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# Report on relations between vegetation types derived from land cover maps and habitats

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| **Main Authors:** | Valeria Tomaselli (CNR) |
| | and contribution by : Palma Blonda (CNR), Carmela Marangi (CNR), Francesco Lovergine (CNR), Andrea Baraldi (BACRES), Paola Mairota (UNIBA), Massimo Terzi (CNR), Sander Mücher (Alterra) |

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| **Abstract** | D6.1 find the relation between vegetation types derived from Land Cover maps and habitat types related to the Habitat Directive and other classification systems widely used in Europe for habitat mapping. Three Land Cover class sets are compared and related to the habitats of interest to select the class set providing an unequivocal class description closest to habitat description and consequently the most useful for the successive provision of Habitat maps from Land Cover maps. |
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## Signatures

| **Written by** | **Responsibility- Company** | **Date** | **Signature** |
|---|---|---|---|
| Valeria Tomaselli | Responsible for D6.1, CNR | 25/03/ 2011 | |
| **Verified by** | | | |
| Harini Nagendra | WP6 Leader, ATREE | 30/03/2011 | |
| **Approved by** | | | |
| Maria Petrou | Quality Manager, CERTH | | |
| Palma Blonda | Project Coordinator, CNR | 31/03/11 | |

# Table of Contents

# 1. Executive summary

In the framework of the WP6 entitled *EODHaM modelling module development*, three tasks have been allocated. Task 6.1 is related to the *Modelling at habitat level.* Deliverable D6.1 is the first Deliverable of WP6, Task 6.1. The main objectives of Task 6.1 are:

- to find the relation between the units of vegetation maps (obtained with field samples) and the habitats types related to the Habitat Directive (and other classification systems widely used in Europe for habitat mapping);
- to find the relation between land cover/land use categories (obtained through remote sensing observation) and habitat types, also on the basis of previous experience;
- to construct a dictionary for linking different land cover/land use into European habitat classification systems.

D6.1 is based on the D2.1 Deliverable, describing the set of selected Biodiversity indicators to be considered in the BIO_SOS project,and the D2.2 Deliverable, reporting the main characteristics of the test sites with the description of habitats and land cover classes of main concern. In turn, D6.1 will provide useful input for Deliverable D4.4, concerning the selection criteria of EO data to be analyzed and also for D6.10 concerning the design and development of the software for habitat map production, to be provided within WP6. It is also at the base of the EO data analysis in WP5.

In the present Deliverable, both natural and not natural habitat types of two Italian Natura 2000 training test sites are first related to the following habitat classification systems: CORINE biotopes, Annex 1 of the European Directive, EUNIS and the recently established General Habitat Categories (GHCs) [EBONE Handbook 2011] since some specific habitats characterizing these two sites as well as other Mediterranean sites are not included in the Annex I description. It underlines the need to deal with the monitoring and conservation of these habitats within the European Directive. Then three Land Cover class sets are compared with and linked to the habitats of interest. The objective of such a comparison is the selection of the class set providing for each site:
*a)* the land cover class set with an unequivocal class description closest to habitat description and consequently the most useful for the successive provision of Habitat maps from Land Cover maps by integrating (the minimum number) of additional environmental attributes (such as, geological structure, soil formation and type, slope, aspect and altitude of the plots, etc.) and in-situ data;
b) the set of rules for the most efficient implementation of the algorithm for automatic class extraction by EO image analysis.
An additional issue to be considered when dealing with land cover class selection and description is the scale of observation/analysis. Beside CORINE Land Cover, the International Global Biosphere Programme IGBP and FAO-Land Cover Classification System (LCCS) have been considered. CLC has been already used in D2.2 to list the set of land cover classes for each site according to existing land cover maps. It is generally used at the European level for GMES core services at High Resolution. FAO-LCCS uses life forms and has been recently adopted by the Global Land Cover 2000 (GLC2000) Project. As recognized in [EBONE Handbook, Bunce et al 2011] FAO-LCCS can be a basis for the definition of habitats through an ecological refinement of land cover classes. As a conclusion of Task 6.1, the FAO-LCCS classification system turns out to be the best candidate to be used for Land Cover mapping as a basis of habitat mapping according to Annex I of the European Directive as well as for GHCs habitat surveillance and monitoring methodology implementation from remotely sensed data. It is described as independent of scales or means used to map. In addition, FAO-LCCS uses a set of diagnostic criteria that allow relation with both existing classifications and other legends and habitats [EBONE GHC Handbook, Version 20110131].

The selected Land Cover classification system can be used in WP4, for on-site data collection of updated ground truth to be used for the validation of LC maps provided within WP5 by RS-IUS module of the EODHaM System.

# 2. Introduction

BIO_SOS is a pilot project for the effective and timely multi-annual monitoring of NATURA 2000 sites and their surroundings in support to management decisions and for the reporting on habitat status and trends according to National and EU obligations. The BIO_SOS objectives include:

- the development and validation of a prototype multi-modular system to provide a reliable long term biodiversity monitoring service at high (HR) to very high-spatial (VHR) resolution;
- the embeding of monitoring information (changes) in innovative ecological (environmental) modelling for Natura 2000 site management(modules will be developed for ecological modelling at: *1)* habitat level for habitat map production from both land cover and on-site data. *2)* landscape level for scenario analysis);
- the continuity of previous/on-going projects on Biodiversity monitoring, e.g BioHab and EBONE.

Expected output products linked to the development of the BIOS_SOS proposed EODHaM monitoring of NATURA 2000 tests sites, are:

- Land Cover (LC) and Land Cover Change (LCC) maps from HR and mainly VHR, to be considerd as an extension of GMES *core services;*
- Habitat (Ha) and Habitat change (HaC) maps as well as Biodiversity Indicators, as an extension of GMES *downstream services*.

Task 6.1 is devoted to ecological modelling at habitat level.

Habitat maps can be obtained by interpreting *land cover maps* of sufficient detail with ancillary data, other EO derived products by re-labelling and, where appropriate, by merging similar land cover classes, according to the 92/43 EEC Directive and to GHCs based on life forms as defined in the previous BioHab project [Bunce *et. al.*. 2008, 2010].

To find the correct relation between the different Land Cover (LC) classes and Habitat types may create some difficulties, due especially to different levels of definition and to different criteria used by the specific classification systems (e.g., in Habitat classification, morphological-structural or physio-ecological criteria rather than phytosociological are considered). The main classification systems dealing with land cover or habitat are limited in their ability to read all aspects of the landscape and often do not contain the whole variety of occurring land covers or habitat types. Some of them describe natural and semi-natural vegetation types in detail while arrange cultivated or managed areas in coarse classes.

For example, the Directive 92/43 EEC (Habitat Directive) only considers natural habitats of Community interest, while agricultural or man-made environments are not considered. Furthermore, there are natural vegetation types, some of which are significant from an ecological point of view, that do not correspond to any habitat *sensu* Directive 92/43 EEC (because they are not mentioned in Annex I). Therefore, this may create confusion in mapping some specific landscapes.

A precise awareness of the potential and limitations of each system is essential in using properly and in correlating the different systems and the related products. The development of protocols for harmonisation of different systems is necessary to convert land cover and habitat categories recorded in previous different monitoring projects in Europe to enable dataset harmonization and standardization.

Therefore, it is essential for BIO_SOS habitat mapping from EO image analysis to compare different Land Cover classification systems for the selection of the most flexible and cost-effective scheme for the specific application in relation to different Habitat classification systems. Some Italian training NATURA 2000 sites will be used for such a comparison.

## 2.1 Habitat classification schemes

The habitat schemes considered in D6.1 are the following.

1) CORINE Biotopes, that is the first uniform classification system for EU habitats.

2) Annex I of the Habitat Directive. The Directive 92/43/EEC or Habitat Directive is the main European Union legal instrument concerning biodiversity and nature conservation of natural habitats. Nevertheless, its habitat classification system (Annex I) shows several gaps. Its structure is not always suitable in detecting habitat changes in landscape elements.

3) EUNIS, a comprehensive pan-European habitat classification system, covering all types of habitats from natural to artificial and designed to be connected with the other main European habitat classification systems.

4) The more recent General Habitat Categories (GHCs) methodology proposed by the BioHab and EBONE projects for habitat surveillance and monitoring. The GHCs are specifically designed to be recorded consistently, especially for detection and mapping of changes. Furthermore, this system applies stringent criteria to ensure that real change is recorded and not results that are distorted by differences in definitions, between observers or recording techniques. One of the key elements of this approach is its potential for the detection and evaluation of flows between habitats [Bunce et al., 2008] .

## 2.2 Land cover classification systems and Land Cover class sets

Land covers (LCs) are 3-D object-models or classes of 3-D objects in the real (3-D) world. LCs are used in a (3-D) land cover classification system of spaceborne (2-D) images, also called “land cover classification scheme", consisting of [Congalton, 1991 ] :

(a) a discrete and finite set of LC classes (categorical variables), equivalent to concepts in the real (3-D) world (e.g., needle-leaf forest); in practice, the LC class set is the adopted classification map legend; and
(b) decision rules in the (2-D) RS image domain (related to the RS image understanding system design and implementation phases) for assigning semantic labels, belonging to a discrete and finite set of LC classes, to image primitives (e.g., pixels, segments).

A classification scheme should be selected by the application developer based on the project objectives and requirements.

In general, any classification scheme must be [Congalton, 1991]:

- *mutually exclusive*, i.e., any image information primitive (e.g., pixel, segment) to be classified should fall into one and only one class (categorical variable), and
- *totally exhaustive*, i.e., every image information primitive is labelled according to the available discrete and finite set of classes (classification map legend).

In practice, these two requirements mean that the adopted discrete and finite set of land cover classes must include class “others” or “outliers”. It is noteworthy that the definition of a rejection rate is a well-known objective of any RS image classification system, e.g., refer to [Swain and Davies, 1978]. Nonetheless, in RS it is a common practice often to apply image classifiers without any outlier detection strategy.

The discrete and finite set of LC classes (classification map legend) includes:

(1) a hierarchical class index (numerical identifier);

(2) a class name and

(3) an (unequivocal) description/explanation/definition in terms of (3-D) surface properties in the real world. This description can be accomplished by a combination of surface type attributes (e.g., tree percent cover > 60% and tree height > 2 m and mixture of forest types none of which exceeds 60% of landscape).

According to [Congalton, 1991], every remotely sensed data understanding project should provide enough information for the LC classification scheme to be reproduced.

In RS common practice, many land cover classification schemes adopt a classification map legend which already exists in existing literature, e.g., the well known CORINE Land Cover (CLC) class set. For example, the CLC was adopted as LC class set in the BIO_SOS Deliverable 2.2 to describe the LC classes of each test site on the basis of available land cover maps (e.g., CORINE2000 for the Greek test sites and CORINE2006 for the Portuguese test sites). CLC is also used in the GMES GEOLAND projects for the Land Cover Map core service.

In general, it is very advantageous to adopt a LC class set hierarchical in nature. The reason is twofold. Firstly, classes within a hierarchical classification scheme can be grouped into more abstract classes based on semantic similarity criteria, i.e., a hierarchical LC class set comprises several semantic granularities. Secondly, a hierarchical LC class set can be applied to a variety of spatial scales (each spatial scale requiring the selection of a scale-specific semantic granularity). For example, the former characteristic is particularly useful to meet the minimum required accuracy standard when a specific sub-class accuracy is below this standard [Congalton, 1991] and/or its difficult to differentiate between sub-classes at a given spatial scale.

The LC class sets (classification map legends) compared in this deliverable are listed below.

1) The European CORINE Land Cover class nomenclature. It is hierarchical but the description (definition) of LC classes appears vague (poorly posed) and/or characterized by low flexibility and a rigid schematic structure for describing natural and semi natural vegetation types with respect to all habitat classification systems and mainly Annex 1 of the Habitat Directive, which is at present the core European Union legal instrument for Biodiversity and Nature conservation.
2) The International Geosphere-Biosphere Programme (IGBP) DISCover Land Cover classification System. IGBP-DISCover is not hierarchical, but it is well posed as it includes (unequivocal) description/explanation of each surface type in the real world. 17 land cover classes are considered. However, these classes are too coarse for the identification of habitats according to Annex I.
3) The Land Cover Classification System as developed by FAO [LCCS, Di Gregorio and Jansen 1998; 2005]. It is noteworthy that, according to the nomencalture adopted in this deliverable inline with the work of Congalton [Congalton, 1991], LCCS is NOT (!) a LC classification system, which contradicts the LCCS name itself, but an LC class set (legend). The LCCS class set analysed in Section 5.3 and Section 6. Since habitats, as defined in the EBONE manual handbook [Handbook, Version 20110131] can be considered an ecological refinement of land cover categorization as developed by FAO. The FAO-LCCS is based on the use of a set of independent diagnostic criteria rather than on establishing a pre-defined land-cover class set. It is both hierarchical and well posed.

## 2.3 Objectives and content outline.

The main objectives of Task 6.1 (*Modelling at habitat level*) are:

- to find the relation between the units of vegetation maps (obtained with field samples) and the habitat types related to the Habitat Directive and other classification systems widely used in Europe for habitat mapping;
- to find the relation between land cover/land use categories obtained through remote sensing observation and habitat types, also on the basis of previous experience.

The habitat classification systems most commonly used in Europe will be first illustrated and compared in Section 3, highlighting strengths and weaknesses. Tables comparing the different habitat taxonomies for some Italian training sites, e.g. IT3 and IT4 (see D2.2) will be provided. Then, in Section 4, the Land Cover (LC) class sets listed in Section 2.2 will be compared and their usefulness for habitat map production will be evaluated in terms of: *easiness to use*, *the level of details for physiognomy/structural*

*features finalized for the final habitat detection and the number of additional in-situ and ancillary additional data/indicators needed to derive Ha from LC maps*. Finally, translation Tables between some of the main LC class sets and Habitat classification systems will be provided for the Italian training sites IT3 and IT4.

# 3. Habitat types Classification systems

In this section the main habitat classification systems more widely used in Europe are presented. It is beyond the scope of the present deliverable to provide a full and comprehensive description of all systems or programs for classification of European habitats. Instead, only the most widely used and potentially useful to the aims of the project are presented.

## 3.1 CORINE Biotopes

The CORINE Biotopes Project [Commission of European Community, 1991a; Moss and Wyatt, 1994] was launched in 1985 in the framework of the CORINE programme (COoRdination of INformation on the Environment) to respond to the need of comprehensive, complete and compatible information on the environment in the European Community. The aim of the CORINE Biotopes Project was the creation of a uniform classification for European habitats.

The first outcome of the CORINE Biotopes project was the realization of the CORINE Biotopes site database, a database containing information about location and status of ecosystems, habitats and species in need of protection.

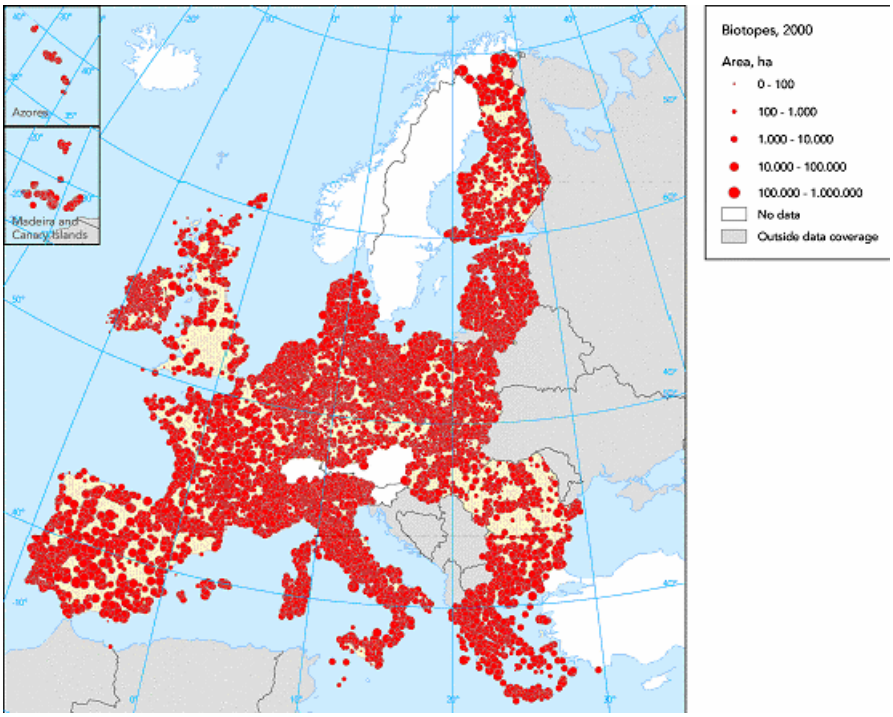


**Figure 1 – Geographic view of the biotopes as area circles**
(source: http://www.eea.europa.eu/data-and-maps/figures/corine-biotopes-map ).

Another outcome of the CORINE Biotopes project was the CORINE Biotopes Habitat Classification, mainly based (as regards natural and semi-natural habitats) on phytosociological classification and including all those habitats essential to the survival of distinctive populations of rare or sensitive species of plants or animals. The hierarchical structure of this habitat classification includes, at the first level, seven main divisions: coastal, wetland, grassland and scrub, woodland, marsh and bog, rocky and agricultural habitats. The second level defines the most important subdivisions of each of these categories. Further levels lead to more detailed habitat categories. This habitat classification is hierarchically structured in categories identified by codes, comprising a wide syntax at the landscape

level to alliances and associations. The individual habitat types often coincide with phytosociological units (alliances or associations).The CORINE Biotopes Habitat Classification system includes also Agricultural and Artificial landscape elements.

