ANNALI DI BOTANICA
Ann. Bot. (Roma), 2014, 4: 9–17
Journal homepage: http://annalidibotanica.uniroma1.it

ECOLOGICAL CLASSIFICATION OF LAND AND ECOSYSTEM MAPPING. TOWARDS THE IMPLEMENTATION OF ACTION 5 OF THE EUROPEAN BIODIVERSITY STRATEGY TO 2020 IN ITALY

Capotorti G., Anzellotti I., Attorre F., Copiz R.*, Mollo B., Zavattero L., Blasi C.

Department of Environmental Biology, Sapienza University of Rome, P.le Aldo Moro 5, 00185, Rome, Italy
**Corresponding author: Telephone: +39 0649912422; e-mail: riccardo.copiz@uniroma1.it*

(Received 20 March 2014; received in revised form 01 April 2014; accepted 04 April 2014)

Abstract – The aim of the present paper is to illustrate the basic data and the methodological approach proposed for the implementation of Action 5 of the European Biodiversity Strategy in Italy. In particular, it focuses on a model for ecosystem mapping and characterisation at the country level that has been built with the interdisciplinary involvement of geobotanists, functional ecologists, forest scientists and zoologists. The first operational steps of the model are based on the cartographic integration between potential natural vegetation, biogeographic regions, and land cover maps. The final step entails characterising the mapped ecosystems in terms of Habitats Directive, local occurrence of threatened plant species and faunal components. The model is going to be tested in Italy, but should also be applied elsewhere in Mediterranean Europe, especially in those countries that have a comparable ecological complexity.

Keywords: biogeography, CORINE land cover, habitats, Mediterranean Europe, vegetation potential

Introduction

The ecological classification of land is the scientific practice that allows ecosystems to be recognised, characterised and mapped as spatially explicit entities on several scales and observation levels (Klijn & Udo de Haes, 1994; Bailey, 1996; Sims et al., 1996). Numerous ecologists from different schools, including those in Europe, North America and Australia, promote ecosystem mapping as a fundamental tool for biodiversity management and conservation (Yaffee, 1999; Leathwick et al., 2003; Metzger et al., 2013), with ecosystems being defined as habitats, vegetation units, ecological land units, environmental units, landscapes, ecoregions or bioregions.

The ecosystem approach, adopted in 2000 by the Conference of the Parties to the Convention on Biological Diversity, represents the foremost transposition of the afore-mentioned scientific orientation within the international policy context (CBD, 2004). Action 5 related to Target 2 of the new European Biodiversity Strategy to 2020, i.e. 'improve knowledge of ecosystems and their services in the EU', is moving in the same direction and a consistent framework to map and assess the state of ecosystems and their services is being applied at the European level by the MAES Working Group (Maes et al., 2013). Owing to the marked environmental and biogeographic heterogeneity across Europe, especially on the Mediterranean side of the continent, Member States are expected to provide a level of detail for this common framework that corresponds to the heterogeneity found in each country.

Some of the Member States, such as Portugal, Spain, and UK, have completed an ecosystem assessment at the national level which is based on a spatially explicit ecosystem mapping, and other Member States are involved in ongoing similar projects, such as Switzerland and several Balkan countries (http://termite.eea.europa.eu/uploads/document/

doi: 10.4462/annbotrm-11806

file/962/2011_06_23_update-on-ecosystem-assessments-in-europe-2-.pdf). The MAES framework has been explicitly designed to overcome the differences that have arisen between indicators and quantification methods adopted by each of these countries.
The aim of the present paper is to illustrate the basic data and the methodological approach proposed for the implementation of Action 5 of the European Biodiversity Strategy in Italy that is consistent with the European framework. It focuses on the first step of the implementation procedure, which concerns ecosystem mapping at the country level. The full procedure, promoted by the Italian Ministry for the Environment with the help of the Italian Botanical Society and of the Italian Zoological Union, includes additional steps for the assessment of ecosystems and the valuation of their services according to Green Infrastructure and Natural Capital Accounting perspectives.

