commission (2012) "Commission note on setting conservation objectives for Natura 2000 sites" http://ec.europa.eu/environment/nature/legislation/habitatsdirective/docs/commission_note2.pdf
Global assessment	Global assessment of the value of the site for conservation of the natural habitat type concerned. This criterion refers to the global assessment of the value of the site for the conservation of the habitat type concerned. This criterion should be used to assess the previous criteria in an integrated way and taking into consideration the different weights they may have for the habitat under consideration. Other aspects may be considered regarding the evaluation of the most relevant elements in order to globally assess their positive or negative influence on the conservation of the habitat type. The 'most relevant' elements may vary from habitat type to habitat type; they may include the human activities, both in the site or in its neighbouring areas, that are likely to influence the conservation status of the habitat type, the ownership of the land, the existing legal status of the site, the ecological relations between the different habitat types and species, etc.	COMMISSION IMPLEMENTING DECISION of 11 July 2011 concerning a site information format for Natura 2000 sites (notified under document C(2011) 4892) (2011/484/EU), para 3.1
Habitat	- natural habitats means terrestrial or aquatic areas distinguished by geographic, abiotic and biotic features, whether entirely natural or semi-natural; - natural habitat types of Community interest means those which, within the territory referred to in Article 2: (i) are in danger of disappearance in their natural range; or (ii) have a small natural range following their regression or by reason of their intrinsically restricted area; or (iii) present outstanding examples of typical characteristics of one or more of the nine following biogeographical regions: Alpine, Atlantic, Black Sea, Boreal, Continental, Macaronesian, Mediterranean, Pannonian and Steppic.	COUNCIL DIRECTIVE 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (OJ L 206, 22.7.1992, p.7), art. 1.c
Impact	Impacts relate to all human activities and natural processes that may have an influence, either positive or negative, on the conservation and management of the site	Commission implementing Decision of 11 July 2011 concerning a site information format for Natura 2000 sites (notified under document C(2011) 4892) (2011/484/EU), para 4.3
Impact type	Impacts stem from threats, pressures and activities - list in accordance with Article 17 codelist. Maintained by: DG Environment, European Environment Agency (EEA), last updated: 12.04.2011	EEA, http://bd.eionet.europa.eu/activities/Natura_2000/Folder_Refrence_Portal/Ref_threats_pressures_FINAL_20110330.xls
Site	- site of Community importance means a site which, in the biogeographical region or regions to which it belongs, contributes significantly to the maintenance or restoration at a favourable conservation status of a natural habitat type in Annex I or of a species in Annex II and may also contribute significantly to the coherence of Natura 2000 referred to in Article 3, and/or contributes significantly to the maintenance of biological diversity within the biogeographic region or regions concerned	COUNCIL DIRECTIVE 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (OJ L 206, 22.7.1992, p.7), art. 1.k
Species	- species of Community interest means species which, within the territory referred to in Article 2, are: (i) endangered, except those species whose natural range is marginal in that territory and which are not endangered or vulnerable in the western palearctic region; or (ii) vulnerable, i.e. believed likely to move into the endangered category in the near future if the causal factors continue operating; or (iii) rare, i.e. with small populations that are not at present endangered or vulnerable, but are at risk. The species are located within restricted geographical areas or are thinly scattered over a more extensive range; or (iv) endemic and requiring particular attention by reason of the specific nature of their habitat and/or the potential impact of their exploitation on their habitat and/or the potential impact of their exploitation on their conservation status.	COUNCIL DIRECTIVE 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (OJ L 206, 22.7.1992, p.7), art. 1.g
Zone type	sono considerate zone territoriali omogenee, ai sensi e per gli effetti dell'art. 17 della legge 6	DECRETO MINISTERIALE 7 aprile 1968, n. 1444 (pubblicato nella g.

Figure 1 - Knowledge glossary: table of concepts (an extract only showing some of the core concepts).