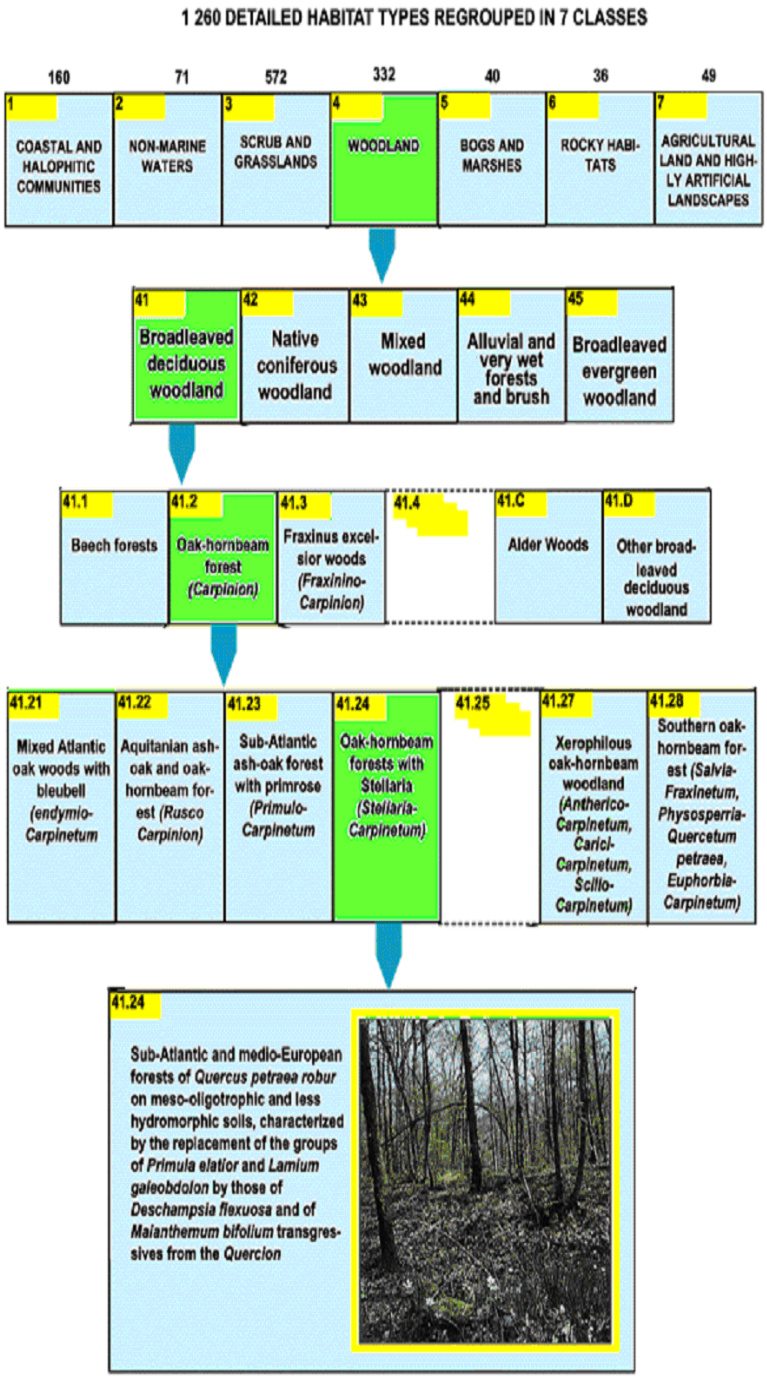


**Figure 2 - CORINE Biotopes Habitat coding system (European Communities, 1991)**

The CORINE Biotopes provided the initial basis for the Commission work on NATURA 2000 and for the description of the Annex I habitat types. The classification was further developed into the Palaearctic classification [Devillers & Devillers-Terschuren, 1993] and the associated Physis database [Devillers et al, 1996], and later into the EUNIS habitat classification (http://eunis.eea.europa.eu/).

The CORINE Biotopes Habitat Classification has been used in several national and international programs, e. g., it has been adopted for the realization of the Map of Nature in Italy [Zurlini et al., 1999; AA.VV., 2004] aiming at supplying an overall evaluation of all the naturalistic heritage of Italy, including the areas which are not officially Protected.

## 3.2 Annex I of the Habitat Directive

Annex I of the Directive 92/43/EEC or Habitat Directive [Council Directive, 1992] is based on the hierarchical classification of European habitats developed in the framework of the CORINE Biotopes project. Only those considered of Community interest were listed and coded in Annex I of Directive 92/43 (Habitats Directive). The Community Directive 97/62 provided some scientific-technical adjustment.

The Habitat Directive (Council of the European Union, 2007) is the main European Union legal instrument concerning biodiversity and conservation of natural habitats [Ladoux et al 2000; Levantis and Kaltsa 2002; Vershuuren, 2002; Mehtälä and Vuorisalo 2007; Bunce et al 2008; Mucher et al 2009].

Annex I of the Habitat Directive, like all the other main European habitat classifications (CORINE Biotopes, Palaearctic Classification, EUNIS), is composed of phytosociology-based habitat types, mostly distinguished by their floristical and geographical characteristics [Bölöni et al. 2007]. Nevertheless, some widely recognized habitats are not directly linked to vegetation associations [Rodwell et al. 2002].

The Habitat Directive classification system considers only natural and semi-natural environments of Community interest, excluding all other vegetated areas, such as cultivated areas, or tree plantations or urban vegetated landscapes.

## 3.3 EUNIS

EUNIS is the European Nature Information System, a project launched in 2000 and developed and managed by the European Topic Centre for Nature Protection and Biodiversity (ETC/NPB in Paris) for the European Environment Agency (EEA) and the European Environmental Information Observation Network (EIONET).

EUNIS classification is a comprehensive pan-European system, covering all types of habitat from natural to artificial and has been designed so that it can be connected to the other main European habitat classification systems. All previous EU regulations about Habitat types can be referred to the EUNIS classification. It constitutes a common classification scheme for the whole of European Union, as it is compatible with the units of protection established in the guidelines of Natura 2000-protected areas.

The EUNIS classification has been developed on the basis of CORINE Biotopes, and the Palaearctic Habitat classification [Devillers & Devillers-Terschuren 1993], adding appropriate redefinitions. The most important innovation of the EUNIS classification with respect to the previous classification concerns the restructuring and deepening of classification of marine environments. These types were missing in the CORINE Biotopes database and in the Palaearctic habitat classification. The EUNIS classification covers the whole of the European land and sea area and, as a consequence, it includes habitat types that were not present in the geographical area originally covered by CORINE biotopes [Davies & Moss, 2002; Davies et al., 2004]. The EUNIS classification includes a new category of “Habitat Complexes” (class X), comprising combinations or mosaics of individual habitat types.

A list of all EUNIS habitat types (codes and scientific names) and the EUNIS habitat classification methodology with a navigation key to level 3 and links between Habitat Directive Annex I habitat types is provided at the URL: http://eunis.eea.europa.eu/related-reports.jsp

Specific features of the EUNIS classification are: the strictly hierarchical structure and the presence of a dichotomous key for the first three hierarchical levels. Criteria for the EUNIS Habitat Classification key have been developed for all units to level 3 and for saltmarshes at level 4. Criteria diagrams for levels 1 to 3 are provided in the Report 2004 [Davies et al., 2004].

Respecting the previous habitat classification systems, strongly based on phytosociological criteria and definition, the EUNIS classification is based also on physical attributes and ecological features and/or some floristic criteria.

This classification system requires a precise awareness of the meaning of scientific terminology, especially that relating to marine and coastal environments [Dauvin et al, 2008].

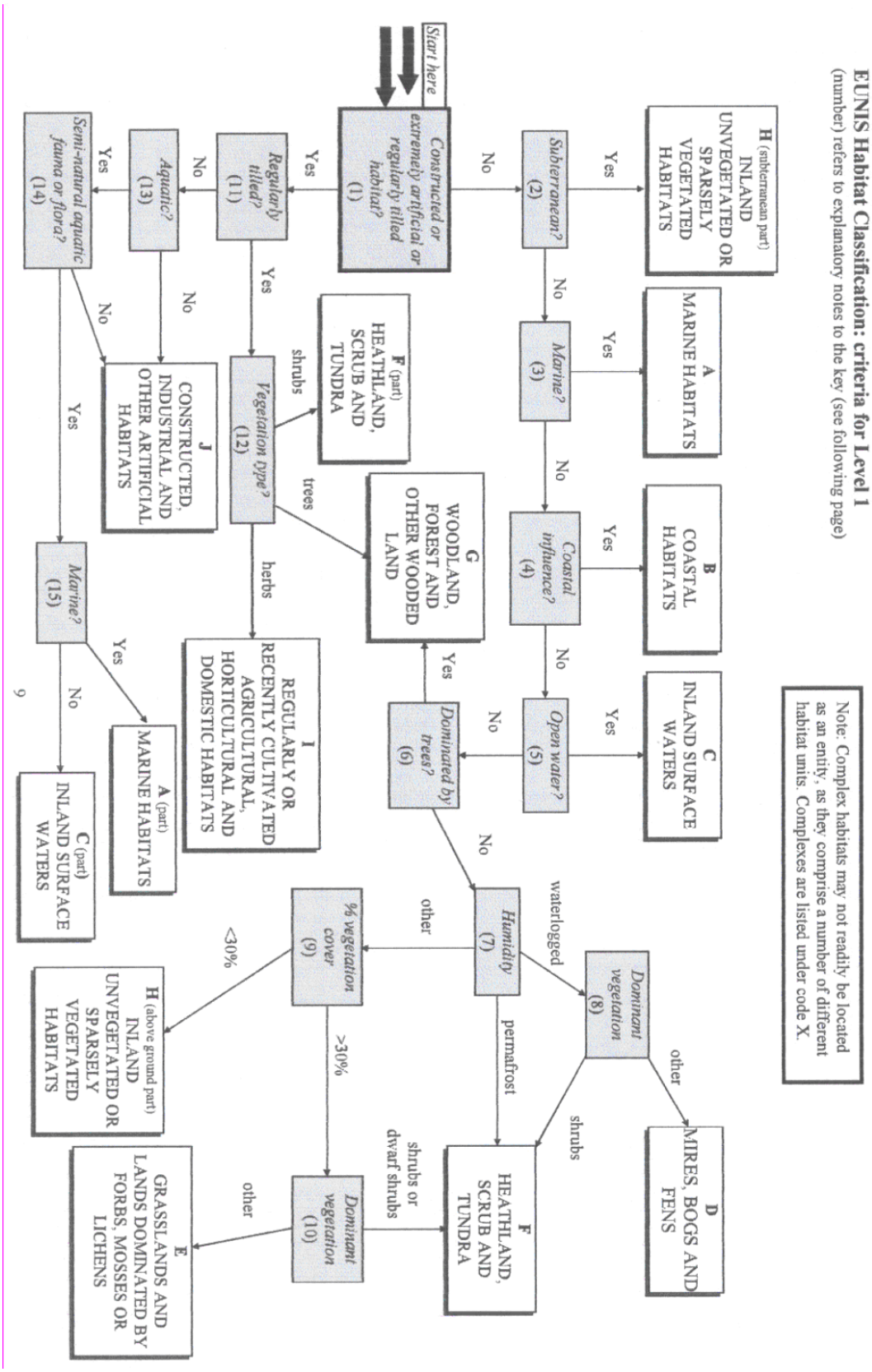


**Figure 3 - Dichotomous key and criteria for the EUNIS classification at the level 1**

*(source: Davies et al., 2004)*

## 3.4 General Habitat Categories

Many studies have been carried out with the aim to find effective procedures for monitoring of EU habitats. Development of consistent recording procedures is essential, especially for long-term monitoring [Haines Young et al., 2000; Dimopoulos et al. 2005; Boteva et al. 2004; Brandt et al., 2002; Bunce et al. 2008].

The General Habitat Categories (GHCs) classification system [Bunce et al, 2008] results from previous Projects such as BIOHAB (www.edinburgh.ceh.ac.uk/biota/biohab_page.htm), EBONE (http://www.ebone.wur.nl), BIOBIO (http://www.biobio-indicator.org) and GEOBON (http://www.earthobservations.org/cop_bi_geobon.shtml), dealing with surveillance and monitoring of biodiversity and from the necessity in getting changes in habitat cover and composition.

The General Habitat Categories (GHCs) are specifically designed for detection and mapping of changes. Furthermore, this system applies stringent criteria to ensure that real change is recorded and not results that are distorted by differences in definitions between observers or in recording technique [ Handbook, Bunce et al. 2011].

This system also arises from the need of harmonizing different habitat characterization processes at a continental or global level.

The GHCs are based on Life Forms [Raunkiaer 1934] with further detailed information (qualifiers) on the environment, site, management and species composition. This system includes natural habitats (Life Forms-LF Habitats) and artificial habitats (Non Life Form Habitats) such as urban, crops and sparsely vegetated.

In the Handbook [Bunce et al, 2011] a key (decision tree) is given for the detection of the six super categories: Urban (URB), Cultivated (CUL), Sparsely Vegetated (SPV), Tree (TRS) and Shrubs, Herbaceous wetland (HER-HEL, HER-SHY, HER-EHY) and other Herbaceous (OTHER HER).

The Decision Tree for the selection of GHCs is reported in Figure 4. A synthetic description of the both life forms and non-life forms as extracted by the Handbook is reported in Table 1.

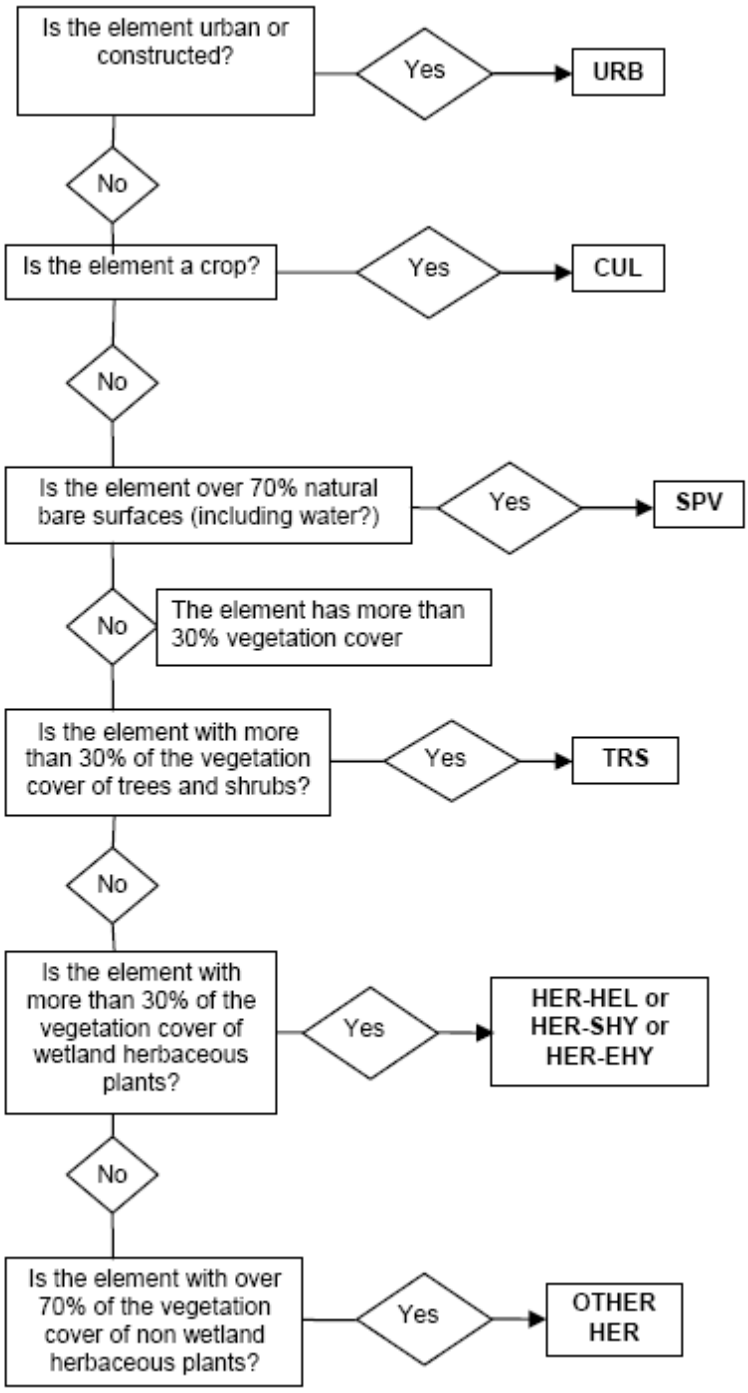


**Figure 4 - Decision tree for super categories**
(from EBONE handbook)

Each GHC contains one or two life forms. A GHC can be expanded by various qualifiers if further detail is required.

The GHCs classification system is a promising tool for the detection of changes, not only those involving a change from one habitat type to another, but also those involving a modification within the same habitat type. Such a change can be represented by adding or modifying environmental qualifiers.

In the EBONE Handbook comments from users throughout Europe, but also in Israel, South Africa and western Australia (Mediterranean biome outside Europe) have been included. In Europe, the procedure has been tested in several countries.