State of the art on ecosystem knowledge in Italy

Italy, which is located in the southern Europe, central Mediterranean basin, is characterised by a complex biogeographic evolution combined with a particularly rich physical heterogeneity in terms of climate, physiography and soils. Biodiversity, in terms of genes, species and ecosystem components, is enriched by this complexity and further modulated by the long history of human land use (Blasi et al., 2007; Martellos et al., 2011).
An integrated process aimed at the ecological classification of land in Italy, which is based on various scientific disciplines including geobotany and landscape phytosociology (Géhu, 1988; Bohn & Neuhäusl , 2000/2003; Biondi et al., 2011; Blasi et al., 2011a), ecosystem geography (Bailey, 2004; Omernik, 2004) and landscape ecology (Forman & Godron, 1986; Zonneveld, 1995), has been in progress since 2000 (Blasi et al., 2000; Blasi et al., 2005; Blasi et al., 2011b). This classification has been based on updated and homogenised maps of physical factors at the national level, i.e. a phytoclimatic, a lithological and a geomorphological map (Blasi & Michetti, 2007; Capotorti et al., 2012a; Smiraglia et al., 2013). Moreover, natural vegetation potential has been investigated by an extensive network of regional experts on the basis of phytosociological field data and scientific knowledge on vegetation dynamics (Blasi et al., 2004; Rosati et al., 2008; Blasi & Frondoni, 2011).
Two complementary products have been obtained from the ecological classification of land: the 'Land Units map of Italy' (Smiraglia et al., 2013), which is oriented more towards physical determinism as a means of characterising the territory, and the 'Vegetation Series map of Italy' (Blasi, 2010), which is oriented more towards the ecological potential of given land unit types.
Although land units and sites with the same vegetation potential can be considered as "complex ecosystems" that may be used to survey, monitor, manage and sustainably develop the territory at the country level, they represent reference models rather than effective systems for the evaluation of conservation status and ecosystem services delivery.
As regards actual ecosystems, complete lists of the habitats according to Directive 92/43/CEE (Biondi et al., 2009), of the habitats according to the CORINE Biotopes classification (Angelini et al., 2009), and of vegetation types at class, order and alliance syntaxonomic levels (Biondi & Blasi, 2013) are now available for Italy. However, neither a real vegetation map nor a habitat map, which may be adopted as spatially explicit proxies for current ecosystems, yet exist for the entire territory.
The CORINE Land Cover (CLC) map at a 1:100,000 scale (updated for the year 2006) is the only existing and complete cartographic representation of current land cover setting in Italy. The legend consists of 5 classes at the first level, 15 classes at the second level and 44 classes at the third level. Unlike the more limited thematic detail that is adopted as a standard at the European level, most of the natural and semi-natural CLC classes are represented in Italy at the IV/V level (Table 1), thereby addressing the need for a better characterisation of forest, scrublands and grasslands to support sustainable management and the planning of natural resources (ISPRA, 2010). This document does not, however, yet depict the outstanding variability of vegetation types across Italy, e.g. the occurrence of different types of deciduous oak woods due to biogeographic, bioclimatic, morphological and edaphic discontinuity.

An integrated model for the mapping and characterisation of Italian ecosystems

Within the framework of the implementation of European Biodiversity Strategy Action 5 in Italy, we propose a model for improving the predictive value of the existing land cover map in terms of ecosystem characteristics (Figure 1). The expected result is a physiognomic map for the actual vegetation cover and agro-ecosystems that covers the whole of Italy and is hierarchically consistent with the more general ecosystem types adopted at the European level (Maes et al., 2013).
The model relies primarily on the integration between the CLC map 2006 (IV level) and the potential natural vegetation (Vegetation Series) map. The accuracy of this model is further improved by the biogeographic regionalisation adopted by the EU Habitats Directive (EEA, 2012), the

Table 1. Levels of the Italian Corine Land Cover legend (from ISPRA, 2010).