The knowledge glossary, in spite of its being an explicit and shared (at least, potentially) specification of the entities that constitute the abstract and simplified model of the AA process developed in the light of the documentary sources examined, is not a formal specification of the domain, up to this point. For the computational aspects, the software program Protégé⁷ was used; concepts were arranged in a hierarchical manner, that is they were organized and grouped into classes and subclasses on the basis of the relationship “is a”. To state that a given element belongs to a subclass of a class is in fact tantamount to affirming that this element belongs to the class and therefore that it inherits its properties. In this way, key concepts identified in the previous phase were first organized in a taxonomy according to the following classes: “Site”, “Habitat”, “Species”, “Conservation objectives”, “Impacts”, “Overlap zones”, “Zone type” and “Overlap zone” and then the corresponding definitions were inserted for each class and subclass.

Next, for each class and subclass, appropriate slots were defined and created. Slots can be used either to characterize the elements of a class by means of attributes of different types (for instance, string, integer, enumerated), or to describe the relationships between instances,

⁷ Protégé is a software program developed by the Stanford Center for Biomedical Informatics Research of Stanford University and freely available at: <http://protege.stanford.edu/>. Version 3.4.7 (frame oriented) was here used.

which are defined as the elements belonging to a given class; in other words, features represent the finest level of granularity and form the basis of the hierarchy. Figure 2(a) illustrates, as an example, the slots assigned to the class “Site”. “Name”, “Area size” and “Ecological requirements” are three descriptive attributes, all required and all having single cardinality (meaning that only one value for each attribute is allowed); the type of the first and that of the third is “string” (meaning that any alphanumeric string is allowed), while that of the second is “float”, as this attribute accounts for a site’s land mass.

CLASS EDITOR
For Class: ● Site (instance of: STANDARD-CLASS)

Name
Site

Role
Concrete ●

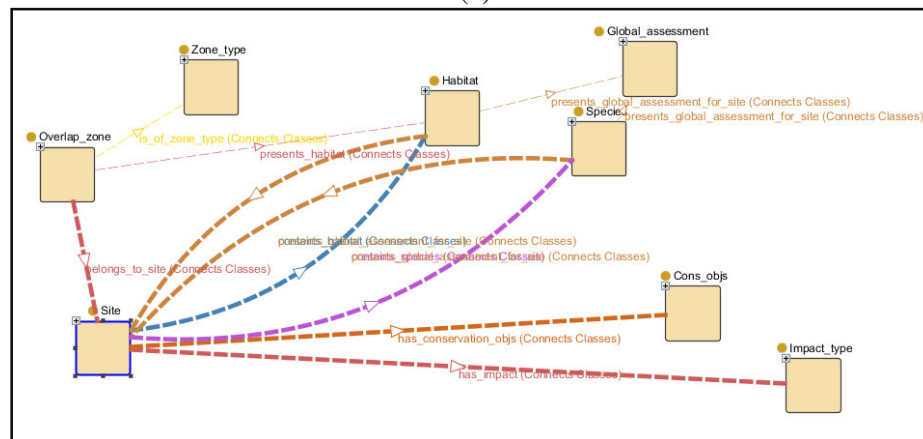
Documentation
Site of Community importance means a site which, in the biogeographical region or regions to which it belongs, contributes significantly to the maintenance or restoration at a favourable conservation

Constraints

Template Slots

Name	Cardinality	Type	Other Facets
area_size	required single	Float	
contains_habitat	required multiple	Instance of Habitat	inverse-slot=habitat_of_site
contains_species	required multiple	Instance of Species	inverse-slot=species_of_site
ecological_requirements	required multiple	String	
has_conservation_objs	required multiple	Instance of Cons_objs	inverse-slot=cons_obj_of_site
has_impact	required multiple	Instance of Impact_type	inverse-slot=occurs_in_site
name	required single	String	
presents_rel_theme	required multiple	Instance of Biotic_comp_faun ...	inverse-slot=theme_of_site

(a)



(b)