**Table 1.** Description of the life forms and non-life forms as a basis for the GHC categories

| Acronym | Name | Detailed description |
|---|---|---|
| ART | Urban Artificial (ART): | All built up land that is covered in buildings, tarmac, concrete or other artificial material. Street lights, electric pylons and telephone poles are not recorded. |
| NON | Urban Non-vegetated (NON): | All non-vegetated land that is within an urban boundary, whether a construction e.g. a fence as an arbitrary boundary e.g. around a quarry. Mostly these categories are the result of urban activity rather than agriculture e.g. quarries, excavation sites and non-tarmac car parks, but water bodies in urban areas are also included here with appropriate qualifiers. |
| VEG | Urban Vegetables (VEG): | Land that is under vegetables and/or fruit trees within an urban area and includes, for example, allotments. These categories will rarely form over 400 m2 as a pure category and will mainly be recorded as combinations. |
| GRA | Urban Herbaceous (GRA): | Land that is within the urban definition and covers less than 30% woody vegetation. This will include mainly grass e.g. playing fields, lawns and recreation areas, but also includes other herbaceous life forms. |
| TRE | Urban Woody (TRE): | This category includes land that is over 30% tree/shrub habitats as defined by the description of urban above. It may form a small area around large houses, but will often be recorded as combinations. |
| SPA | Cultivated bare ground (SPA): | Elements with no crops planted or less than 30% cover of vegetation, including volunteers (self-seeded crop plants). Includes therefore only bare fallow or recently ploughed land which otherwise is recorded as a qualifier together with appropriate GHC. |
| CRO | Cultivated herbaceous crop (CRO): | Includes both annual e.g. barley and sunflowers and perennials, e.g. lucerne and strawberries. Also includes crops that are technically bulbs e.g. daffodils. |
| WOC | Cultivated woody crops (WOC): | Includes all elements with trees or shrubs, e.g. orchards, vineyards and olive groves. Cover cannot be used as a criterion because of pruning. Therefore the rule is that there should be at least 20 trees/shrubs per ha, otherwise the scattered tree code can be used. |
| SEA | Sea (SEA): | Sea below mean low water mark. |
| TID | Tidal (TID): | Coastal platforms/sediments between mean low water mark and mean high water mark i.e. the main tidal zone. |
| AQU | Aquatic (AQU): | Permanent water bodies, whether rivers, canals, lakes or ponds, with less than 30% vegetation cover, otherwise use the HERBACEOUS GHCs. |
| ICE | Ice/snow (ICE): | Permanent ice/snow. |
| ROC | Rock (ROC): | Continuous rock divided by cracks, crevices or gullies |
| BOU | Boulders (BOU): | Boulders over 0.20 m diameter |
| STO | Stones (STO): | Rocks and stones 0.05-20 m diameter |
| GRV | Gravel (GRV): | Gravel 0.01-0.05 m diameter |
| SAN | Sand (SAN): | Sand 0.001-0.01 m diameter |
| EAR | Earth (EAR): | Earth, mud, silt and bare soil below 0.001 m diameter |
| SHY | Submerged hydrophytes (SHY): | Plants that grow in aquatic conditions with the whole plant submerged in water. This category includes marine species and floating species which overwinter below the surface. Excludes aquatic bryophytes. |

| | | |
|---|---|---|
| EHY | Emergent hydrophytes (EHY): | Plants that grow in aquatic conditions with the main plant above water. |
| HEL | Helophytes (HEL): | Plants that plants that grow in waterlogged conditions. |
| LHE | Leafy hemicryptophytes (LHE): | Broad leaved herbaceous species, sometimes termed forbs. |
| CHE | Caespitose hemicryptophytes (CHE): | Perennial monocotyledonous grasses and sedges. |
| THE | Therophytes (THE): | Annual plants that survive during the unfavourable season as seeds. |
| GEO | Geophytes (GEO): | Plants with buds below the soil surface |
| CRY | Cryptogams (CRY): | Non saxicolous bryophytes and lichens. Includes aquatic bryophytes, e.g. Sphagna and Racomitrium lanuginosum which is not saxicolous |
| HCH | Herbaceous chamaephytes (HCH): | Plant with non succulent leaves and not a shrubby form. |
| DCH | Dwarf chamaephytes (DCH): | Dwarf shrubs below 0.05 m e.g. Dryas octopetala, Salix herbacea. |
| SCH | Shrubby chamaephytes (SCH): | Undershrubs 0.05-0.3 m. e.g. Thymus vulgaris, Lavendula stoechas |
| LPH | Low phanerophytes (LPH): | Low shrubs, buds between 0.30-0.6 m, e.g. Myrica gale, Betula nana |
| MPH | Mid phanerophytes (MPH): | Mid shrubs, buds between 0.6-2.0 m, e.g. Pistacia lentiscus, Cornus mas |
| TPH | Tall phanerophytes (TPH): | Tall shrubs, buds between 2.0-5.0 m, e.g. Salix cinerea, Corylus avellana |
| FPH | Forest phanerophytes (FPH): | Trees over 5.0 m, e.g. Quercus robur, Fagus sylvatica |
| GPH | Mega phanerophytes (GPH): | Trees over 40m. |
| DEC | Winter deciduous (DEC): | e.g. Quercus robur, Fraxinus excelsior |
| EVR | Evergreen (EVR): | e.g. Quercus ilex, Laurus nobilis |
| CON | Conifers (CON): | e.g. Pinus nigra., Juniperus communis. |
| NLE | Non-leafy evergreen (NLE): | e.g. Sarothamnus scoparia, Ulex europaeus |
| SUM | Summer deciduous (SUM): | e.g. Sarcopotherium spinosum, Astragalus massiliensis |

GHCs, as listed in the Handbook, contain information about life form, leaf type, phenology and height.

Other qualifiers can be added to express variations between elements that may have the same GHC, to identify a habitat type. Qualifiers are: Environmental, Site and Management.

**Environmental qualifiers**: soil moisture, soil reaction, soil salinity and eutrophy-the last three derived from plant indicators [Ellemberg, 1974].

**Site qualifiers**, are mainly geomorphological: geomorphology, geology, soil or archaeology. The complete list is provided in the Handbook.

**Management qualifiers** are organised in several levels, the first level being the time of the management, the second level the general categories where management is taking place, e.g. forest or urban, and the third level is a more specific management activity.

# 4. Relations between vegetation units and habitats types of the Habitat Directive (and other classification systems widely used in Europe for habitat mapping)

Vegetation in most cases plays a major and basic role in habitat classification. Nevertheless, as clearly follows from all existing ecological definitions of the habitat concept, a habitat classification system should also express and describe the habitats and the conditions necessary for animals and other organisms. To be able to describe habitats (or a habitat classification system) in an appropriate way, other quantitative and qualitative data are necessary in addition to the specification of vegetation type [Andersson, 2001].

Habitat maps can be derived from both in-situ samples by relating the vegetation types (and their potential vegetation serial stages) to habitat categories and remote sensing observation through automatic classification of satellite images in land cover maps and relating land cover categories to habitat categories on the base of additional information (e.g. attributes, indicators).

The recording of vegetation types is one of the main step [Haines-Young et al 2000; Kutiel 2001; Berberoglu et al 2004; Dimopoulos et al 2005; Bunce et al 2008] in the realization of a Habitat map, especially from field work. When analysing the main relations between vegetation units and habitat types of Annex I (or other habitat classifications), the main issues are the following.

a) **To find the relation between the vegetation units and the Annex I habitat types** (or other habitat classification systems). E. g., many vegetation types are not reported in Annex I of the Habitat Directive and many of these are rare or threatened. Petermann and Ssymank [2007] presented a list of the syntaxa which are covered by Annex I within Natura 2000 sites in Germany and also the gaps, intended as the syntaxa, which are threatened or are important for protection, not covered by Annex I habitats. The communities belonging to “eutraphent reed and sedge beds”, including the three alliances *Phragmition*, *Magnocaricion*, and *Glycerio-Sparganion*, were found to be almost not covered, even though these types are important habitats in coastal wetlands, for bird reproduction, and a number of rare (at region scale) species are present. Coastal environments host a high level of biodiversity but, while the heterogeneity of the coastal sand dune systems is described with 17 habitat types in Annex I, not all the coastal wetland environments are well represented in the Habitat directive [Carranza et al. 2008]. These syntaxa and the associated habitat types need to be addressed in nature conservation activities at national as well as regional level. This would also contribute to enhancing the coherence of the Natura 2000 network as these syntaxa are often functionally linked to habitats already listed in Annex I. These types are listed in EUNIS and CORINE Biotopes.

b) Another crucial issue is the **interpretation of the Habitat Directive (or other habitat classification system) to find the correct correspondence between vegetation units and habitat types**. With regard to the Habitat Directive, main tools are the “Interpretation Manual of European Union Habitats” [European Commission 2007] and the “Technical Reports for the Management of Natura 2000 Habitats” [European Commission 2008]. The first Interpretation Manual of European Union Habitats (EUR 12) for the interpretation of Annex I was approved in 1995 and originated by the discordances between Habitat directive and CORINE Biotopes habitat types. The EUR15 version (1999) updates the definitions of habitat types on the basis of the information of the PHYSYS database. Accordingly, the CORINE codes were also replaced by the Palaearctic codes. The EUR25 (2002) and the EUR27 (2007)versions include new habitats and amendments from the expected addition of new states. Some technical reports about the Management of Natura 2000 Habitats have been issued in 2008 (http://ec.europa.eu/environment/nature/natura2000/management/habitats/models_en.htm).
Each document includes information on the distribution, ecological requirements of the habitat, main trends and threats. Relevant management actions and prescriptions are described in detail. Main constraints, risks and modifiers of the proposed management have been also included.

Several EU countries have produced Interpretation Manuals of the EU Habitats at national level, in order to help the adjustment of the Interpretation Manual of Annex I to different national and regional or local states. For instance, the "Interpretation Manual of European Union Habitats present in Italy" has been published (http://vnr.unipg.it/habitat/) in 2009. However, when adhering strictly to these documents, some types of vegetation, which are certainly worthy of preservation, cannot be regarded as Annex I habitat types. This is the case of *Myrto-Pistacietum lentisci*, a typical woody vegetation of consolidated dunes, characterized by evergreen scrub species, such as *Myrtus communis* and *Pistacia lentiscus*, and widespread along Mediterranean coastal environments and subject to significant reduction and fragmentation caused by human pressure. The conservation of this coastal habitat should be of prime importance but, strictly complying to the Habitat directive, no Annex I type can be referred to this vegetation type. However, pending future amendments of Annex I, these syntaxa need to be addressed by nature conservation activities.

Annex I Habitat types of the training study sites IT4 and IT3 have been listed and related to the corresponding types of CORINE Biotopes and EUNIS in Table IT4_1 and Table IT3_1. CLC types, at third level, are also reported in the first column, to evaluate the usefulness (friendliness) of such a LC classification scheme for the successive detection phase of habitat types.

For all BIO_SOS study sites, Deliverable D2.2 presented the list of habitat types according to Annex I, and the corresponding GHC and the EUNIS component were also envisaged .

In tables IT4_1 and IT3_1 presented here are listed also the non-Annex I habitat types (natural and not-natural). The EUNIS and the CORINE Biotope codes are also reported for each of them. The need to represent all habitat types (natural and non natural) of the selected study sites arises by a twofold requirement: a) to fill the gaps of Annex I and b) to include all those habitat types ( artificial or managed), within and in the neighbourhood of the considered Natura2000 sites, whose changes can affect in various ways the state of conservation of natural habitats.

So, these tables represent a further step in understanding the potential of each classification system.

*EUNIS and CORINE Biotope codes, for habitats of the Italian sites are not available from the literature or from previous projects. In the "Interpretation Manual of European Union Habitats present in Italy" an association EUNIS-Annex I codes is given at a provisional level, with many gaps and inaccuracies. Therefore, the allocation of EUNIS and CORINE Biotope codes requires a careful interpretation and a precise awareness of both classification systems.*

For the link Annex I – EUNIS habitat types, we referred to eunis.eea.europa.eu/upload/Link%20EUNIS%20and%20AnnexI.xls available at the URL http://eunis.eea.europa.eu/related-reports.jsp

For the link CORINE Biotopes – EUNIS, the Italian Agency for Environment (APAT) developed a table allowing the link between the two habitat classification systems [AA.VV. 2004]. However, as stated by the authors, this is a first attempt based on the experience of the Map of Nature in Italy and requires further deepening.

As far as the link between EUNIS and CLC, the European Environment Agency produced a document providing the cross-references between the EUNIS habitat classification and the nomenclature of CORINE Land Cover [Moss and Davies, 2002].

The first consideration is that Annex I does not consider all kinds of artificial or agricultural habitats, which are listed in EUNIS and CORINE biotopes (corresponding fairly accurately to CLC classes; please, note in EUNIS also Road Networks). With regard to natural and semi-natural habitats, EUNIS appears to have a major ability to contain more habitats and with more detail.

As far the Annex I is concerned, a few issues are highlighted emerging from the analysis of the two Italian sites.

1. In IT4 *Pistacia lentiscus* thermo-mediterranean maquis and *Erica forskalii* garrigues are habitat types worthy of conservation. However strictly complying to the Interpretation Manual 2007, they should be excluded by Annex I list (*Pistacia lentiscus* thermo-mediterranean maquis correspond

to 5330 description but no diagnostic species are present; *Erica manipuliflora* contains one diagnostic species but no correspondence with 5420 description and geographical distribution) and then reported as no Annex I habitat types. These two habitat types are fairly well represented both in CORINE Biotopes (with the types 32.214 - *Pistacia lentiscus* dominated or rich formations and 32.5C - Eastern *Erica* garrigues) and EUNIS classification (F5.514 – Lentisc brush and F6.2C - Eastern *Erica* garrigues). In Table IT4_1_Cesine as well as in other Tables of D6.1 both habitat types (Annex I and EUNIS) have been reported in connection to the GHCs. However, referring to *Pistacia lentiscus* communities only the EUNIS type was indicated as the Annex I is not defined.

2. As mentioned above, reeds and sedges communities belonging to the three alliances *Phragmition*, *Magnocaricion*, and *Glycerio-Sparganion*, are not covered by Annex I (they are covered by the EUNIS and Biotopes classifications, instead).
3. Habitat 6220 is a habitat type with a wide meaning that contains, according to the Interpretation Manual (European Commission, 2007), both perennial herbaceous communities (the case of the perennial grasslands in Murgia Alta ) and annual types (the case of the annual *Tuberarietea* grasslands in Le Cesine-IT4 Le Cesine). Both communities can be assigned to CLC class 3.3.3, but their discrimination does require the use of multi-temporal EO images
4. According to the CORINE Land Cover technical guide (Bossard et al 2000), "fallow lands" or "abandoned arable land not under a rotation system used as pastures" (usually herbaceous annual, nitrophilous and sub nitrophilous vegetation types, EUNIS type E1.6), have been included in class 231 (pastures), while the natural grasslands subjected to overgrazing (EUNIS types E1.C1 and E1.C2) have been included in class 321 according to class descriptions: " grasslands which can be grazed, never sown and not otherwise managed by way of application of fertilizers, pesticides, drainage or reseeding except by burning".
5. As a result, CLC class 3.2.1 – “Natural grassland” includes a wide range of natural and semi-natural vegetation types. Only some of these are habitats (6210, 6220, 62A0) according to Annex I , which excludes nitrophilous and sub-nitrophilous (subject to grazing) and that are, at least in part, included in EUNIS (E1.C1, “*Asphodelus* fields”; E1.C2, “Thistle fields”).

**Table IT4_1_Cesine.** Annex I Habitat types are listed and related to corresponding types of CORINE Biotopes and EUNIS. CLC class set, at third level, are also reported to show the capability of such a LC legend to provide a base for habitat identification. The Eunis types have been assigned by using the level 2 EUNIS key to classification [Davies et al 2004] and the link to Annex I [EUNIS habitats 2004; http://eunis.eea.europa.eu/upload/EUNIS_2004_report.pdf]. The CLC types have been assigned following the CORINE land cover technical guide – Addendum 2000 (Bossard et al 2000). The CorineBiotopes types have been assigned by means of the Corine Biotopes manual [Commission of European Communities, 1991b]. The Eunis types D5.1, D 5.2 and D5.24, in this specific case, have been referred to CLC 4.2.1, because of their belonging to salt marshes complexes. In presence of fresh water (water fringe vegetation) these types can be referred to CLC 4.1.1 (Inland marshes). Cereal crops and vegetable crops have been referred to CB 82.11 and 82.12 (belonging to 82.1 unbroken intensive croplands) and to Eunis type I1.3 (extensive or crops grown by low-intensity agricultural methods) cause of different interpretative rules of the two classification systems. For each site, the description of CLC classes at level 3 is reported in the technical CORINE technical guide at **http://www.eea.europa.eu/publications/tech40add**

| CLC3 | | Annex I | | CORINE Biotopes | | EUNIS Level 4 | |
|---|---|---|---|---|---|---|---|
| **Class Code** | **Class Name** | **Habitat Code** | **Habitat Name** | **Habitat Code** | **Habitat name** | **Habitat Code** | **Habitat name** |
| 1.1.2 | Discontinuous urban fabric | X | X | 86.2 | Villages | J2.1 | Scattered residential buildings |
| 1.2.2 | Road and rail networks and associated land | X | X | X | X | J4.2 | Road networks |
| 2.1.1 | Non-irrigated arable land | X | X | 82.11 | Field crops | I1.3 | Arable land with unmixed crops grown by low-intensity agricultural methods |
| 2.1.2. | Permanently irrigated land | X | X | 82.12 | Market gardens and horticulture | | |
| 2.2.3 | Olive groves | X | X | 83.11 | Olive groves | G2.91 | Olea europaea groves |
| 2.3.1 | Pastures | X | X | 34.81 | Mediterranean subnitrophilous grass communities | E1.6 | Subnitrophilous annual grassland |
| 3.1.2 | Coniferous forest | X | X | 83.31 | Conifer plantations | G3.F1 | Native conifer plantations |

| CLC3 | | Annex I | | CORINE Biotopes | | EUNIS Level 4 | |
|---|---|---|---|---|---|---|---|
| 3.2.4. | Transitional woodland shrub | X | X | 31.8A2 | Italo-Sicilian sub-Mediterranean deciduous thickets | F5.51 | Thermo-Mediterranean brushes, thickets and heath-garrigues |
| 3.2.3 | Sclerophyllous vegetation | 2250* | Coastal dunes with *Juniperus* spp. | 16.271 | *Juniperus oxycedrus* ssp. *macrocarpa* thickets | B1.63 (B1.631) | Dune *Juniperus* thickets (Dune prickly juniper thickets) |
| | | 5330 | Thermo-Mediterranean and pre-desert scrub | 32.25 | Pre-desert scrub | F5.55 | Mediterranean pre-desert scrub |
| | | X | X | 32.214 | Lentisc brush *Pistacia lentiscus* dominated or rich formations | F5.51 (F5.514) | Thermo-Mediterranean brushes, thickets and heath-garrigues (Lentisc brush) |
| | | X | X | 32.5C | Eastern *Erica* garrigues | F6.2C | Eastern *Erica* garrigues |
| 3.3.1 | Beaches, dunes, and sand plains | 1210 | Annual vegetation of drift lines | 16.12 | Sand beach annual communities (*Cakiletea maritimae*) | B2.13 | Gravel beach communities of the mediterranean region |
| | | 2110 | Embryonic shifting dunes | 16.211 | Embryonic dunes (*Agropyrion juncei*) | B1.31 | Embryonic shifting dunes |
| | | 2120 | Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes) | 16.212 | White dunes (Ammophilion arenariae) | B1.32 | White dunes |
| | | 2230 | *Malcolmietalia* dune grasslands | 16.228 | Mediterraneo-Atlantic dune *Malcolmia* communities | B1.48 | Tethyan dune deep sand therophyte communities |
| 3.3.3 | Sparsely vegetated areas | 6220* | Pseudo-steppe with grasses and annuals of the *Thero-Brachypodietea* | 34.5 | Mediterranean xeric grasslands (*Thero-Brachypodietea*) | E1.313 | Mediterranean annual communities of shallow soils |
| 4.1.1 | Inland marshes | 3170* | Mediterranean temporary ponds | 22.341 | Short Mediterranean amphibious swards (*Isoetion*) | C3.42 (C3.421) | Mediterraneo-Atlantic amphibious communities (Short Mediterranean amphibious communities) |
| 4.2.1 | Salt marshes | 1310 | *Salicornia* and other annuals colonizing mud | 15.1 | Salt pioneer swards (*Thero-Salicornietea, Frankenion* | A2.51 … | Saltmarsh driftlines … |

| CLC3 | | Annex I | | CORINE Biotopes | | EUNIS Level 4 | |
|---|---|---|---|---|---|---|---|
| | | | and sand | | *pulverulentae, Saginion maritimae*) | A2.55<br>… | Pioneer saltmarshes<br>… |
| | | 1410 | Mediterranean salt meadow (*Juncetalia maritimi*) | 15.5 | Mediterranean salt meadows (*Juncetalia maritimi)* | A2.52 (A2.522) | Upper saltmarshes (Mediterranean *Juncus maritimus* and *Juncus acutus* saltmarshes) |
| | | | | | | A2.53<br>… | Mid-upper saltmarshes<br>… |
| | | 1420 | Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*) | 15.6 | Saltmarsh scrubs (*Arthrocnemetea fruticosi*) | A2.52 (A2.526) | Upper saltmarshes (Mediterranean saltmarsh scrubs) |
| | | 7210 | Calcareous fens with *Cladium mariscus* and species of the *Carcion davallianae* | 53.31 | Fen *Cladium* beds | D5.24 | Fen *Cladium mariscus* beds |
| | | X | X | 53.1<br>… | Reeds beds (*Phragmition australis, Scirpion maritimi*)<br>… | D5.1<br>… | Reedbeds normally without free-standing water<br>… |
| | | | | 53.2 | Large sedge communities (*Magnocaricion*) | D5.2<br>… | Beds of large sedges normally without free-standing water<br>… |
| 5.1.1 | Water courses | X | X | 53.4 | Small reed beds of fast flooding waters (*Glycerio-Sparganion*) | C2 | Surface running waters |
| 5.2.1 | Coastal lagoons | 1150 | Coastal lagoons | 23.2 | Vegetated brackish and salt waters | X03 | Brackish coastal lagoons |