I Level	II Level	III Level	IV (V) Level
1 Artificial surfaces	11 Urban fabric	111 Continuous urban fabric	
		112 Discontinuous urban fabric	
	12 Industrial, commercial and transport units	121 Industrial or commercial units	
		122 Road and rail networks and associated land	
		123 Port areas	
		124 Airports	
	13 Mine, dump and construction sites	131 Mineral extraction sites	
		132 Dump sites	
		133 Construction sites	
	14 Artificial, non-agricultural vegetated areas	141 Green urban areas	
		142 Sport and leisure facilities	
2 Agricultural areas	21 Arable land	211 Non-irrigated arable land	2111 Intensive crops
			2112 Extensive crops
		212 Permanently irrigated land	
		213 Rice fields	
	22 Permanent crops	221 Vineyards	
		222 Fruit trees and berry plantations	
		213 Rice fields	
	23 Pastures	231 Pastures	
	24 Heterogeneous agricultural areas	241 Annual crops associated with permanent crops	
		242 Complex cultivation patterns	
		243 Land principally occupied by agriculture, with significant areas of natural vegetation	
		244 Agro-forestry areas	
3 Forest and semi natural areas	31 Forests	311 Broadleaved forest	3111 Evergreen oak forests (holm and cork oaks)
			3112 Deciduous oak forests (turkey, downy, Italian, sessile, pedunculate oaks)
			3113 Mixed forests dominated by other native broadleaved (maple, ash, hornbeam, flowering ash)
			3114 Chestnut forests
			3115 Beech forests
			3116 Hygrophilous forests (willows, poplars, alders)
			3117 Woods and former plantations dominated by exotic broadleaved (black locust and *Ailanthus altissima*)

follow →

I Level	II Level	III Level	IV (V) Level
		312 Coniferous forest	3121 Mediterranean pines and cypress forests (pine, maritime pine, Aleppo pine)
			3122 Oro-Mediterranean and mountain pine forests (black pine and larch, Scots pine, Bosnian pine)
			3123 Fir forests (silver fir and spruce)
			3124 Larch and/or Swiss pine forests
			3125 Woods and former plantations dominated by exotic conifers (Douglas fir, Monterey pine, white pine)
		313 Mixed forest	3131 Mixed coniferous and broadleaved forests (seven V level subtypes)
			3132 Mixed broadleaved and coniferous forests (five V level subtypes)
	32 Scrub and/or herbaceous vegetation associations	321 Natural grasslands	3211 Continuous grasslands
			3212 Discontinuous grasslands
		322 Moors and heathland	
		323 Sclerophyllous vegetation	3231 High maquis
			3232 Low maquis and garrigues
		324 Transitional woodland-shrub	
	33 Open spaces with little or no vegetation	331 Beaches, dunes, sands	
		332 Bare rocks	
		333 Sparsely vegetated areas	
		334 Burnt areas	
		335 Glaciers and perpetual snow	
4 Wetlands	41 Inland wetlands	411 Inland marshes	
		412 Peat bogs	
	42 Maritime wetlands	421 Salt marshes	
		422 Salines	
		423 Intertidal flats	
5 Water bodies	51 Inland waters	511 Water courses	
		512 Water bodies	
	52 Marine waters	521 Coastal lagoons	
		522 Estuaries	
		523 Sea and ocean	

physiognomic and syntaxonomic characterisation of the seral vegetation stages provided in the monograph that accompanies the Vegetation Series map (Blasi, 2010), the description of the habitats of community interest (Biondi et al., 2009; Biondi et al., 2012), and the analysis of the faunistic component associated with the different vegetation types (Boitani et al., 2003; Maiorano et al., 2006).

The first operational step entails simplifying the potential natural vegetation map and its legend. The original map is, in fact, very detailed and contains approximately 300 types and 4,900 polygons, which are derived not only from the structural and physiognomic diversity, but also from the syntaxonomic diversity, of the mature seral stages. Aggregation rules will be based on i) the structural and/or physiognomic characteristics of these stages, e.g. ambits for 'acidophilous chain of herbaceous vegetation series of high mountain areas' or ambits for '*Quercus pubescens* forests', and ii) on the biogeographic setting of their sites of occurrence, which will lead, for example, to '*Quercus pubescens* forests' being divided in 'Alpine' 'Continental' and 'Mediterranean' (Table 2).