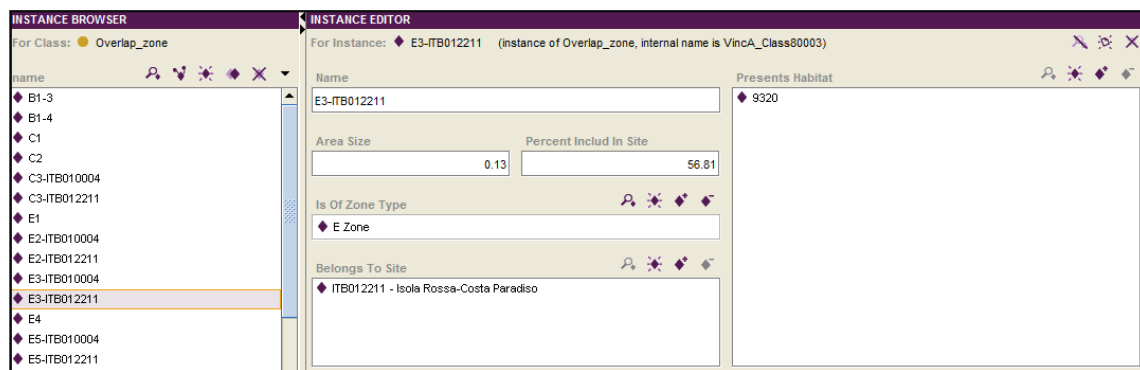
Figure 2 - (a) An example of descriptive and relational slots assigned to the class “Site” in Protégé; (b) A graphical representation of relations corresponding to these slots.

As far as the other five (“Contains habitat”, “Contains species”, “Has conservation objectives”, “Has impact”, “Presents relevant theme”) are concerned, they make the relations between the class “Site” on the one hand and, respectively, the classes “Habitat”, “Species”, “Conservation objectives”, “Impacts” and subclasses of the class “Phenomena” on the other hand explicit, or, more precisely, they make the relations between features belonging to the

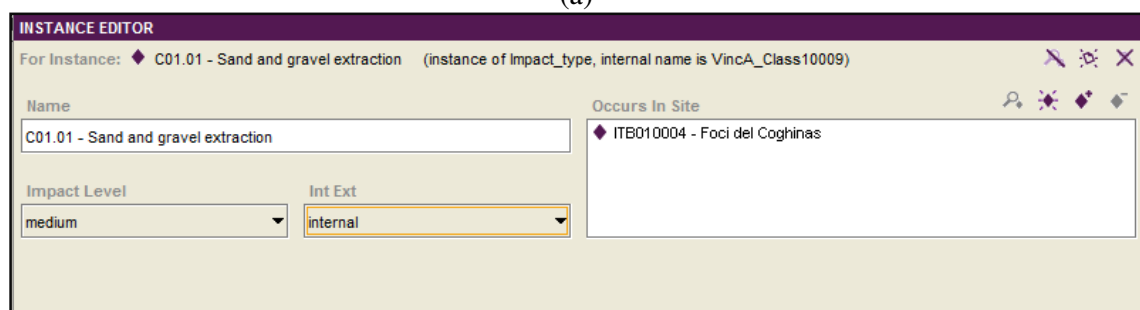
aforementioned classes explicit. These relations are represented by means of graphs in Figure 2(b).

All of the five slots have multiple cardinality (that is, an instance of the class “Site” can host more than one instance of the class “Habitat” or more than one instance of the class “Species”, it can have more than one conservation objective (which depend on both the types of habitats and species present in a certain site and on their conservation status in that site), it can be subject to more than one type of impacts (as identified and listed in the site’s SDF), and it is affected by a plurality of phenomena that need to be taken into account when assessing the plan’s effect on the site. Inverse relations are also defined, as shown in Figure 2(b).

The construction of the ontology continues with the creation of instances and the filling-in of the values of the slots, and this is done by entering these values in appropriate forms that prevent users from including values which are inconsistent with the ontological hierarchy previously defined. Figure 3 shows two examples of this phase.