**Table IT3_1_Murgia_Alta**. Annex I Habitat types are listed and related to corresponding types of CORINE Biotopes and EUNIS. CLC types, at third level, are also reported to show the capability of such a LC classification to detect habitat types. The Eunis types have been assigned by using the EUNIS key to the classification to level 2 [Davies et al 2004] and the link to Annex I [EUNIS habitats 2004; http://eunis.eea.europa.eu/upload/EUNIS_2004_report.pdf]. The CLC types have been assigned following the CORINE land cover technical guide – Addendum 2000 (Bossard et al 2000). The CORINE Biotopes types have been assigned by means of the Corine Biotopes manual [European Communities, 1991b]. For each site, the description of CLC classes at level 3 is reported in the technical CORINE technical guide at http://www.eea.europa.eu/publications/tech40add

| CLC 3 | Class Name CLC3 | Habitat Annex 1 | Description Annex I | Biotopes CORINE | Description C Biotopes | EUNIS Level 4 | Description EUNIS |
|---|---|---|---|---|---|---|---|
| 1.1.1 | Continuous urban fabric | X | X | 86.1 | Towns | J1.1 | Residential buildings of city and town centres |
| | | | | | | J1.2 | Residential buildings of villages and urban peripheries |
| 1.1.2 | Discontinuous urban fabric | X | X | 86.2 | Villages | J2.1 | Scattered residential buildings |
| 1.2.1 | Industrial or commercial units | X | X | 86.3 | Active industrial sites | J2.3 | Rural industrial and commercial sites still in active use |
| | | | | | | J2.4 | Agricultural constructions |
| 1.2.2 | Road and rail networks and associated land | X | X | X | X | J4.2 | Road networks |
| 1.3.1 | Mineral extraction sites | X | X | 86.41 | Quarries | J3 | Extractive industrial sites |
| 2.1.1 | Non-irrigated arable land | X | X | 82.11 | Field crops | I1.3 | Arable land with unmixed crops grown by low-intensity agricultural methods |
| 2.2.1 | Vineyards | X | X | 83.21 | Vineyards | FB.4 | Vineyards |
| 2.2.2 | Fruit trees and berry plantations | X | X | 83.15 | Fruit orchards | G1.D4 | Fruit orchards |
| 2.2.3 | Olive groves | X | X | 83.11 | Olive groves | G2.91 | Olea europaea groves |
| 2.3.1 | Pastures | X | X | 34.81 | Mediterranean subnitrophilous grass communities | E1.6 | Subnitrophilous annual grassland |
| | | | | | | E1C<br>E1.C2 | Dry mediterranean lands with unpalatable non-vernal herbaceous vegetation<br>Thistle fields |

| CLC 3 | Class Name CLC3 | Habitat Annex 1 | Description Annex I | Biotopes CORINE | Description C Biotopes | EUNIS Level 4 | Description EUNIS |
|---|---|---|---|---|---|---|---|
| | | | | 87.1 | Fallow fields | E1.6 | Subnitrophilous annual grassland |
| 2.4.1 | Annual crops associated with permanent crops | X | X | - | - | - | - |
| 3.1.1 | Broad-leaved forest | 91AA | Eastern white oak woods | 41.73 | Eastern white oak woods | G1.73 | Eastern *Quercus pubescens* woods |
| 3.1.1 | Broad-leaved forest | 9250 | *Quercus trojana* woods | 41.782 | *Quercus trojana* woods of Puglia | G1.782 | Apulian Trojan oak woods |
| 3.1.2 | Coniferous forest | X | X | 83.31 | Conifer plantations | G3.F | Highly artificial coniferous plantations |
| 3.1.3 | Mixed forest | X | X | 43 | Mixed woodland | G1.732 | Italo-Sicilian *Quercus pubescens* woods |
| 3.1.4 | Grasslands with trees | X | X | - | - | E7 | Sparsely wooded grasslands |
| 3.2.1 | Natural grasslands | 6210 | Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (important orchid sites) | 34.33 | Sub-Atlantic very dry calcareous grasslands | E1.2 | Perennial calcareous grassland and basic steppes |
| | | 6220* | Pseudo-steppe with grasses and annuals of the *Thero-Brachypodietea* | 34.5 | Mediterranean xeric grasslands | E1.3 | Mediterranean xeric grassland |
| | | | | | | E1C E1.C1 | Dry mediterranean lands with unpalatable non-vernal herbaceous vegetation *Asphodelus fields* |
| | | 62A0 | Eastern sub-Mediterranean dry grasslands (Scorzoneratalia villosae) | 34.53 | East Mediterranean xeric grasslands | E1.55 | Eastern sub Mediterranean dry grassland |
| 3.2.4. | Transitional woodland shrub | X | X | 31.8A2 | Italo-Sicilian sub-Mediterranean deciduous thickets | F5.51 | Thermo-Mediterranean brushes, thickets and heath-garrigues |
| | | | | | | F5.32 | Italo-French pseudomaquis |
| 3.3.3 | Sparsely vegetated areas | 8210 | Calcareous rocky slopes with chasmophytic vegetation” | 62.14 | Southern Italian calcareous cliffs | H3.2 | Basic and ultra basic inland cliffs |

## 4.1 Relations between GHCs and Annex I

Within EBONE a rule based key using GHCs to Annex I habitats has been produced (EBONE-Deliverable 4.2). This is not a direct key, but a rule based system [Bunce et al., 2010].

Some Annex I habitats are not single habitats, but rather habitat complexes or landscape classes.

So, in the rule based system two main categories have been identified:

a) landscape classes and habitat complexes, that is, those Annex I habitats consisting of landscape classes or habitat complexes (e.g. 1130 Estuaries) and consisting of more than three GHC's; this group comproses mainly coastal environments, cliffs and screes;

b) single habitat categories.

Within the rule based system, all Annex I habitats have been described and are characterised by indicator species (at the moment habitat 5420 is not yet considered because it is mainly present in Eastern Mediterranean Countries. The BIO_SOS project will offer the opportunity to define also this habitat).

There is no unique correspondence between Annex 1 habitat types and GHCs habitat types according to the rule based system. Some habitats may appear in more than one place in the system, e.g. according to the different level of conservation or degradation or based on vegetation structure. For example, pre-desert scrub (5330) may be SCH/EVR, MPH/EVR or LPH/EVR depending upon local conditions.

In the case of natural habitat types not included in Annex I, only the GHC can be recorded.

The same applies to artificial or managed habitats, for which there is no Annex I type.

When identifying which habitat or combination of habitats the element is, the following combinations are considered [EBONE-Deliverable 4.2]:

1. The element corresponds to the description of the Annex I habitat only, e.g. 4060 Alpine and Boreal heaths.
2. The element satisfies the description of the Annex I habitat, but also forms part of a landscape class or habitat complex – therefore having a dual code, e.g. 1310 Salicornia beds within 1130 Estuaries.
3. The element does not fulfil the description of Annex I in itself, but forms part of a landscape class or habitat complex, which does belong to Annex I, e.g. grasslands (CHE) dominated by Agrostis repens within 1130 Estuaries.
4. The element is not in Annex I and does not form part of a habitat complex, e.g. a Pinus sylvestris plantation (FPH/CON) in southern England.
5. The element according to the GHC rules is made up of a matrix of an Annex I habitat within which there are point features of another Annex I habitat, e.g. Atlantic wet heaths (4020) may contain point features of Rhynchospora alba vegetation (7150).

Tables IT4_2 and IT3_2 illustrate the correspondence between GHCs with Annex I habitats and other natural and artificial habitat types, identified by EUNIS. LC classes are identified by only CLC in the first column of the two Tables.

As already noted in Deliverable 2.2, some Annex I habitat types could have multiple GHCs entries in the system. This is the case of habitat 5330 and 7210. Habitat 5330 could correspond to four possible habitat types according to the Key GHC rule based system. On the base of only the known height of vegetation in IT4, 5330 habitat as been assigned to *6.4.6.2.3 - LPH/EVR+MPH/EVR + xeric soils + indicators* in Table IT4_2_Cesine. Habitat 7210 could correspond to two different possible habitat types

according to the Key, but considering the real condition of this vegetation in IT4, 7210 should be assigned to *5.1.2.1.1 - EHY+CHE + fresh water + eutrophic/calcareous + indicators.*

On the other hand, habitat types 2110 and 2120 have the same habitat type according to the GHC handbook.

This topic has already been developed in Deliverable D2.2.

In D2.2 have been presented tables listing, for all study sites, the habitat types according to Annex I and the corresponding GHCs. In Tables IT4_2 and IT3_2 of the present deliverable beside all naturaland semi-natural also not-natural habitat types are listed and indicated with the appropriate EUNIS code For all of these habitats, an appropriate GHC class should be established.

In a provisional and indicative way only, in Tables IT4_2 and IT3_2 a super-category and a GHC have been shown in red. More proper definitions will be provided within the GHC training courses to be held throughout the project lifetime.

**Table IT4_2_Cesine.** Correspondence between GHC with Annex I habitats and other habitat types. GHCs of non-AnnexI habitat types have been assigned by using the Decision tree for super categories of EBONE handbook (Bunce et al 2011). GHCs and Divisions of AnnexI habitat types have been assigned by using the EBONE D42 KeyAnnex1. In red GHC codes for habitat types coded in EUNIS but not available in Annex 1

| CORINE CLC3 | | Annex 1 | EUNIS | GHC | | |
|---|---|---|---|---|---|---|
| **Class code** | **Class Name** | **Habitat code** | **Habitat code at Level 4** | **Super categories** | **Divisions of the Annex I rule based system Level 4** | **Divisions of the Annex I rule based system Level 5** |
| 1.1.2 | Discontinuous urban fabric | X | J2.1 | URB | URB - **to define** | URB - **to define** |
| 1.2.2 | Road and rail networks and associated land | X | J4.2 | URB | URB - ART/NON | URB - ART/NON |
| 2.1.1 | Non-irrigated arable land | X | I1.3 | CUL | CUL - CRO | CUL - CRO |
| 2.1.2. | Permanently irrigated land | X | I1.3 | CUL | CUL - CRO | CUL - CRO |
| 2.2.3 | Olive groves | X | G2.91 | CUL | CUL - WOC | CUL - WOC |
| 2.3.1 | Pastures | X | E1.6 | HER | HER - **to be defined** | HER - **to be defined** |
| 3.1.2 | Coniferous forest | X | G3.F1 | TRS | TRS – **to be defined** | TRS – **to be defined** |
| 3.2.4. | Transitional woodland shrub | X | F5.51 | TRS | TRS - **to be defined** | TRS - **to be defined** |
| 3.2.3 | Sclerophyllous vegetation | 2250* | B1.63 (B1.631) | TRS | 6.4.3.3.1 Dry/neutral | MPH/CON + dry sandy soils + coastal dunes + Juniperus species |
| | | 5330 | F5.55 | TRS | 6.4.2.6.3 Xeric/neutral | LPH/EVR+MPH/EVR + xeric soils + indicators |

| CORINE CLC3 | | Annex 1 | EUNIS | GHC | | |
|---|---|---|---|---|---|---|
| | | X | F5.51<br>(F5.514) | TRS | X | **to be defined** |
| | | X | F6.2C | TRS | X | **to be defined** |
| 3.3.1 | Beaches, dunes, and sand plains | 1210 | B2.13 | HER | 5.2.2.9.1<br>Moist/saline | LHE/CHE + saline soils + sand or gravel + linear coastal feature |
| | | 2110 | B1.31 | HER | 1.3.5.2.1<br>Dune systems | TER (sand) +THE+CHE+ THE/CHE + LHE/CHE |
| | | 2120 | B1.32 | HER | 1.3.5.2.2<br>Dune systems | TER (sand) +THE+CHE+ THE/CHE + LHE/CHE |
| | | 2230 | B1.48 | HER | 5.2.1.4.1<br>Dry/neutral | LHE/THE + coastal dunes + local knowledge + indicator species |
| 3.3.3 | Sparsely vegetated areas | 6220* | E1.313 | HER | 5.2.1.7.2<br>Xeric/basic | CHE/THE + xeric + calcareous + critical species + expert knowledge |
| 4.1.1 | Inland marshes | 3170* | C3.42<br>(C3.421) | HER | 5.2.1.3.1<br>Seasonally wet/neutral | THE + GEO + THE/GEO + evidence of winter flooding + indicator species |
| 4.2.1 | Salt marshes | 1310 | A2.51<br>… | HER | 5.2.1.1.1<br>Waterlogged/saline | THE + SPV/TER + mud + saline |
| | | | A2.55<br>… | | | |
| | | 1410 | A2.52<br>(A2.522) | HER W | 5.2.2.12.1<br>Dry/saline | LHE/CHE + saline + SCH |
| | | | A2.53<br>… | | | |
| | | 1420 | A2.52<br>(A2.526) | TRS | 6.2.2.3.2<br>Moist/saline | SCH/EVR or LPH/ EVR + saline soils + indicator species |
| | | 7210* | D5.24 | HER W | 5.1.2.1 Aquatic/neutral and Waterlogged/neutral | EHY+CHE + fresh water + eutrophic/calcareous + indicators |
| | | X | D5.1 | HER W | X | **to be defined** |

| CORINE CLC3 | | Annex 1 | EUNIS | GHC | | |
|---|---|---|---|---|---|---|
| | | | D5.2 | HER W | X | **to be defined** |
| 5.1.1 | Water courses | X | C2 | HER W | X | **to be defined** |
| 5.2.1 | Coastal lagoons | 1150 | X03 | Habitat complex SPV/HER-W/TER | 1.1.3 | AQU+TER+SHY+EHY+CHE+LHE/CHE. Mainly SHY with locally patches of EHY + brackish to salt water + highly saline + shallow water separated from sea in lagoons or ponds |

**Table IT3_2_Murgia_Alta.** Correspondence between GHC with Annex I habitats and other habitat types. GHCs of non-AnnexI habitat types have been assigned by using the Decision tree for super categories of EBONE handbook (Bunce et al 2011). GHCs and Divisions of AnnexI habitat types have been assigned by using the EBONE D42 KeyAnnex1. In red GHC codes for habitat types coded in EUNIS but not available in Annex I.

| CORINE CLC3 | | Annex 1 | EUNIS | GHC | | |
|---|---|---|---|---|---|---|
| **Class code** | **Class Name** | **Habitat code** | **Habitat code at Level 4** | **Super categories** | **Divisions of the Annex I rule based system Level 4** | **Divisions of the Annex I rule based system Level 5** |
| 1.1.1 | Continuous urban fabric | X | J1.1<br>J1.2 | URB | URB - ART/NON | URB - ART/NON |
| 1.1.2 | Discontinuous urban fabric | X | J2.1 | URB | URB - **to be defined** | URB - **to be defined** |
| 1.2.1 | Industrial or commercial units | X | J2.3<br>J2.4 | URB | URB - **to be defined** | URB - **to be defined** |
| 1.2.2 | Road and rail networks and associated land | X | J4.2 | URB | URB - ART/NON | URB - ART/NON |
| 1.3.1 | Mineral extraction sites | X | J3 | URB | URB - ART/NON | URB - ART/NON |
| 2.1.1 | Non-irrigated arable land | X | I1.3 | CUL | CUL - CRO | CUL - CRO |
| 2.2.1 | Vineyards | X | FB.4 | CUL | CUL - WOC | CUL - WOC |
| 2.2.2 | Fruit trees and berry plantations | X | G1.D4 | CUL | CUL - WOC | CUL - WOC |
| 2.2.3 | Olive groves | X | G2.91 | CUL | CUL - WOC | CUL - WOC |
| 2.3.1 | Pastures | X | E1.6<br>E1C<br>E1.C2 | HER | HER - **to be defined** | HER - **to be defined** |

| CORINE CLC3 | | Annex 1 | EUNIS | GHC | | |
|---|---|---|---|---|---|---|
| 2.4.1 | Annual crops associated with permanent crops | X | - | CUL | CUL – CRO/WOC | CUL – CRO/WOC |
| 3.1.1 | Broad-leaved forest | 91AA | G1.73 | TRS | 6.6.1.10 Very dry/neutral | 6.6.1.10.3 Eastern white oak woods<br><br>FPH/DEC + Quercus pubescens over 30% + Quercus virgiliana + dry soils + expert knowledge |
| 3.1.1 | Broad-leaved forest | 9250 | G1.782 | TRS | 6.6.1.8 Dry/neutral | 6.6.1.8.7 Quercus trojana woods<br><br>FPH/DEC + Quercus trojana over 70% + dry soils + expert local information |
| 3.1.2 | Coniferous forest | X | G3.F | TRS | TRS – **to be defined** | TRS – **to be defined** |
| 3.1.3 | Mixed forest | X | G1.732 | TRS | TRS – **to be defined** | TRS – **to be defined** |
| 3.1.4 | Grasslands with trees | X | E7 | **to be defined** | **to be defined** | **to be defined** |
| 3.2.1 | Natural grasslands | 6210 | E1.2 | HER | 5.2.2.11 Dry/basic | 5.2.2.11.1 Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia, * important orchid sites)<br><br>LHE/CHE + dry calcareous soils + indicators |
| | | 6220 | E1.3<br>E1C<br>E1.C1 | HER | 5.2.1.7 Xeric/basic | 5.2.1.7.2 Pseudo-steppe with grasses and annuals of the Thero-Brachypodietea<br><br>CHE/THE + xeric + calcareous + critical species + expert knowledge |
| | | 62A0 | E1.55 | HER | 5.2.2.13 Very dry/neutral | 5.2.2.13.3 Eastern sub-Mediterranean dry grasslands (Scorzoneratalia villosae)<br><br>LHE/CHE + xeric + indicators |
| 3.2.4. | Transitional woodland shrub | X | F5.51<br>F5.32 | TRS | TRS - **to be defined** | TRS - **to be defined** |
| 3.3.3 | Sparsely vegetated areas | 8210 | H3.2 | Habitat Complexes | 1.2.2 Vegetated Inland Cliffs | 1.2.2.1 Calcareous rocky slopes with chasmophytic vegetation<br><br>Inland cliff + limestone rocks + chasmophytes + LHE + CHE + LHE/CHE+SCH/EVR+ TER + possible HCH |

# 5. Land Cover class sets

In this section, attention will mainly focus on the CORINE Land Cover nomenclature, perhaps the most widespread in Europe (as an example, in GMES Geoland projects), and the FAO LCCS on which several international committees are paying increasing attention to its flexibility.