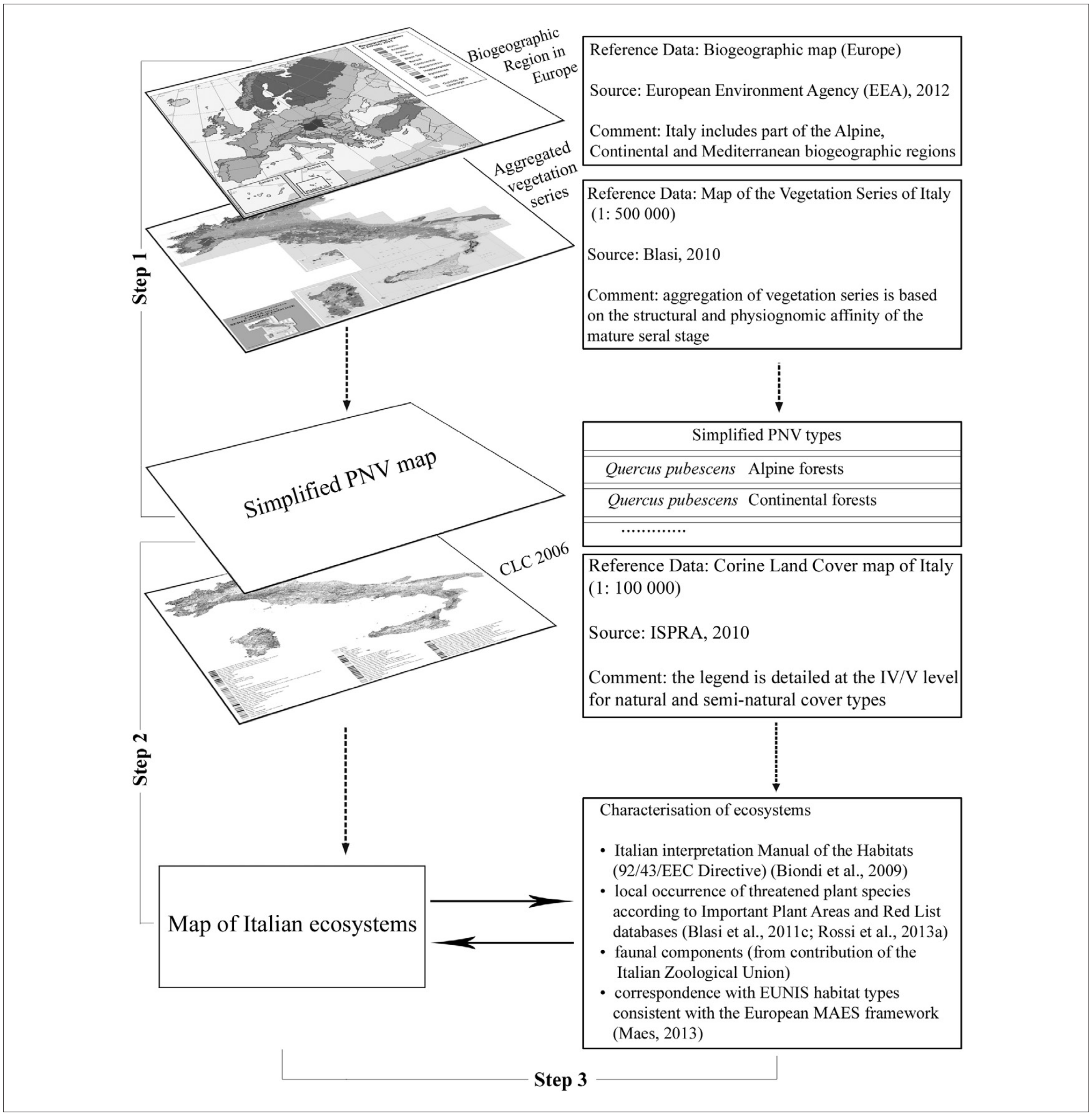

Figure1: Integrated model for the mapping and characterisation of Italian ecosystems.
(Abbreviations: PNV/Potentian Natural Vegetation; CLC/Corine Land Cover; MAES/Mapping and Assessment of Ecosystems and their Services).

Table 2. Simplified potential natural vegetation (PNV) for the characterisation and mapping of Italian ecosystems. Some examples concerning deciduous oak forest PNV types.