(a)



(b)

Figure 3 - An example of instance belonging to the class “Overlap zone” (a) and one belonging to the class “Impact type” (b), also showing their slots filled out in Protégé.

Once the instances have been created and their slots have been filled in, the ontology is fully and formally defined, even though it can be continually adjusted and integrated; moreover, the ontology can be represented graphically as a graph tree in which classes, subclasses and

instances are represented as nodes, and relations as arches, allowing users to navigate the whole hierarchy (Figure 4), or only a part (Figure 5). Graphs can be tailored to the user's needs, meaning that the user can choose whether to display all of the ontology, or only a part of it, by selecting the nodes to be represented or filtering the relationships to be shown, which allows for a more effective and more understandable representation and exploration in case of complex ontologies.

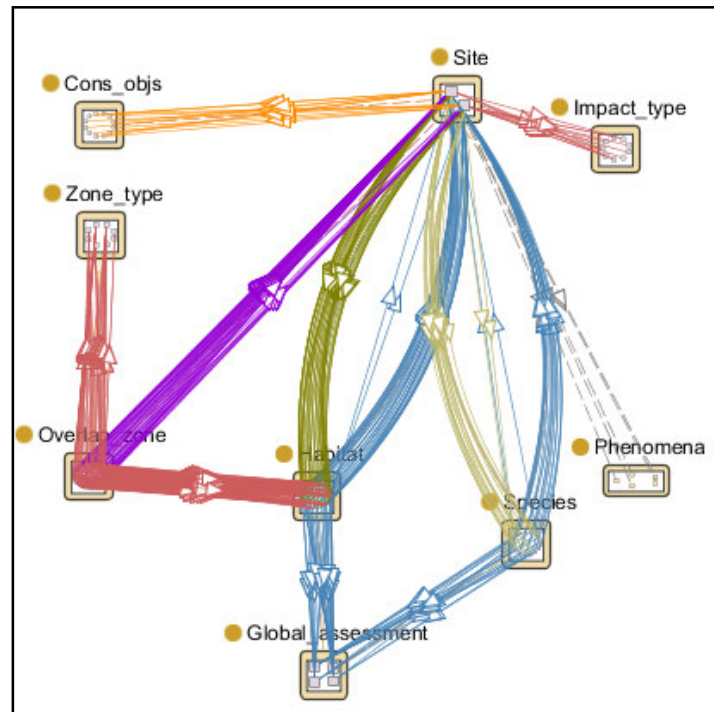


Figure 4 - Classes and subclasses of the domain in Protégé: graph tree showing the qualitative intensity of relationships between classes.

5 Conclusions

This paper has attempted to build an ontological representation of the AA of an MMP, which can be useful for at least two reasons.

First, this approach provides all the participants involved in the AA process (be they institutions, organizations or private citizens) with a better understanding of the domain of interest (Uschold and Gruninger, 1996), through an iterative learning process that can continually be refined; this learning process is, in principle, inclusive, because the construction of the glossary can be improved by integrating the definition of concepts, relations, and descriptive attributes, here carried out solely on the basis of documentary sources in a participative way, by including, for instance, experts in the domains of ecology, botany, zoology, planning and environmental assessment, or representatives of the public

administrations involved. Such a collective conceptualization of the domain would also greatly improve the chances of sharing and reusing the ontology in the domain field.

Second, since the ontology here proposed is a domain ontology, therefore aimed at structuring, representing and communicating knowledge on a specific area of interest irrespective of potential applications, the ontology of the AA of MMP's can be updated, refined and reused in the given domain (Agarwal, 2005), and it can lay the bases for the development of task-dependent or application-oriented ontologies in the same domain, for instance focusing on administrative and procedural tasks.