In support of environmental assessment, the need for updated information on land cover (LC) has become important at the regional, national and international level and has led to an increasing number of land-cover databases, derived by different initiatives and programmes (with different class sets and mapping methodologies), resulting in low compatibility between the data sets [Herold et al., 2006]. Different mapping methodologies make it difficult to separate land changes themselves from changes that are result of a different methodology used to create the map. That is why harmonized and standardized spatial reference data are considered mandatory in support to the environmental management.

Land cover changes are usually expressed as the change from one land cover type to another. A LC change is interpreted as a categorical change, when one LC class or its part is replaced by another LC class [Feranec et al 2007]. Alterations within the same type or category are detected with more difficulty, because the more widespread a land cover map legend (or habitat) classification system is, the lower its flexibility and the more rigid its schematic structure. is

A very articulate (and with a large number of categories) classification class set system ensures the possibility to represent changes but, at the same time, it may generate confusion, especially when limits between different categories are not clear (often generating overlapping) and/or when the type definition is imprecise, ambiguous or absent. In these cases the classification system fails to provide internal consistency.

The EU Member States are currently using different conceptual frameworks in order to define and map land cover types, resulting in different legends.

## 5.1 CORINE Land Cover nomenclature

The CORINE programme (COoRdination of INformation on the Environment) was established in 1985 by the European Commission, aiming at the creation of a common data base for gathering, coordinating and ensuring consistency of information on the state of the environment and natural resources in the European Community.

The first CORINE1990 land cover nomenclature was released in 1999 and updated in 2000. The new CORINE2000 land cover dataset became available in 2005.

CLC2000 provides information on land cover (and changes) in most western and central European countries, including the 27 member states of the European Union [CEC-EEA, 1993; JRC-EEA, 2005].

The mapping is based on the CORINE nomenclature and interpretation methods at an original scale of 1:100,000. The nomenclature comprises 44 land cover classes on three levels at a minimum mapping unit of 25 ha.

The CLC nomenclature is based mainly upon physiognomic attributes of landscape objects and their spatial relationships. These attributes are crucial for identification of LC classes on satellite images. Artificial surfaces and agricultural areas are also discerned by functional attributes and are related to land use. For this reason it is considered desirable to take into account physiognomic and functional attributes of landscape objects together [Feranec et al 2007].

The land cover nomenclature is organized in three hierarchical levels:

• Level 1: five features (artificial surface, agricultural area, forest and semi-natural area, wetland).

• Level 2: 15 features or headings.

• Level 3: 44 features or headings.

A manual for the interpretation of the comprehensive characteristics of the CLC nomenclature has been provided [Heymann et al., 1994]. In the Addendum to the Technical Guide [Bossard et al 2000], to each CLC class at the third level are associated: an exhaustive description of the class, a list of the land cover types included in the heading and a list of the land cover types excluded.

The CLC class set has been used in European projects dealing with the detection of land cover changes, e. g. LACOAST (LAnd cover changes in COASTal zones) project for the detection of LC changes of the European coastal zones from 1975 to 1990; I&CLC2000 (IMAGE 2000 & CORINE Land Cover 2000) project for the detection of general LC changes in Europe between 1990 and 2000; BiOPPRESS Project, linking pan-European LC change to pressures on biodiversity [http://www.creaf.uab.es/biopress] [Feranec et al, 2007] and in determining changes and flows in European landscapes during the period 1990–2000 [Feranec et al, 2010].

CLC taxonomy is currently proposed for the new Pan-EU Land monitoring GMES service under the GMES Regulation in 2011. The service will encompass continuity of CLC for 2012 and will start with the Pan-EU land cover component. It will include the production of five additional High Resolution (10-20m) Pan-EU layers with specific land cover characteristics in complement to CLC: artificial surfaces (i.e. impervious areas), forests agricultural areas (mapping of permanent grassland with possible distinction of agricultural/semi-natural areas), wetlands, and small water bodies.

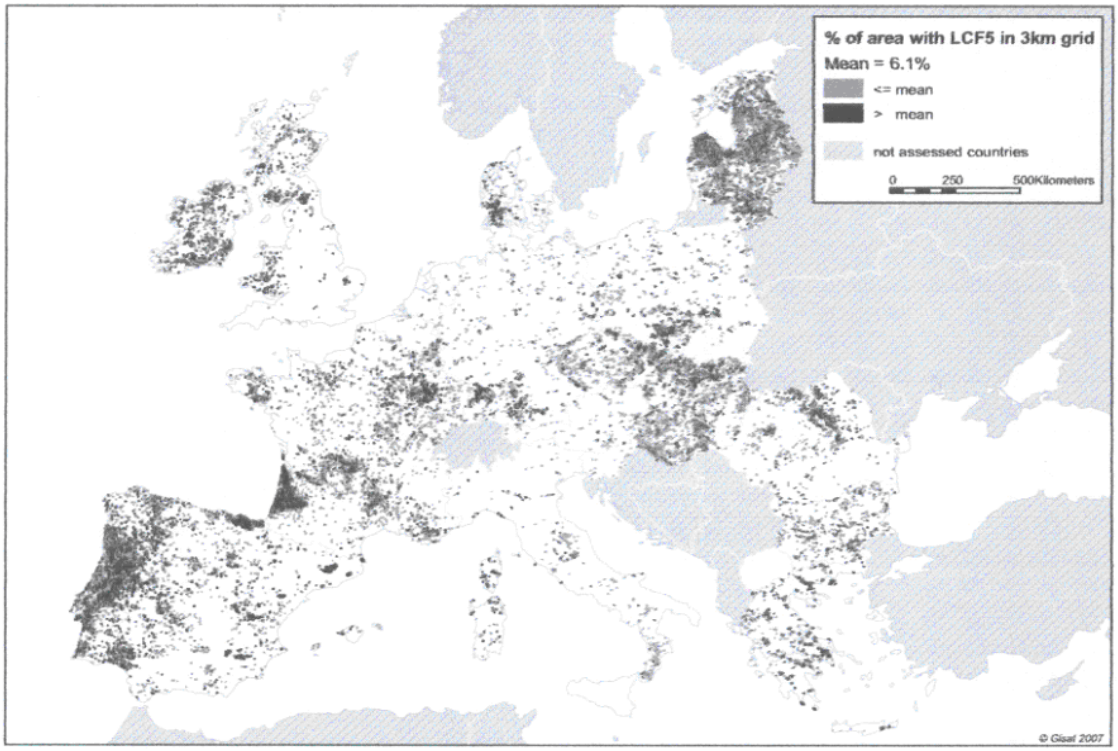


**Figure 5 – Deforestation in 24 EU countries 1999-2000 on CLC data**
(source: Feranec et al 2010)

## 5.2 IGBP DISCover Land Cover units.

The DISCover Land Cover units were delivered within the Geosphere-Biosphere Programme of the *Forest Resourse* Assessment Programme systems by FAO. The legend and class description was developed to be exhaustive, so that every part of the Earth's surface was assigned to a class; exclusive, so that classes did not overlap; and structured so that classes were equally interpretable with 1km data, higher resolution remotely-sensed imagery, or ground observation. The categories were chosen so that they embraced the climate-independence and canopy component philosophy presented by [Running et. al., 1994] but modified to be compatible with classification schemes currently used for environmental modelling to provide, where possible, land use implications and to represent landscape mosaics [Belward 1996] The legend comprises 17 so-called DISCover classes and these are defined in Table 2.

**Table 2.** DISCover units

| Code | Class Name | Description |
|---|---|---|
| 1 | Evergreen Needleleaf Forests | Lands dominated by trees with a percent canopy cover >60% and height exceeding 2 meters. Almost all trees remain green all year. Canopy is never without green foliage. |
| 2 | Evergreen Broadleaf Forests | Lands dominated by trees with a percent canopy cover >60% and height exceeding 2 meters. Almost all trees remain green all year. Canopy is never without green foliage. |
| 3 | Deciduous Needleleaf Forests | Lands dominated by trees with a percent canopy cover >60% and height exceeding 2 meters. Consists of seasonal needleleaf tree communities with an annual cycle of leaf-on and leaf-off periods. |
| 4 | Deciduous Broadleaf Forests | Lands dominated by trees with a percent canopy cover >60% and height exceeding 2 meters. Consists of seasonal broadleaf tree communities with an annual cycle of leaf-on and leaf-off periods. |
| 5 | Mixed Forests | Lands dominated by trees with a percent canopy cover >60% and height exceeding 2 meters. Consists of tree communities with interspersed mixtures or mosaics of the other four forest cover types. None of the forest types exceeds 60% of landscape. |
| 6 | Closed Shrublands | Lands with woody vegetation less than 2 meters tall and with shrub canopy cover is >60%. The shrub foliage can be either evergreen or deciduous. |
| 7 | Open Shrublands | Lands with woody vegetation less than 2 meters tall and with shrub canopy cover is between 10-60%. The shrub foliage can be either evergreen or deciduous. |
| 8 | Woody Savannas | Lands with herbaceous and other understorey systems, and with forest canopy cover between 30-60%.The forest cover height exceeds 2 meters. |
| 9 | Savannas | Lands with herbaceous and other understorey systems, and with forest canopy cover between 10-30%.The forest cover height exceeds 2 meters. |
| 10 | Grasslands | Lands with herbaceous types of cover. Tree and shrub cover is less than 10%. |
| 11 | Permanent Wetlands | Lands with a permanent mixture of water and herbaceous or woody vegetation that cover extensive areas. The vegetation can be present in either salt, brackish, or fresh water. |
| 12 | Cropland | Lands covered with temporary crops followed by harvest and a bare soil |

| | | |
|---|---|---|
| | | period (e.g., single and multiple cropping systems. Note that perennial woody crops will be classified as the appropriate forest or shrub land cover type. |
| 13 | Urban and Built-up | Land covered by buildings and other man-made structures. Note that this class will not be mapped from the AVHRR imagery but will be developed from the populated places layer that is part of the Digital Chart of the World. |
| 14 | Cropland/Natural Vegetation Mosaics | Lands with a mosaic of croplands, forest, shrublands, and grasslands in which no one component comprises more than 60% of the landscape. |
| 15 | Snow and Ice | Lands under snow and/or ice cover throughout the year. |
| 16 | Barren | Lands exposed soil, sand, rocks, or snow and never has more than 10% vegetated cover during any time of the year. |
| 17 | Water Bodies | Oceans, seas, lakes, reservoirs, and rivers. Can be either fresh or salt water bodies |

## 5.3 Land Cover Classification System (LCCS) FAO

The harmonization of different LC class sets (legends), so that data from multiple sources and data prepared in different application environments can be compared and integrated, is a crucial factor for both the economic and environmental EU policies in order to ensure equability in actions undertaken in different EU countries or regions. Any map deriving from a land cover classification is an approximation of the reality with an intrinsic degree of generalization of the information, resulting from human interpretation. Thus, the standardizations and formalization of the semantics (legends) of land covers is a key factor for proper communication among technical operators, different public administration or end users.

The Food and Agriculture Organization (FAO) and UNEP (United Nations Environment Programme). have introduced a new Land Cover Classification System (LCCS) [Di Gregorio & Jansen, 1998; 2005], based on the use of a set of independent diagnostic criteria rather than on the establishment of pre-defined land-cover classes. As already mentioned in Section 2.2, it is noteworthy that, according to the nomenclature adopted in this deliverable in line with the work of Congalton [Congalton, 1991], LCCS is NOT (!) an LC classification system, which contradicts the LCCS name itself, but an LC class set (legend).

The main aim in developing the LCCS legend was to provide a tool for harmonization and standardization of land cover information and mapping products. This system is intended to be capable of capturing any land cover all over the world, independently of specific applications and/or geographical areas. The LCCS is also intended to overcome problems due to the interpretation of different land-cover class definitions, because, rather than establishing other land cover classes based on nomenclature, it defines a set of independent diagnostic criteria strictly based on vegetation physiognomy and structure leading to criteria based land-cover classes, compatible with any definition and allowing for relation with existing classifications and labels. A land-cover class is defined by a dynamic combination of classifiers which can be combined to describe the more complex semantics of each land-cover class [Di Gregorio & Jansen, 2005].

The first operational application of the LCCS was in the framework of the Africover project (http://www.africover.org/), which was developed by the FAO in the early 1990s in order to increase the availability of reliable land-cover information over East and Central Africa countries, based on uniform mapping specifications.

LCCS was also adopted within the Global Land Cover 2000 (GLC2000) project. It was carried out under the Fifth Framework Programme 1999-2002 for Research of the European Commission and co-ordinated by the Joint Research Center (JRC) of the European Commission (EC) in partnership with

more than 30 partner institutions around the world, with the aim of realizing a harmonized land cover database covering the major land cover types of the world for the year 2000 [Bartholomé & Belward, 2005]. During the project, a one kilometer resolution map showed in Figure 6 was produced from SPOT-4 Vegetation Instrument data.

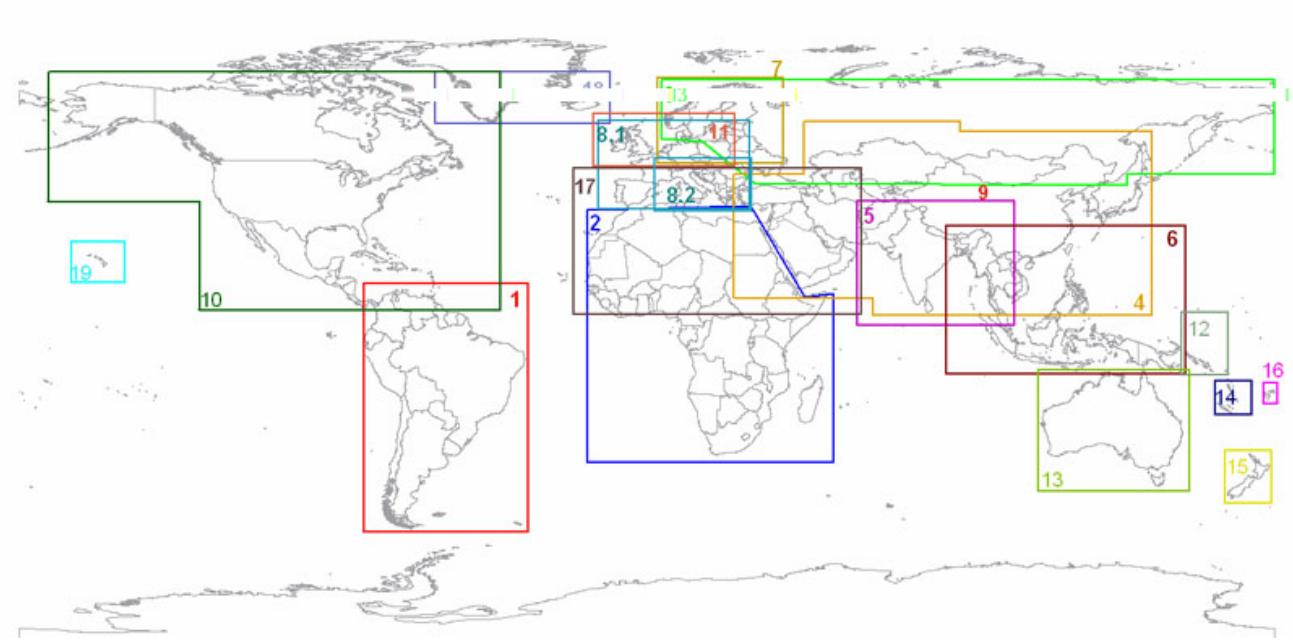


**Figure 6 - 19 different windows mapped under the GLC2000 by LCCS,**
from [Bartholomé & Belward, 2005]

For compatibility purpose, LCCS was then adopted within the new GlobCover project (http://postel.mediasfrance.org/en/PROJECTS/Preoperational-GMES/GLOBCOVER/), an ESA initiative launched in 2005 in partnership with JRC, EEA, FAO, UNEP, GOFC-GOLD and IGBP to update the GLC2000 global cover map. The main project outcome was the new 2009 global Land-Cover map based on MERIS Full Resolution (i.e. 300m.) mode data of the ENVISAT satellite. The legend of the new GlobCover map consists of 23 land cover classes

LCCS has proven to be a valid tool in the detection of changes. In fact, a land cover change may occur in two ways, as a conversion from one land cover class to another, or as a modification within the same class. Conversion implies an evident change and can be easily be represented on a map (changing the LC class), whereas modifications are less apparent and their representation in a map is not always possible, depending on the detail and flexibility of the LC classification used. With the LCCS approach land cover change detection becomes possible both at the level of conversion of a class, and modification within a certain class type. In this last case, the change becomes immediately identifiable by a difference in classifier, or through the use of additional classifiers, although maintaining the same major class type [Jansen & Di Gregorio, 2002a].