Original polygons of vegetation series (legend voices from: Blasi, 2010)	Structure	Physiognomy (dominant species of the mature seral stage)	Biogeographic setting (data source: EEA, 2012)	Simplified PNV
Western Alps soil independent *Quercus pubescens* vegetation series (*Quercion pubescenti-petraeae*)	Deciduous forest	Downy oak (*Quercus pubescens*)	Alpine	***Quercus pubescens* Alpine forests**
Central and southern Alps acidophilous *Quercus pubescens* vegetation series (*Arabidi turritae-Querco pubescentis sigmetum*)	Deciduous forest	Downy oak (*Quercus pubescens*)	Alpine	
Central Apennine neutrobasiphilous *Quercus pubescens* vegetation series (*Cytiso sessilifolii-Querco pubescentis sigmetum*)	Deciduous forest	Downy oak (*Quercus pubescens*)	Alpine	
Northern Apennine subacidophilous *Quercus cerris* vegetation series (*Erythronio dentis-canis-Quercion petraeae*)	Deciduous forest	Turkey oak (*Quercus cerris*)	Mediterranean	***Quercus cerris* Mediterranean forests**
Umbria and Marche Apennine neutrobasiphilous *Quercus cerris* vegetation series (*Aceri obtusati-Querco cerridis sigmetum*)	Deciduous forest	Turkey oak (*Quercus cerris*)	Mediterranean	
Central and northern pre-Apennine neutrobasiphilous *Quercus cerris* vegetation series (*Lonicero xylostei-Querco cerridis sigmetum*)	Deciduous forest	Turkey oak (*Quercus cerris*)	Mediterranean	

The second step entails attributing the CLC classes to different ecosystem types depending on their occurrence in different ambits of aggregated vegetation potential. For example, according to the afore-mentioned case, integration between the two documents will allow the '*Quercus pubescens* Mediterranean forests' ecosysytem to be distinguished from the '*Quercus cerris* Mediterranean forests' ecosystem within the IV level CLC class '3.1.1.2 Deciduous oak forests (dominated by *Quercus cerris* and/or *Q. pubescens* and/or *Q. frainetto* and/or *Q. petraea* and/or *Q. robur*)'.

The integration is expected to provide a finer definition not only of forests, but also of shrub and herbaceous ecosystems through the full description of the seral stages that belong to each vegetation series. The description will help to establish, for example, that CLC polygons belonging to the class '3.2.1. Natural grassland' and falling within the ambit of '*Quercus cerris* Mediterranean forests' are prevalently dominated by either *Bromus* species in semi-natural conditions or *Agropyron* species in post-crop recovery aspects.

The third step consists of a further characterisation of the ecosystem types in terms of: i) Habitats Directive, e.g. as regards the environmental conditions, ecological peculiarities, possible variants and subtypes, structural features, floristic composition, dynamic, associated alien species, and rarity (Biondi et al., 2009); ii) local occurrence of threatened plant species, according to the project for the Important Plant Areas of Italy (Blasi et al., 2011c) and the new IUCN Red List of vascular plants (Rossi et al., 2013a, 2013b); iii) faunal components of the ecosystems, through the contribution of scientists from the Italian Zoological Union.

Discussion

Italy has the adequate scientific knowledge to undertake a process of ecosystem mapping on a national scale, as is required of each Member State by the EU Biodiversity Strategy to 2020.

Indeed, updated documents and maps on the ecological classification of land and vegetation potential, actual land cover /land use, vegetation and habitat types are available for the entire country. Geobotanists have, on the basis of these data combined with their expertise, thus been able to build an integrated model for the characterisation and mapping of Italian ecosystems that may be adopted for a wide range of purposes, e.g. to assess the faunal component of the ecosystem types and, subsequently, the ecosystem conservation status and associated services.

The suitability of this model may also be attributed to the involvement of complementary skills, such as those related to functional ecology, forestry and zoology, in the early stages of the comprehensive project of 'Mapping and Assessment of Ecosystems and their Services' conducted in Italy. This interdisciplinary involvement has already proved to be very effective in other pilot projects at the sub-national level, including the design of green infrastructures (Blasi et al., 2008), the assessment of forest naturalness (Blasi et al., 2010; Marchetti et al., 2010), the natural capital account for protected areas (Capotorti et al., 2012b), and the valuation of ecosystem services (Manes et al., 2012a, 2012b; Marchetti et al., 2012; Blasi et al., 2011d).