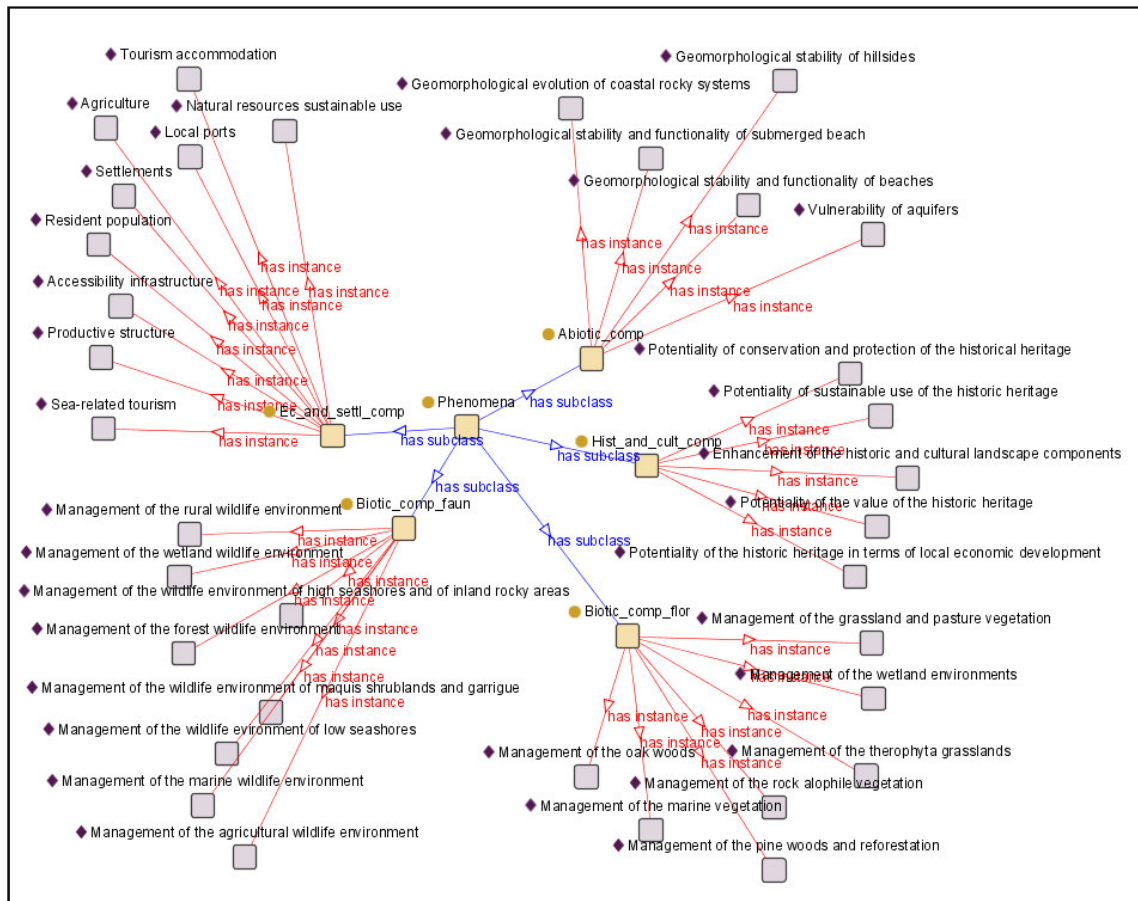


Figure 5 - Classes and subclasses of the domain in Protégé: (a) graph tree showing the qualitative intensity of relationships between classes; (b) graph tree of the class “Phenomena”, its subclasses and instances.

A strong point of this paper is that the ontological approach here utilized can be readily exported throughout the countries where an AA of MMP's is required in compliance with the Habitats Directive; however, the domain ontology here developed is grounded on the normative framework that regulates MMP's in Italy, and, as a consequence, some adjustments would be necessary so as to reuse this ontology to describe the AA procedure in Member

states of the European Union other than Italy. Another important limitation to exportability of the ontology in other contexts lies in the fact that the definitions of concepts are based, at least to some extent, on Italian laws and regulations, technical documents and vocabularies; for this reason, the table of concepts here presented was partially built in Italian in the first place, and afterwards translated into English, which can cause some issues of semantic precision in English.

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