One of the basic principles of LCCS is that a given land cover class is defined by the combination of a set of independent diagnostic attributes, the so-called “classifiers”. The increase of detail in the description of a land cover class is linked to the increase of the number and types of the classifiers [Di Gregorio & Jansen, 1998].

The classification according to LCCS has two main phases:

1) The *Dichotomous phase*, where a dichotomous key is used to define eight major land cover types. In the Dichotomous phase of LCCS three classifiers are used: Presence of Vegetation, Edaphic Condition and Artificiality of Cover. The eight major land cover categories identified are:

    - **primarily vegetated**: A11 (cultivated and managed terrestrial areas), A12 (natural and semi-natural terrestrial vegetation), A23 (cultivated aquatic or regularly flooded areas), A24 (natural and semi-natural aquatic or regularly flooded vegetation), and
    - **primarly non vegetated**: B15 (artificial surfaces and associated areas), B16 (bare areas), B27 (artificial waterbodies, snow and ice), B28 (natural water bodies, snow and ice).

2) The *Modular-Hierarchical phase*, where a combination of a set of classifiers, different for each of the main land cover types, allows the definition of more detailed land cover classes. The set of classifiers changes from one class to another. In each set, the classifiers are divided in three groups:

    - "*pure land cover*" classifiers,
    - "*environmental*" attributes,
    - and "*specific technical*" attributes.

    The first obligatory step is the use of "*pure land cover*" classifiers. As an example, in the A12 class including natural and semi-natural terrestrial vegetation, pure classifiers are: life form, cover, height and pattern, leading to specific land cover classes which are described not just by a predefined name but by the set of classifiers used. By using these pure land cover classifiers, the third and the fourth level of the Modular-Hierarchical phase are described for the natural terrestrial class and for the natural aquatic/flooded class, respectively.

    In successive steps, through additional *environmental attributes* (if information is available), further detailed classes can be defined.

    The last step of the modular-Hierarchical phase is the definition of "*specific technical*" attributes As an example, for A12 (i.e. natural and semi-natural terrestrial vegetation) and for A24 (i.e. natural and semi-natural aquatic/flooded vegetation), specific attributes are the floristic aspects; for A11 and A23 (i.e. cultivated), specific attributes are specifications of crop types. This means that, in the case of cultivated areas, the crop type is specified to the last level.

    A complete description of the classification sequence for A12 and A24 is reported in the following. For the **terrestrial A12 class**:

    1. *Pure land-cover* classifiers to be used are:

        - **Life form** (woody(trees, shrubs), herbaceous (forbs, graminoids), lichens/moss) and **cover**, **height**, **spatial distribution**
        - **Leaf type** and **phenology**
        - **Stratification**

    2. *Environmental attributes*:

        - **Landform, lithology, soils**
        - **Climate, altitude, erosion,**

    3. *Specific technical attributes*

        - **Floristic features**

    For the **aquatic or flooded A24 class**:

1. *Pure land-cover classifiers* are:
    - **Life form** (woody(trees, shrubs), herbaceous(forbs, graminoids), lichens/moss) and **cover**, **height**, **spatial distribution**
    - **Water seasonality**
    - **Leaf type** and **phenology**
    - **Stratification**
2. *Environmental attributes*:
    - **Landform**, **lithology**, **soils**, **climate**
    - **Altitude**, **erosion**, **water quality**
3. *Specific technical attributes*
    - **Floristic features**

In LCCS classification system the user is not obliged to follow and check the whole series of classifiers and attributes: when no more information is available, or if no more details are required, it can stop and derive the description of the land cover class. The more information (classifiers and attributes) is available and checked, the more detailed is the land cover class derived.

A software program (http://www.africover.org/software_down.htm) has been created to make easier the selection of the appropriate class, using a step by step process. The main hierarchical LCCS scheme is reported in Fig. 6. Table 3 from (www.fao.org/docrep/003/x0596e/X0596e02b.htm#P2150_116570) includes the major land cover types and their structural domain.

**Figure 6 - Two phases and classifiers of LCCS**
(De Gregorio & Jansen, 1998)

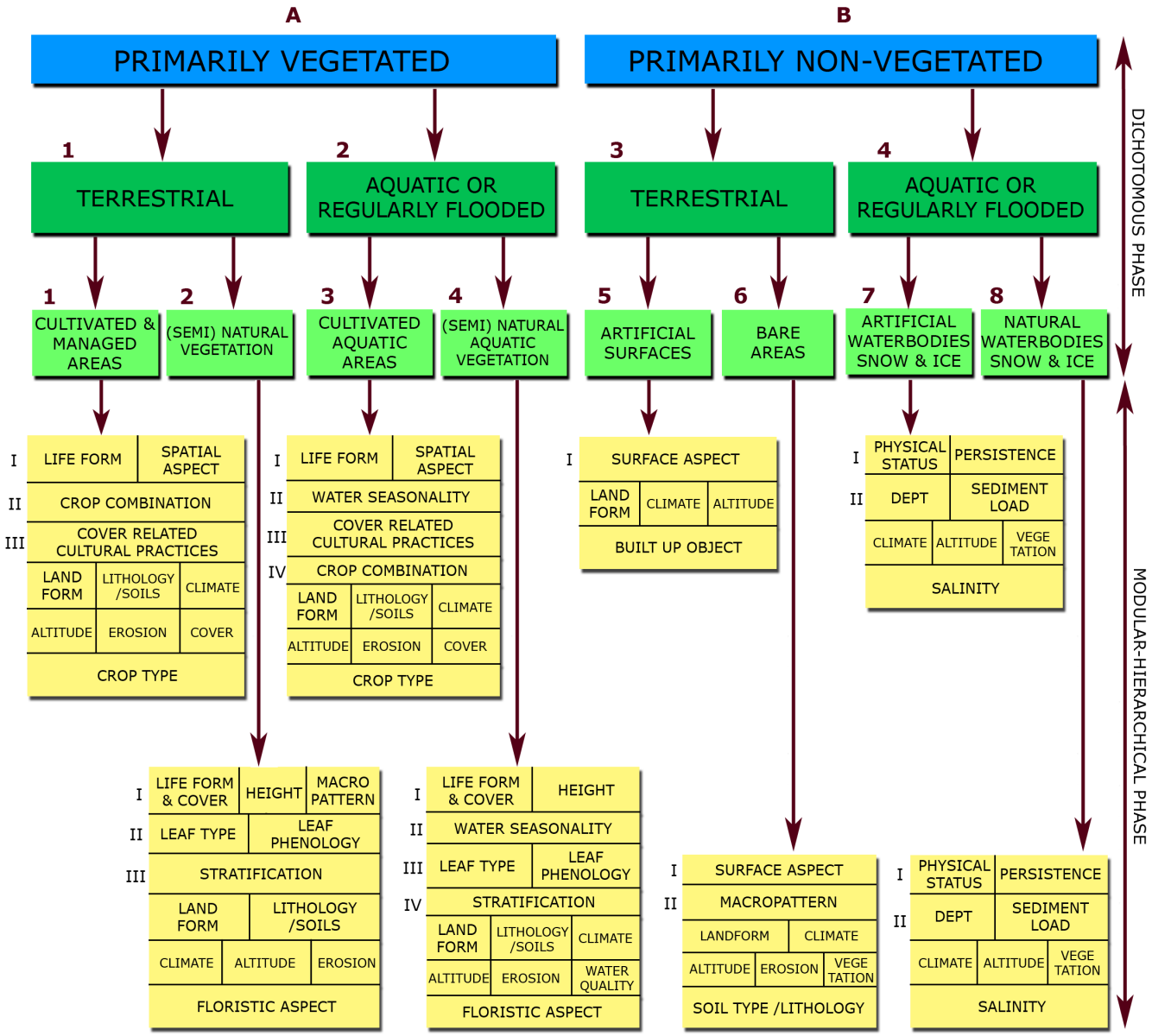

**Table 3.** Major Land Cover type and their structural domain.

| A11. CULTIVATED AND MANAGED TERR. AREAS | |
|---|---|
| I. A. Life Form of the Main Crop | Code |
| Trees | A1 |
| Broadleaved | A7 |
| Needleleaved | A8 |
| Evergreen | A9 |
| Deciduous | A10 |
| Shrubs | A2 |
| Broadleaved | A7 |
| Needleleaved | A8 |
| Evergreen | A9 |
| Deciduous | A10 |
| Herbaceous | A3 |
| Graminoids | A4 |
| Non-Graminoids | A5 |
| Urban Vegetated Area(s) | A6 |
| Parks | A11 |
| Parkland | A12 |
| Lawns | A13 |
| B. Spatial Aspect - Field Size | |
| Large To Medium Sized Field(s) | B1 |
| Large Sized Field(s) | B3 |
| Medium Sized Field(s) | B4 |
| Small Sized Field(s) | B2 |
| B. Spatial Aspect - Field Distribution | |
| Continuous | B5 |
| Scattered Clustered | B6 |
| Scattered Isolated | B7 |
| II. C. Crop Combination | |
| Single Crop | C1 |
| Multiple Crop | C2 |
| One Additional Crop | C3 |
| Trees | C5 |
| Shrubs | C6 |
| Herbaceous Terrestrial | C7 |
| Herbaceous Aquatic | C8 |
| Simultaneously | C17 |
| Overlapping | C18 |
| Sequential | C19 |
| Two Additional Crops | C4 |
| Trees | C9 |
| Shrubs | C10 |
| Herbaceous Terrestrial | C11 |
| Herbaceous Aquatic | C12 |
| Simultaneously | C17 |
| Overlapping | C18 |
| Sequential | C19 |
| Trees | C13 |
| Shrubs | C14 |
| Herbaceous Terrestrial | C15 |
| Herbaceous Aquatic | C16 |
| Simultaneously | C17 |
| Overlapping | C18 |
| Sequential | C19 |
| III. D. Cultural Practices - Water Supply | |
| Rainfed | D1 |
| Postflooding | D2 |

| A12. SEMINATURAL TERR. VEGETATION | |
|---|---|
| I. A. Life Form of the Main Strata | Code |
| Woody | A1 |
| Trees | A3 |
| Shrubs | A4 |
| Herbaceous | A2 |
| Forbs | A5 |
| Graminoids | A6 |
| Lichens/Mosses | A7 |
| Lichens | A8 |
| Mosses | A9 |
| A. Cover | |
| Closed (>70-60%) | A10 |
| Open (70-60 - 20-10%) | A11 |
| (70-60 - 40%) | A12 |
| (40 - 20-10%) | A13 |
| Sparse (20-10 - 1%) | A14 |
| (<20-10 - 4%) | A15 |
| Scattered (4 - 1%) | A16 |
| B. Height | |
| 7 - 2m (for Woody) | B1 |
| >30 - 3m (for Trees) | B2 |
| >14m | B5 |
| 14-7m | B6 |
| 7-3m | B7 |
| 5 - 0.3m | B3 |
| 5-0.5m | B14 |
| 5-3m | B8 |
| 3-0.5m | B9 |
| <0.5m | B10 |
| 3 - 0.03m | B4 |
| 3-0.3m | B15 |
| 3-0.8m | B11 |
| 0.8-0.3m | B12 |
| 0.3-0.03m | B13 |
| C. Spatial Distribution/Macropattern | |
| Continuous | C1 |
| Fragmented | C2 |
| Striped | C4 |
| Cellular | C5 |
| Parklike Patches | C3 |
| II. D. Leaf Type | |
| Broadleaved | D1 |
| Needleleaved | D2 |
| Aphyllous | D3 |
| E. Leaf Phenology | |
| Evergreen | E1 |
| Semi-Evergreen | E4 |
| Deciduous | E2 |
| Semi-Deciduous | E4 |
| Mixed | E3 |
| Mixed (for Forbs/Graminoids) | E5 |
| Annual | E6 |
| Perennial | E7 |
| III. F. Stratification - Second Layer | |
| Second Layer Absent | F1 |
| Second Layer Present | F2 |

| A24. SEMINATURAL AQUATIC VEGETATION | |
|---|---|
| I. A. Life Form of the Main Strata | Code |
| Woody | A1 |
| Trees | A3 |
| Shrubs | A4 |
| Herbaceous | A2 |
| Forbs | A5 |
| Rooted | A8 |
| Free Floating | A9 |
| Graminoids | A6 |
| Lichens/Mosses | A7 |
| Lichens | A10 |
| Mosses | A11 |
| A. Cover | |
| Closed (>70-60%) | A12 |
| Open (70-60 - 20-10%) | A13 |
| (70-60 - 40%) | A14 |
| (40 - 20-10%) | A15 |
| Sparse (20-10 - 1%) | A16 |
| (<20-10 - 4%) | A17 |
| Scattered (4 - 1%) | A18 |
| B. Height | |
| 7 - 2m (for Woody) | B1 |
| >30 - 3m (for Trees) | B2 |
| >14m | B5 |
| 14-7m | B6 |
| 7-3m | B7 |
| 5 - 0.3m | B3 |
| 5-0.5m | B14 |
| 5-3m | B8 |
| 3-0.5m | B9 |
| <0.5m | B10 |
| 3 - 0.03m | B4 |
| 3-0.3m | B15 |
| 3-0.8m | B11 |
| 0.8-0.3m | B12 |
| 0.3-0.03m | B13 |
| II. C. Water Seasonality | |
| More than 4 Months A Year | C1 |
| Persistent For Whole Day | C4 |
| With Daily Variations | C5 |
| Less than 4 but More than 2 Months | C2 |
| Waterlogged | C3 |
| III. D. Leaf Type | |
| Broadleaved | D1 |
| Needleleaved | D2 |
| Aphyllous | D3 |
| E. Leaf Phenology | |
| Evergreen | E1 |
| Semi-Evergreen | E3 |
| Deciduous | E2 |
| Semi-Deciduous | E3 |
| Mixed | E4 |
| Mixed (for Forbs/Graminoids) | E5 |
| Annual | E6 |
| Perennial | E7 |
| IV. F. Stratification - Second Layer | |

| B15. ARTIFICIAL SURFACES AND ASS. AREAS | |
|---|---|
| I. A. Surface Aspect | Code |
| Built Up | A1 |
| Linear | A3 |
| Roads | A7 |
| Paved | A8 |
| Unpaved | A9 |
| Railways | A10 |
| Comm. Lines/Pipelines | A11 |
| Non-Linear | A4 |
| Industrial a/o Other | A12 |
| High Density | A14 |
| Medium Density | A15 |
| Low density | A16 |
| Urban Areas | A13 |
| High Density | A14 |
| Medium Density | A15 |
| Low density | A16 |
| Non Built Up | A2 |
| Waste Dump Deposits | A5 |
| Extraction Sites | A6 |
| A. BUILT-UP OBJECT | |
| (scroll list with pre-defined entries) | |

| B16. BARE AREAS | |
|---|---|
| I. A. Surface aspect | Code |
| Consolidated | A1 |
| Bare Rock a/o Coarse Fragm. | A3 |
| Bare Rock | A7 |
| Gravel/Stones/Boulders | A8 |
| Gravel | A14 |
| Stones | A15 |
| Boulders | A16 |
| Hardpans | A4 |
| Ironpan/Laterite | A9 |
| Petrocalcic | A10 |
| Petrogypsic | A11 |
| Unconsolidated | A2 |
| Bare Soil a/o Other Uncon. Mat. | A5 |
| Stony (5 - 40%) | A12 |
| Very Stony (40 - 80%) | A13 |
| Loose and Shifting Sands | A6 |
| Stony (5 - 40%) | A12 |
| Very Stony (40 - 80%) | A13 |
| II. B. Macropattern - Sands | |
| Dunes | B1 |
| Barchans | B2 |
| Saturated | B5 |
| Unsaturated | B8 |
| Parabolic Dunes | B3 |
| Saturated | B6 |
| Unsaturated | B9 |
| Longitudinal Dunes | B4 |
| Saturated | B7 |
| Unsaturated | B10 |
| B. Macropattern - Soils | |
| Gilgai | B11 |

# 6. Classification class sets for habitat mapping in Italian training sites

In the following sub-sections LCCS is first compared with CLC. Then, LCCs is related to Annex I and GHCs for habitat mapping.

## 6.1 CLC and LCCS comparison

LCCS is *a* classification system providing all possible combinations of the considered classifiers and has a good consistency, defining unique classes and avoiding overlapping. It is particularly suitable for mapping programs. One of its advantages consists in the possibility of integrating and harmonizing, in the same map, different levels of detail and information. This is a system that allows systematic treatment and mapping of heterogeneous areas [Di Gregorio & Jansen, 2005]. However, LCCS is not informative about eco-climatic features, such as information on average yearly phenological behaviour of distinct vegetation types, which may vary significantly within each LCCS class depending on local eco-climatic conditions. Including information on these features would therefore greatly enhance the LCCS characterization of vegetation properties [Maselli et al 2009].

When comparing CLC and LCCS class sets, a certain level of spatial disagreement is observed between the CORINE2000 and GLC2000 datasets [Herold and Schmullius, 2004; Neumann et al, 2007].