Conclusions

The strength of the model proposed here for the mapping of ecosystems resides above all in the fine characterisation it provides of the actual land cover types by taking into account the ecological potential of land, vegetation dynamics and biogeographic setting. The model is going to be tested in Italy, but should also be applied elsewhere in Mediterranean Europe, especially in those countries that have a comparable environmental and biogeographic complexity.

References

Angelini P., Bianco P., Cardillo A., Francescato C., Oriolo G., 2009. Gli habitat in Carta della Natura. Schede descrittive degli habitat per la cartografia alla scala 1:50.000. ISPRA, Manuali e Linee Guida 49/2009. Retrived from http://www.isprambiente.it

Bailey R. G., 1996. Ecosystem geography. Springer-Verlag, New York.

Bailey R. G., 2004. Identifying ecoregion boundaries. Environmental Management 34(1), S14–S26.

Biondi E., 2011. Phytosociology today: Methodological and conceptual evolution. Plant Biosystems 145(1), 19-29.

Biondi E., Blasi C., 2013. Prodromo della vegetazione d'Italia. Retrived from http://www.prodromo-vegetazione-italia.org/

Biondi E., Blasi C., Burrascano S., Casavecchia S., Copiz R., Del Vico E., Galdenzi D., Gigante D., Lasen C., Spampinato G., Venanzoni R., Zivkovic L., 2009. Manuale Italiano di interpretazione degli habitat della Direttiva 92/43/CEE. Società Botanica Italiana. Ministero dell'Ambiente e della tutela del territorio e del mare, D.P.N. Retrived from http://vnr.unipg.it/habitat/

Biondi E., Burrascano S., Casavecchia S., Copiz R., Del Vico E., Galdenzi D., Gigante D., Lasen C., Spampinato G., Venanzoni R., Zivkovic L., Blasi C., 2012. Diagnosis and syntaxonomic interpretation of Annex I Habitats (Dir. 92/43/EEC) in Italy at the alliance level. Plant Sociology 49(1), 5-37.

Blasi C., 2010. La Vegetazione d'Italia con Carta delle Serie di Vegetazione in scala 1:500.000. Palombi & Partner S.r.L, Rome.

Blasi C., Biondi E., Izco J., 2011a. 100 years of plant sociology: A celebration. Plant Biosystems 145(1), 1-3.

Blasi C., Boitani L., La Posta S., Manes F., Marchetti M. (Eds), 2007. Biodiversity in Italy. Contribution to the National Biodiversity Strategy. Palombi Editori, Rome.

Blasi C., Capotorti G., Frondoni R., 2005. Defining and mapping typological models at the landscape scale. Plant Biosystems 139(2), 155-163.

Blasi C., Capotorti G., Frondoni R., Guida D., Mollo B., Smiraglia D., Zavattero L., 2011b. Vegetation science and the ecoregional approach: a proposal for the ecological land classification of Italy. Fitosociologia 48 (1), 67-80.

Blasi C., Carranza M.L., Frondoni R., Rosati L., 2000. Ecosystem classification and mapping: a proposal for Italian landscape. Applied Vegetation Science 3, 233-242.

Blasi C., Feoli E., Galante G., Incerti G., Manes F., Zaccarelli N., Zurlini G., Capotorti G., 2011d. Ecoregions of Italy and ecological services. Book of abstracts, First International Symposium of the FIP on the Global Strategy for Plant Conservation. Botanical Garden of the University of Valencia, Valencia.

Blasi C., Filibeck G., Frondoni R., Rosati L., Smiraglia D., 2004. The map of the vegetation series of Italy. Fitosociologia 41 (1), 21-25.

Blasi C., Frondoni R., 2011. Modern perspectives for plant sociology: the case of ecological land classification and the ecoregions of Italy. Plant Biosystems 145, 30-37.

Blasi C., Marchetti M., Chiavetta U., Aleffi M., Audisio P., Azzella M. M., Brunialti G., Capotorti G., Del Vico E., Lattanzi E., Persiani A.M., Ravera S., Tilia A., Burrascano S., 2010. Multi-taxon and forest structure sampling for old-growth indicators identification and forest monitoring.