The process of converting the CLC nomenclature to the LCCS is limited by given situations, some of which are listed in

http://lusi.eionet.europa.eu/EAGLE/Information_provided_EAGLE_MS/16_CLC_to_LCCS_conversion_notes_v1.0.pdf

The comparison of CLC and LCCS is provided in this section for the two considered Italian training NATURA 2000 sites in Tables IT4_3 and IT3_3. In these two Tables, CLC (at the third level) and LCCS (at the third for terrestrial and at the fourth level for aquatic/flooded) classes are reported, respectively. The pure "land cover" LCCS classes (i.e. the ones detected by using the pure land cover classifiers of the Modular-Hierarchical phase) are listed. EUNIS, Annex I and GHC habitat types are also listed in order to highlight the capability of each classification legend in identifying natural habitats.

More specific details of the land cover LCCS classifiers used for both cultivated areas and natural and semi natural areas are described in Tables IT4_4a and IT4_4b for Le Cesine and in Table IT3_4a and IT3_4b for Murgia Alta, respectively.

For the two test sites, additional information, such as the phenology of vegetation communities and the flooding period (months) of acquatic/flooded communities are specifically provided in the columns titled *expert prior information.* Such information cannot be included in the classification process since it is not considered as an LCCS attribute.

A complete list of the environmental and technical attributes that can be used to deeply discriminate classes having similar attributes in the previous levels of the hierarchical phase is reported in Table IT4_5 for only the IT4 study site. In this table, habitats are listed in columns and attributes in lines.

With regard to the comparison between CLC and LCCS with respect to the artificial and agricultural LC class types discrimination, there is a fairly good correspondence between these two systems, although the classifier "cultural practices" in level III of the Modular-Hierarchical phase may provide more details than the CLC system. In LCCS further specifications can be added by using other environmental or technical attributes to define interactively the specific crop type.

Some land cover types fall into "natural" or "managed" classes according to the classification legend adopted. In any case, sometimes the allocation can be ambiguous. Some main issues are highlighted in the following, for two land cover classes widely distributed in Mediterranean Natura 2000 sites (such as the two Italian training test sites).

1. In CLC, forest (conifer) plantations are referred to as 3.1.2 "Coniferous forests", which includes

both natural forests and plantations [Bossard et al, 2000]. In LCCS, this type is well described in A11 (cultivated and managed terrestrial areas) as “Large sized fields of needle-leaved evergreen tree crops” with the indication of “Plantation”. This class, which directly corresponds to a habitat, is well represented also in CORINE Biotopes and EUNIS (“conifer plantation” and “native conifer plantation”, respectively). In Annex I Forest plantations are not considered.

2. The CLC class 2.3.1 “pastures” includes “extensively used grasslands with presence of farm structure...or regular agricultural works” and “temporary and artificial pastures not under a rotation system which become permanent grasslands five years after ploughing” or “abandoned arable land not under a rotation system used as pastures (after 3 years)” [Bossard et al 2000], meaning the presence of some level of human activity in this area (managed). In LCCS this type of sub-nitrophilous vegetation cannot be included in A11 (cultivated and managed terrestrial areas), because this class implies the presence of one or more crops for A11. So, in Tables IT4_3 and IT3_3 this land cover class type (pasture) has been assigned to A12 (natural and semi-natural terrestrial vegetation). In this case, there is some difficulty in the attribution of grazed areas in both systems.
3. The CLC class 2.2.3 “Olive groves” is described as “broadleaved evergreen tree crops” in LCCS third level and the use of LCCS technical attributes just provide the specific class label. Additional *attributes,* such as some agricultural practices (e.g. *sesto di impianto*), which are not yet included in the LCCS scheme, should be used to discriminate this class from other crop types.

**LCCS achieves greater detail than CLC mainly for natural and semi natural class types discrimination. After determining a pure land cover class and by adding further classifiers of most detailed classification levels, the definition can reach almost the level of a habitat type.**

As regards the usefulness of LCCS and CLC classifiers toward habitat classification for IT4 and IT3 sites, the main issues are highlighted as follows.

1. The CLC classes 3.2.3 – “Sclerophyllous vegetation”, 3.3.1 – “Beaches, dunes, and sand plains” and 4.2.1 – “Salt marshes” have a broad ecological value. Each of them includes several natural vegetation types and then corresponding habitat types. Confusion is expected with CLC. On the contrary, LCCS can provide more classes. In the case of “Sclerophyllous vegetation” four possible classes are discriminated in the IT4 site (see IT4_3 Table).
2. In some cases, the same LCCS class (at the third level for terrestrial and at the fourth level for aquatic/flooded) may correspond to two or more habitat types: this is the case of Annex I habitat types 3170 and 1310, or 2230 and 6220 or the EUNIS types D5.24, D5.1 and D5.2. As an example, Annex I habitats 3170 and 1310 belong to the same LCCS land cover class ( i.e. A2.A13.B4.C2.E5/A15.B13.E7-see Table IT4_3) but correspond to two different classes in CLC ( 4.1.1 and 4.2.1, respectively). However, the CLC class 4.2.1 can be used for a larger number of habitat types (i.e. 1410, 1420, 7210) as you can see in IT4_3 Table. Also the CLC fourth level does not seem useful for the discrimination of habitat 1310.

   In LCCS, by adding environmental attributes, such as lithology, soils, landform and water quality, and technical attributes (floristic) the discrimination of different habitat types is possible (e.g. between 1310 and 3170 or also 2230 and 6220). See Table IT4_5 where the specific environmental attributes useful for discriminating the previous habitats are identified.

   Please, note that the specific LCCS classifier “cycle” includes only the discrimination between annual and perennial for herbaceous. By adding the phenology of plant communities, i.e the period during which each vegetation type appears (for annual types) or shows the maximum of biomass (for perennial), habitat discrimination is possible. For this reason the phenology of plant communities has been added in both Table IT4_4b_Cesine and in IT3_4b_Murgia Alta. As an example, habitat 3170 and 1310 are annual but the former appears in May-June, whereas the latter has its maximum in August- October.

   However, environmental attributes are still not sufficient for discriminating some EUNIS habitat types corresponding to the same land cover class, as in the case of D5.24, D5.1 and D5.2. The

technical attributes “floristic” for dominant or diagnostic species are required. This means that in-situ data are mandatory since these specific species cannot be inferred by other attributes.

3. In the CLC sytem, class 3.2.1 - “Natural grassland” includes different natural and semi-natural vegetation types, some of which are habitat according to Annex I (6210, 6220, 62A0) but not all of them. The CLC fourth level does not help in this case.
   In the LCCS system (at the third level of *terrestrial* and at fourth level for *aquatic/flooded* types), the previous cited vegetation types belong to the same LCCS class (A6.A10.B4.E5 / B12.E6 - Closed perennial medium tall grasslands), except for the vegetation type *fields Thistle* (E1.C2 in EUNIS), that has been classified as "forbs"(A5) and not "graminoids (A6, grasslands). In this case, the selection of additional environmental indicators, such as "lithology", "soil", "erosion", etc. can provide additional features for the discrimination between different habitats by LCCS.
4. As a detail, in LCCS the term “graminoids” means “all herbaceous grasses and other narrow-leaf grass-like plants which are not grasses according to the taxonomic definition [Kuechler & Zonneveld, 1988], e.g., sedges and rushes” [Choudhury & Jansen, 1998; Di Gregorio & Jansen, 2005]. So, Annex I habitat types 1410 (Mediterranean salt meadows/Juncetalia maritimi) and 7210 (Calcareous fens with Cladium mariscus) and EUNIS types such as D5.1 (Reeds beds/Phragmition australis, Scirpion maritimi), D5.2 (Large sedge communities/Magnocaricion), C2 (Small reed beds of fast flooding waters/Glycerio-Sparganion) should be classified as “graminoids” and then as “grasslands”.

## 6.2 LCCS and GHC

GHCs contain information about life form, height, leaf type and cycle. Therefore, it seems that LCCS classes as defined by means of pure classifiers (including life form, height, leaf type and cycle) can provide a good match with GHCs. As an example, LHE category (i.e. leafy hemicryptophytes) corresponds to "perennial medium tall forbs" class in LCCS; MPH/CON (i.e. mid phanerophytes/conifers) corresponds to "needledleaved evergreen - medium high thicket" in LCCS (see IT4_3 and IT3_3 Tables).

Both the two classifications have been designed to meet the fundamental attributes of the logic for global vegetation classification proposed in [Running et al. 1995]. It is worth noting that the definition of *life forms* according to FAO-LCCS adopts a plant classification in trees, shrubs, herbs (graminoids and forbs) and it is different from the one adopted in GHCs [Raunkiaer, 1904], [Bunce 2008].

However, some discrepancies between the two systems can be highlighted. For example, ranges in height defined by GHC for chamaephytes and phanerophytes do not correspond exactly to the ranges defined by LCCS for trees and shrubs. In addition, LCCS defines different ranges of height for herbaceous type, whereas these ranges are not provided in GHC. This might probably be due to the different use of height information in the two systems. The GHCs have been set-up by ecologists from an ecological perspective and have a basis in the UK countryside survey, while the LCCS has been set up by land cover, forest and remote sensing specialists who had a different background than the above mentioned ecologists.

GHC methodology provides *environmental, site, management and other* qualifiers, as in EBONE Handbook (Bunce et al 2011) for habitat definition. A key is also provided ( see the Ebone Deliverable 4.2) to achieve habitats of Annex I. A selection of GHC site qualifiers useful for IT4 habitat detection is provided in Table IT4_6.

**Table IT4_3_Cesine.** Correspondence between CLC (at third level), IGBP and LCCS (at second and third level) class sets and habitats in different habitat classification systems. In the column of Modular Hierarchical phase/Level I, *basic* classifiers and modifiers are separated by a slash. Different colours correspond to different classifiers/modifiers.
Please, note that perennial woody crops will be classified as the appropriate forest or shrub land cover type (e.g. Olive groves = Evergreen forest).

| | CORINE | IGBP | LCCS | | | | EUNIS | ANNEXI | GHC | |
|---|---|---|---|---|---|---|---|---|---|---|
| CLC 3 | Class Description | IGBP | III lev Dichotomous phase | Modular Hierarchical phase Level I | Modular Hierarchical phase Level II / III | Class Description | Habita code at Level 4 | Habitat code | Acronym | Level 5 |
| 1.1.2 | Discontinuous urban fabric | 13 Urban and built-up | B15 Artificial surfaces and associated areas | A4.A12.A17 | | Scattered industrial or other areas | J2.1 | X | URB | URB - **to be defined** |
| 1.2.2 | Road and rail networks and associated land | | | A3.A8 | | Paved roads | J4.2 | X | URB | URB - ART/NON |
| 2.1.1 | Non-irrigated arable land | 12 Croplands | A11 Cultivated and managed terrestrial areas | A4.B2.C1.D1 | | Monocolture of small size field of rainfed graminoid crops | I1.3 | X | CUL | CUL - CRO |
| 2.1.2. | Permanently irrigated land | | | A5.B2. C2.D3 | | Small size field of irrigated no-graminoid crops | I1.3 | X | CUL | CUL - CRO |

| | CORINE | IGBP | LCCS | | | | EUNIS | ANNEXI | GHC | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.2.3 | Olive groves | 2 Evergreen Forests | | A1.B1. C1.D1-W8/A7.A9.B4 | | Monocolture of medium size field of broadleaved evergreen of rainfed tree crops Orchards | G2.91 | X | CUL | CUL - WOC |
| 3.1.2 | Coniferous forest | | | A1.B1.B5-W7/A8.A9.B3 | | Large sized fields of needleleaved evergreen tree crops Plantations | G3.F1 | X | TRS | TRS – **to be defined** |
| 2.3.1 | Pastures | 10 Grasslands | A12 Natural and semi natural primarily terrestrial vegetation | A5.A10.B4/B12 | A5.A10.B4.E5/B12.E7 | Closed annual medium/tall forbs | E1.6 | X | HER | HER - **to be defined** |
| 3.2.4. | Transitional woodland shrub | 6 Closed Shrublands | | A4.A10.B3/D1.E2 B9 | | Broadleaved deciduous closed medium/high shrubland | F5.51 | X | TRS | TRS - **to be defined** |
| 3.2.3 | Sclerophyllous vegetation | | | A4.A10.B3/B9 | A4.A10.B3.D2.E1/B9. | Needleaved evergreen medium/high closed shrubland (thickets) | B1.63 (B1.631) | 2250* | TRS | 6.4.3.3.1 MPH/CON + dry sandy soils + coastal dunes + Juniperus species |
| | | | | A4.A10.B3./B9 | A4.A10.B3.D1.E1/B9 | Broadleaves evergreen closed medium/high shrubland | F5.55 | 5330 | TRS | 6.4.2.6.3 LPH/EVR+MPH/EVR + xeric soils + indicators |

| | CORINE | IGBP | LCCS | | | | EUNIS | ANNEXI | GHC | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | F5.51 (F5.514) | X | TRS | **to be defined** |
| | | | | A4.A11.B3/ B10 | A4.A11.B3. D1.E1/ B10 | Broadleaves evergreen open dwarf shrubland | F6.2C | X | TRS | **to be defined** |
| 3.3.1 | Beaches, dunes, and sand plains | 10 Grasslands | | A5.A11.B4/ A13.B13 | A5.A11.B4.E5/ A13.B13.E7 | Open (40-(20-10)%) annual short forbs | B2.13 | 1210 | HER | 5.2.2.9.1 LHE/CHE + saline soils + sand or gravel + linear coastal feature |
| | | | | A6.A11.B4/ A12.B12 | A6.A11.B4.E5/ A12.B12.E6 | Open ((70-60)-40%) perennial medium-tall grasslands | B1.31 | 2110 | HER | 1.3.5.2.1 TER (sand) +THE+CHE+ THE/CHE + LHE/CHE |
| | | | | A6.A10.B4/ A12.B11 | A6.A10.B4.E5/ A12.B11.E7 | Closed perennial tall grasslands | B1.32 | 2120 | HER | 1.3.5.2.2 TER (sand) +THE+CHE+ THE/CHE + LHE/CHE |
| | | | | A2.A11.B4/ A13.B13 | A5.A11.B4.E5/ A13.B13.E7 | Open (40-(20-10)%) annual short herbaceous vegetation | B1.48 | 2230 | HER | 5.2.1.4.1 LHE/THE + coastal dunes + local knowledge + indicator species |
| 3.3.3 | Sparsely vegetated areas | 16 Barren or Sparsely Vegetated | | A2.A11.B4/ A13.B13 | A5.A11.B4.E5/ A13.B13.E7 | Open (40-(20-10)%) annual short herbaceous vegetation | E1.313 | 6220* | HER | 5.2.1.7.2 CHE/THE + xeric + calcareous + critical species + expert knowledge |

| | CORINE | IGBP | LCCS | | | | EUNIS | ANNEXI | GHC | |
|---|---|---|---|---|---|---|---|---|---|---|
| 4.1.1 | Inland marshes | | A24 Natural and semi natural aquatic or regularly flooded vegetation | A2.A13.B4/ A15.B13 | A2.A13.B4.C2. E5/ A15.B13.E7 | Annual open (40-(20-10)%) short herbaceous vegetation on temporarily flooded land | C3.42 (C3.421) | 3170* | HER | 5.2.1.3.1 THE + GEO + THE/GEO + evidence of winter flooding + indicator species |
| 4.2.1 | Salt marshes | 11 Permanent Wetlands | | | | | A2.51 … | 1310 | HER | 5.2.1.1.1 THE + SPV/TER + mud + saline |
| | | | | | | | A2.55 … | | | |
| | | | | A6.A12.B4/ B12 | A6.A12.B4.C3. E5/ B12.E6 | Perennial closed medium-tall grasslands on waterlogged soil | A2.52 (A2.522) | 1410 | HER W | 5.2.2.12.1 LHE/CHE + saline + SCH |
| | | | | | | | A2.53 … | | | |
| | | | | A4A12B3/ B10 | A4A12B3C3D3 F1/ B10 | Aphyllous cosed dwarf shrubs on temporarily flooded land | A2.52 (A2.526) | 1420 | TRS | 6.2.2.3.2 SCH/EVR or LPH/ EVR + saline soils + indicator species |
| | | | | A6.A12.B4/ B11 | A6.A12.B4.C2. E5./ B11.E6 | Perennial closed tall grasslands on temporarily flooded land | D5.24 | 7210 | HER W | 5.1.2.1.1 EHY+CHE + fresh water + eutrophic/calcar eous + indicators |
| | | | | | | | D5.1 … | X | HER W | **to be defined** |
| | | | | | | | D5.2 … | X | HER W | **to be defined** |

| | CORINE | IGBP | LCCS | | | | EUNIS | ANNEXI | GHC | |
|---|---|---|---|---|---|---|---|---|---|---|
| 5.1.1 | Water courses | 1 Water Bodies | | A6.A12.B4/ B12 | A6.A12.B4.C2. E5./ B12.E6 | Perennial closed medium-tall grasslands on temporarily flooded land | C2 | X | HER W | **to be defined** |
| 5.2.1 | Coastal lagoons | | | A2.A13.B4/ A15.B12 | A2.A13.B4.C1. E5/ A15.B12.E6 | Perennial open (40-(20-10)%) medium-tall herbaceous vegetation on permanently flooded land | X02 | 1150 | Habitat complex SPV/HER-W/TER | 1.1.3 AQU+TER+SHY+EHY+CHE+LHE/CHE. Mainly SHY with locally patches of EHY + brackish to salt water + highly saline + shallow water separated from sea in lagoons or ponds |

**Table IT4_4a_Cesine.** Cultivated areas (habitat)

| EUNIS | Annex I | LCCS Modular-Hierarchical phase: land cover classifiers | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | *Life Form* | *Leaf type* | *Leaf Phenology* | *Orchard / Plantation* | *Spatial aspect- Field size* | *Crop combination* | *Water supply* | *Cultivation time* |
| I1.3 | x | Herbaceous/Graminoids | | | | Small | Single crop | Rainfed | |
| I1.3 | x | Herbaceous/Non graminoids | | | | Small | Single crop | Irrigated | |
| G2.91 | x | Woody/trees | Broadleaved | Evergreen | Orchard | Medium | Single crop | Rainfed | Permanent |
| G3.F1 | x | Woody/trees | Needleleaved | Evergreen | Plantation | Large | Single crop | Rainfed | Permanent |