Plant Biosystems 144 (1), 160-170.

Blasi C., Marignani M., Copiz R., Fipaldini M., Bonacquisti S., Del Vico E., Rosati L., Zavattero L., 2011c. Important Plant Areas in Italy: from data to mapping. Biological Conservation 144, 220-226.

Blasi C., Michetti L., 2007. The climate of Italy. In: C. Blasi, L. Boitani, S. La Posta, F. Manes, M. Marchetti (Eds) Biodiversity in Italy, pp. 57-66. Palombi Editori, Roma.

Blasi C., Zavattero L., Marignani M., Smiraglia D., Copiz R., Rosati L., Del Vico E., 2008. The concept of land ecological network and its design using a land unit approach. Plant Biosystems 142 (3), 540–549.

Bohn U., Neuhäusl R. (Eds.), 2000/2003. Map of the Natural Vegetation of Europe/Scale 1: 2,500,000. Federal Agency for Nature Conservation, Bonn, Germany.

Boitani L., Falcucci A., Maiorano L., Montemaggiori A., 2003. National Ecological Network: The Role of the Protected Areas in the Conservation of Vertebrates. DCN – Ministero Ambiente, Dep. BAU – University of Rome "La Sapienza, IEA".

Capotorti G., Guida D., Siervo V., Smiraglia D., Blasi C., 2012a. Ecological classification of land and conservation of biodiversity at the national level: The case of Italy. Biological Conservation 147, 174-183.

Capotorti G., Zavattero L., Anzellotti I., Burrascano S., Frondoni R., Marchetti M., Marignani M., Smiraglia D., Blasi C., 2012b. Do National Parks play an active role in conserving the natural capital of Italy? Plant Biosystems 146(2), 258-265.

CBD /Convention on Biological Diversity, 2004. Ecosystem approach. COP 7 Decision VII/11. Retrieved from http://www.cbd.int/decision/cop/?id=7748.

EEA, 2012. Biogeographic regions in Europe. Retrieved from http://www.eea.europa.eu/data-and-maps/figures/biogeographical-regions-in-europe-1

Forman R.T.T., Godron M., 1986. Landscape ecology. John Wiley & Sons, New York.

Géhu J.M., 1988. L'analyse symphytosociologique et geosymphytosociologique de l'espace. Theorie et methodologie. Colloques Phytosociologiques XVII, 11-46.

ISPRA, 2010. La realizzazione in Italia del Progetto Corine Land Cover 2006. ISPRA, RAPPORTI 131/2010. Retrived from http://www.isprambiente.gov.it/it/pubblicazioni/rapporti/la-realizzazione-in-italia-del-progetto-corine

Klijn F., Udo de Haes H. A., 1994. A hierarchical approach to ecosystems and its implications for ecological land classification. Landscape Ecology 9(2), 89-104.

Leathwick J. R., Overton J. M., McLeod M., 2003. An Environmental Domain Classification of New Zealand and Its Use as a Tool for Biodiversity Management. Conservation Biology 17, 1612-1623.

Maes J., Teller A., Erhard M., Liquete C., Braat L., Berry P., Egoh B., Puydarrieux P., Fiorina C., Santos F., Paracchini M.L., Keune H., Wittmer H., Hauck J., Fiala I., Verburg P.H., Condé S., Schägner J.P., San Miguel J., Estreguil C., Ostermann O., Barredo J.I., Pereira H.M., Stott A., Laporte V., Meiner A., Olah B., Royo Gelabert E., Spyropoulou R., Petersen J.E., Maguire C., Zal N., Achilleos E., Rubin A., Ledoux L., Brown C., Raes C., Jacobs S., Vandewalle M., Connor D., Bidoglio G., 2013. Mapping and Assessment of Ecosystems and their Services. An analytical framework for ecosystem assessments under action 5 of the EU biodiversity strategy to 2020. Publications office of the European Union, Luxembourg.

Maiorano L., Falcucci A., Boitani L., 2006. Gap analysis of terrestrial vertebrates in Italy: priorities for conservation planning in a human dominated landscape. Biological Conservation 133, 455-473.

Manes F., Blasi C., Salvatori C., Capotorti G., Galante G., Feoli E., Incerti G., 2012a. Natural vegetation and ecosystem services related to air quality improvement: tropospheric ozone removal by evergreen and deciduous forests in Latium (Italy). Annali di Botanica 2, 79-86.

Manes F., Incerti G., Salvatori E., Vitale M., Ricotta C., Costanza R., 2012b. Urban ecosystem services: tree diversity and stability of tropospheric ozone removal. Ecological Applications 22(1), 349-360 .

Marchetti M., Sallustio L., Ottaviano M., Barbati A., Corona P., Tognetti R., Zavattero L., Capotorti G., 2012. Carbon sequestration by forests in the National Parks of Italy. Plant Biosystems 146(4), 1001-1011.

Marchetti M., Tognetti R., Lombardi F., Chiavetta U., Palumbo G., Sellitto M., Colombo C., Iovieno P., Alfani A., Baldantoni D., Barbati A., Ferrari B., Bonacquisti S., Capotorti G., Copiz R., Blasi C., 2010. Ecological portrayal of old-growth forests and persistent woodlands in the Cilento and Vallo di Diano National Park (southern Italy). Plant Biosystems 144 (1), 130-147.

Martellos S., Attorre F., De Felici S., Cesaroni D., Sbordoni V., Blasi C., Nimis P. L., 2011. Plant sciences and the Italian National Biodiversity Network. Plant Biosystems 145 (4), 758-761.

Metzger M. J., Bunce R. G. H., Jongman R. H. G., Sayre R., Trabucco A., Zomer R., 2013. A high-resolution bioclimate map of the world: a unifying framework for global biodiversity research and monitoring. Global Ecology and Biogeography, 22: 630-638.

Omernik J.M., 2004. Perspectives on the nature and definition of ecological regions. Environmental Management 34 (1), 27-38.

Rosati L., Marignani M., Blasi C., 2008. A gap analysis comparing Natura2000 vs National Protected Area network with potential natural vegetation. Community Ecology 9(2), 147-154.

Rossi G., Montagnani C., Abeli T., Gargano D., Peruzzi L., Fenu G., Magrini S., Gennai M., Foggi B., Wagensommer R.P., Ravera S., Cogoni A., Aleffi M., Alessandrini A., Bacchetta G., Bagella S., Bartolucci F., Bedini G., Bernardo L., Bovio M., Castello M., Conti F., Domina G., Farris E., Gentili R., Gigante D., Peccenini S., Persiani A.M., Poggio L., Prosser F., Santangelo A., Selvaggi A., Villani M.C., Wilhalm T., Zappa E., Zotti M., Tartaglini N., Ardenghi N.M.G., Blasi C., Raimondo F.M., Venturella G., Cogoni D., Puglisi M., Campisi P., Miserere L., Perrino E.V., Strumia S., Iberite M., Lucchese F., Fabrini G., Orsenigo S., 2013a. Are Red Lists really useful for plant conservation? The New Red List of the Italian Flora in the perspective of national conservation policies. Plant Biosystems, published online. DOI: 10.1080/11263504.2013.868375

Rossi G., Montagnani C., Gargano D., Peruzzi L., Abeli T., Ravera S., Cogoni A., Fenu G., Magrini S., Gennai M., Foggi B., Wagensommer R.P., Venturella G., Blasi C., Raimondo F.M., Orsenigo S. (Eds.), 2013b. Lista Rossa della Flora Italiana. 1. Policy Species e altre specie minacciate. Comitato Italiano IUCN e Ministero dell'Ambiente e della Tutela del Territorio e del Mare. Retrived from http://www.minambiente.it/sites/default/files/archivio/biblioteca/protezione_natura/lista_rossa_flora_italiana_policy_species.pdf

Sims R.A., Corns I.G.W., Klinka K., 1996. Global to local: ecological land classification. Environmental Monitoring and Assessment 39, 1-10.

Smiraglia D., Capotorti G., Guida D., Mollo B., Siervo V., Blasi C., 2013. Land units map of Italy. Journal of Maps 9(2), 239-244.

Yaffee S. L., 1999. Three Faces of Ecosystem Management. Conservation Biology 13, 713-725.

Zonneveld I.S., 1995. Land ecology. SPB Academic Publishing, Amsterdam.