**Table IT4_4b_Cesine.** Natural and semi-natural areas (habitat). For two LCCS classifiers, i.e. *Water seasonality and Cycle*, expert knowledge, which is not required at the moment within the LCCS scheme, is provided. In particular, the months corresponding to the flooding period (if any) and the months of maximum biomass and/or flowering are reported for the cited classifiers.

| **EUNIS** | **Annex I** | **LCCS Modular-Hierarchical phase: land cover classifiers** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Life Form* | *Cover* | *Height* | *Water seasonality* | | *Leaf type* | *Leaf Phenology* | *Cycle* | | *Stratification* |
| | | | | | Flooding period | ***Expert Prior Information*** | | | Annual/ Perennial | ***Expert Prior Information*** | |
| E1.6 | X | Herbaceous/Forbs | > 65% | 0.8-3 m | | | | | Annual | April-June | |
| F5.51 | X | Woody/shrubs | > 65% | 0.5-3 m | | | Broadleaved | Deciduous | Perennial | April-Oct | |
| B1.631 | 2250 | Woody/shrubs | > 65% | 0.5-3 m | | | Needle-leaved | Evergreen | Perennial | Full year | |
| F5.55 | 5330 | Woody/shrubs | > 65% | 0.5-3 m | | | Broadleaved | Evergreen | Perennial | Full year | |
| F5.514 | X | Woody/shrubs | > 65% | 0.5-3 m | | | Broadleaved | Evergreen | Perennial | Full year | |
| F6.2C | X | Woody/shrubs | 65-40% | < 0.5 m | | | Broadleaved | Evergreen | Perennial | Full year | |
| B2.13 | 1210 | Herbaceous/Forbs | 40-15% | 0.3-0.03 m | | | | | Annual | June-August | |
| B1.31 | 2110 | Herbaceous/Graminoids | 65-40% | 0.8-0.3m | | | | | Perennial | June-August to Oct | |
| B1.32 | 2120 | Herbaceous/Graminoids | > 65% | 3-0.8 m | | | | | Perennial | June-August to Oct | |
| °B1.48 | 2230 | Herbaceous | 40-15% | 0.3-0.03 m | | | | | Annual | April-May | |
| °E1.313 | 6220 | Herbaceous | 40-15% | 0.3-0.03 m | | | | | Annual | April-May | |
| *C3.421 | 3170 | Herbaceous | 40-15% | 0.3-0.03 m | temporarily flooded | dec-mar | | | Annual | *May-June | |
| *A2.51/A2.55 | 1310 | Herbaceous | 40-15% | 0.3-0.03 m | temporarily flooded | (dec) jan-apr (may) | | | Annual | *Aug-Sept | |
| A2.522 | 1410 | Herbaceous/Graminoids | > 65% | 0.8-0.3m | waterlogged | | | | Perennial | June-August to Oct | |
| A2.526 | 1420 | Woody/shrubs | > 65% | < 0.5 m | temporarily flooded | (depending on veg.type) | Aphyllous | | Perennial | July -August to Oct | |
| **D5.24 | 7210 | Herbaceous/Graminoids | > 65% | 3-0.8 m | temporarily flooded | (dec) jan-mar (apr | | | Perennial | June-August | |
| **D5.1 | X | Herbaceous/Graminoids | > 65% | 3-0.8 m | temporarily flooded | (dec) jan-mar (apr) | | | Perennial | June-August | |
| **D5.2 | X | Herbaceous/Graminoids | > 65% | 3-0.8 m | temporarily flooded | (dec) jan-mar (apr) | | | Perennial | June-August | |
| C2 | X | Herbaceous/Graminoids | > 65% | 0.8-0.3m | temporarily flooded | (dec) jan-mar | | | Perennial | June-August | |
| X03 | 1150 | Herbaceous | 40-15% | | permanently flooded | | | | Perennial | June-August to Oct | |

**Table IT4_5_Cesine.** List of LCCS environmental and technical (i.e. floristic) attributes for natural-seminatural areas used for discriminating some habitat types.

| | **ANNEX1** | X | X | 2250 | 5330 | X | X | 1210 | 2110 | 2120 | 2230 | 6220 | 3170 | 1310 | 1410 | 1420 | 7210 | X | X | X | 1150 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **EUNIS** | E1.6 | F5.51 | B1.631 | F5.55 | F5.514 | F6.2C | B2.13 | B1.31 | B1.32 | B1.48 | E1.313 | C3.421 | A2.51/ A2.55 | A2.522 | A2.526 | D5.24 | D5.1 | D5.2 | C2 | X03 |
| **LCCS environmental and technical attributes** | | | | | | | | | | | | | | | | | | | | | |
| *Landform_Major landforms* | | | | | | | | | | | | | | | | | | | | | |
| *Landform_Slope classes* | | | | | | | | | | | | | | | | | | | | | |
| *Lithology-Parent material* | | | | | | | | | | | X1 | Y1 | | | | | | | | | |
| *Lithology_Age* | | | | | | | | | | | | | | | | | | | | | |
| *Soil - surface aspect* | | | | | | | | | | | X2 | Y2 | | | | | | | | | |
| *Soil - suburface aspect* | | | | | | | | | | | X3 | Y3 | | | | | | | | | |
| *Climate - Thermal zone* | | | | | | | | | | | | | | | | | | | | | |
| *Climate - Lenght of growing period* | | | | | | | | | | | | | | | | | | | | | |
| *Altitude* | | | | | | | | | | | | | | | | | | | | | |
| *Water quality* | | | | | | | | | | | | | fresh | salt | | | | | | | |
| *Erosion* | | | | | | | | | | | | | | | | | | | | | |
| *Floristic* | | | | | | | | | | | | | | | | | | | | | |

**Table IT4_6_ Cesine.** GHC site *qualifiers* used for discriminating some habitat types. Per each Eunis habitat (in column) different GHC site qualifiers are reported per each line.

| **EUNIS habitat types** | E1.6 | F5.51 | B1.631 | F5.55 | F5.514 | F6.2C | B2.13 | B1.31 | B1.32 | B1.48 | E1.313 | C3.421 | A2.51/ A2.55 | A2.522 | A2.526 | D5.24 | D5.1 | D5.2 | C2 | X03 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***GHC site qualifiers*** | | | | | | | | | | | | | | | | | | | | |
| *Geomorphological element* | | | 1.25 dune | | | | | 1.25 dune | 1.25 dune | 1.25 dune | 1.2 rock outcrop | | | | | | | | | |
| *Inland water* | | | | | | | | | | | | 2.21 pond-temporary | | | | | | | | |
| *Historical element* | | | | | | | | | | | | | | | | | | | | |
| *Sea/Marine element* | | | | | | | | | | | | | | | | | | | | |
| *Coastal element* | | | | | | | 5.5 strand line | 5.1 yellow/ white dune | 5.1 yellow/ white dune | | | | 5.4 salt marsh | 5.4 salt marsh | 5.4 salt marsh | 5.4 salt marsh | | | | 5.4 salt marsh |
| *Bogs/Mires/Wetlands* | | | | | | | | | | | | | | | | | | | | |
| *Element with woodland* | | | | | | | | | | | | | | | | | | | | |
| *Additional habitat complexes* | | | | | | | | | | | | | | | | | | | | |
| *Related to water(ways)* | | | | | | | | | | | | | | | | | | | | |
| *Paths and tracks* | | | | | | | | | | | | | | | | | | | | |
| *Walls* | | | | | | | | | | | | | | | | | | | | |
| *Fences* | | | | | | | | | | | | | | | | | | | | |
| *Hedges* | | | | | | | | | | | | | | | | | | | | |

**Table IT3_3_Murgia Alta.** Correspondence between CLC (at third level), IGBP and LCCS (at second and third level) class sets and habitats in different habitat classification systems. In the column of Modular Hierarchical phase/Level I, *basic* classifiers and modifiers are separated by slash. Different colours correspond to different classifiers/modifiers.
Please, note that perennial woody crops will be classified as the appropriate forest or shrub land cover type (e.g. Olive groves = Evergreen forest).

| CORINE CLC3 | | IGBP | LCCS | | | | Annex I | EUNIS | GHC | |
|---|---|---|---|---|---|---|---|---|---|---|
| Code | Class name | Code and class name | Dichotomous phase III lev | Modular Hierarchical phase Level I | Modular Hierarchical phase Level II / III | Class Description | Habitat code at | Habitat code Level 4 | Acronym | Level 5 |
| 1.1.1 | Continuous urban fabric | 13 Urban and built-up | B15 Artificial surfaces and associated areas | A4.A13.A14 | | High density urban areas | X | J1.1 | URB - **to be defined** | |
| | | | | A4.A13.A16 | | Low density urban areas | | J1.2 | | |
| 1.1.2 | Discontinuous urban fabric | | | A4.A13.A17 | | Scattered urban areas | X | J2.1 | URB - **to be defined** | |
| 1.2.1 | Industrial or commercial units | | | A4.A13.A16 | | Low density industrial and/or other areas | X | J2.3 | URB - **to be defined** | |
| | | | | A4.A13.A17 | | Scattered industrial and/or other areas | | J2.4 | | |
| 1.2.2 | Road and rail networks and associated land | | | A3.A8 | | Paved roads | X | J4.2 | URB - ART/NON | |
| 1.3.1 | Mineral extraction sites | | | A2.A6 | | Extraction sites | X | J3 | URB - ART/NON | |
| 2.1.1 | Non-irrigated arable land | 12 Croplands | A11 Cultivated and managed terrestrial areas | A4.B2 | A4.B2.C1.D1 | Monocolture of small size field of rainfed graminoid crops | X | I1.3 | CUL - CRO | |
| 2.2.1 | Vineyards | | | A2.B2 -W7/ A7.A10 | A2.B2.C1. D1.D9-W7/ A7.A10 | Permanently cropped area with Monocolture of small size fields of Rainfed broadleaved deciduous shrub crops Plantations | X | FB.4 | CUL - WOC | |
| 2.2.2 | Fruit trees and berry plantations | | | A1 B2-W8/ A7.A10 | A1 B2. C2-W8/ A7.A10 | Small size fields of broadleaved deciduous tree crops Orchards | X | G1.D4 | CUL - WOC | |
| 2.2.3 | Olive groves | 2 Evergreen Forests | | A1.B1-W7/A7.A9.B4 | A1.B1. C1.D1-W7/A7.A9.B4 | Monocolture of medium size field of broadleaved evergreem of rainfed tree crops Plantations | X | G2.91 | CUL - WOC | |

| CORINE CLC3 | | IGBP | LCCS | | | | Annex I | EUNIS | GHC | |
|---|---|---|---|---|---|---|---|---|---|---|
| 3.1.2 | Coniferous forest | | | A1.B1.B5-W7/A8.A9.B3 | | Large sized fields of needleleaved evergreen tree crops Plantations | X | G3.F | TRS – **to be defined** | |
| 2.4.1 | Annual crops associated with permanent crops | 12 Croplands | | A5.B2.D3-W8 | A5.B2.C2.D3-W8/ C3.C5.C17 | Small size fields of non-graminoid crops (one additional crop – tree crop with simultaneous period) Orchards | X | ? | CUL – CRO/WOC | |
| 2.3.1 | Pastures | 10 Grasslands | A12 | A5.A10.B4/ B12 | A5.A10.B4.E5/ B12.E7 | Closed annual medium/tall forbs | X | E1.6<br>E1C E1.C2 | HER – **to be defined** | |
| 3.1.1 | Broad-leaved forest | 4 Deciduous Broadleaf Forests | | A3.A10.B2/ B7 | A3.A10.B2.D1.E2/ B7 | Broadleaved deciduous closed low trees | 91AA | G1.73 | TRS FPH/DEC | 6.6.1.10.3 Eastern white oak woods<br>FPH/DEC + Quercus pubescens over 30% + Quercus virgiliana + dry soils + expert knowledge |
| 3.1.1 | Broad-leaved forest | | | A3.A10.B2/ B7 | A3.A10.B2.D1.E2/ B7.E4 | Semi-deciduous closed low trees | 9250 | G1.782 | TRS FPH/DEC | 6.6.1.8.7 Quercus trojana woods<br>FPH/DEC + Quercus trojana over 70% + dry soils + expert local information |
| 3.1.3 | Mixed forest | 5 Mixed Forests | | **to be defined** | **to be defined** | **to be defined** | X | G1.732 | TRS – **to be defined** | **to be defined** |
| 3.1.4 | Grasslands with trees | 10 Grasslands | | A6.A10.B4./ B12 | A6.A10.B4.E5.F2.F5.F10.G2/ B12.E6.G7 | Medium-tall grasslands with low trees | X | E7 | **to be defined!** | **to be defined** |

| CORINE CLC3 | | IGBP | LCCS | | | | Annex I | EUNIS | GHC | |
|---|---|---|---|---|---|---|---|---|---|---|
| 3.2.1 | Natural grasslands | | | A6.A10.B4 / B12 | A6.A10.B4.E5/ B12.E6 | Closed perennial medium-tall grasslands | 6210 | E1.2 | HER LHE/CHE | 5.2.2.11.1 Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia, * important orchid sites)<br><br>LHE/CHE + dry calcareous soils + indicators |
| | | | | A6.A10.B4 / B12 | A6.A10.B4.E5/ B12.E6 | Closed perennial medium-tall grasslands | 6220 | E1.3<br>E1C E1.C1 | HER CHE/THE | 5.2.1.7.2 Pseudo-steppe with grasses and annuals of the Thero-Brachypodietea<br><br>CHE/THE + xeric + calcareous + critical species + expert knowledge |
| | | | | A6.A10.B4 / B12 | A6.A10.B4.E5/ B12.E6 | Closed perennial medium-tall grasslands | 62A0 | E1.55 | HER LHE/CHE | 5.2.2.13.3 Eastern sub-Mediterranean dry grasslands (Scorzoneratalia villosae)<br><br>LHE/CHE + xeric + indicators |
| 3.2.4. | Transitional woodland shrub | 6 Closed Shrublands | | A4.A10.B3/D1.E2 B9 | | Broadleaved deciduous closed medium/high shrubland | X | F5.51<br>F5.32 | TRS - **to be defined** | **to be defined** |

| CORINE CLC3 | | IGBP | LCCS | | | | Annex I | EUNIS | GHC | |
|---|---|---|---|---|---|---|---|---|---|---|
| 3.3.3 | Sparsely vegetated areas | 16 Barren or Sparsely Vegetated | | to be defined | to be defined | to be defined | 8210 | H3.2 | Habitat Complexes | 1.2.2.1 Calcareous rocky slopes with chasmophytic vegetation<br><br>Inland cliff + limestone rocks + chasmophytes + LHE + CHE + LHE/CHE+SCH/EVR+ TER + possible HCH |

**Table IT3_4a_Murgia Alta.** Cultivated areas

| EUNIS | Annex I | LCCS Modular-Hierarchical phase: land cover classifiers | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | *Life Form* | *Leaf type* | *Leaf Phenology* | *Orchard/ Plantation* | *Spatial aspect- Field size* | *Crop combination* | *Water supply* | *Cultivation time* |
| I1.3 | x | Herbaceous Graminoids | | | | | Single crop | Rainfed | |
| FB.4 | x | Woody/trees | Broadleaved | Deciduous | Plantation | Small | Single crop | Rainfed | Permanent |
| G1.D4 | x | Woody/trees | Broadleaved | Deciduous | Orchard | Small | | | |
| G2.91 | x | Woody/trees | Broadleaved | Evergreen | Orchard | Medium | Single crop | Rainfed | Permanent |
| G3.F1 | x | Woody/trees | Needle-leaved | Evergreen | Plantation | Large | Single crop | Rainfed | Permanent |
| | | Herbaceous/ non Graminoids | | | | Small | Multiple crops/ One additional crops | Irrigated | |

**Table IT3_4b_Murgia Alta.** Natural and semi natural areas. For *Cycle* LCCS classifier, expert knowledge, which is not required at the moment within the LCCS scheme, is provided. In particular, the months corresponding to maximum biomass and/or flowering are reported for *Cycle* classifier

| **EUNIS** | **Annex I** | **LCCS Modular-Hierarchical phase: land cover classifiers** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | *Life Form* | *Cover* | *Height* | *Leaf type* | *Leaf Phenology* | *Cycle* | | *Stratification* |
| | | | | | | | Annual/ Perennial | **Expert Prior Information** | |
| E1.6 | X | Herbaceous/Forbs | > 65% | 0.8-3 m | | | Annual | April-June | |
| G1.73 | 91AA | Woody/trees | > 65% | | Broadleaved | Deciduous | | April-October | |
| G1.782 | 9250 | Woody/trees | > 65% | | Broadleaved | Semi-deciduous | | April-October | |
| E7 | X | Herbaceous/Graminoids | > 65% | | | | | April-June | |
| E1.2 | 6210 | Herbaceous/Graminoids | > 65% | | | | Perennial | April-June | |
| E1.3 | 6220 | Herbaceous/Graminoids | > 65% | | | | Perennial | May-June | |
| E1.55 | 62A0 | Herbaceous/Graminoids | > 65% | | | | Perennial | May-June | |
| E1.C1 | X | Herbaceous/Graminoids | > 65% | | | | Perennial | May-July | |
| E1.C2 | X | Herbaceous/Forbs | > 65% | | | | Perennial | May-July | |
| F5.51 | X | Woody/shrubs | > 65% | 0.5-3 m | Broadleaved | Deciduous | | April-October | |

# 7. Conclusions

Land cover maps are at the basis of habitat maps and Biodiversity indicators extraction. However, most of the land cover legends currently in use lead to a rough discrimination at the habitat level, especially when considering natural and semi-natural vegetation types. For example, in the case of the CLC, widely used in Europe for the creation of land cover maps and also for the detection of land cover changes, the same land cover class can include many natural and/or semi-natural habitats (some of which are included in Annex I), as evidenced by the analysis of the IT4 and IT3 training sites.

The BIO_SOS project will develop an algorithm for the conversion of Land Cover (LC) maps in Habitat maps for biodiversity monitoring by the integrated use of remotely sensed data with *in-situ* and ancillary data. Therefore, there is the need to adopt a classification legend whose LC class set and description (refer to section 2.1) are as close as possible to habitat categories.

The FAO-LCCS classification legend uses an independent set of "classifiers" and "attributes" which can be combined to describe the more complex semantics of each land-cover class.

The analysis and comparison of several classification land cover legends applied to the two training sites showed that, compared to CORINE and IGBP, LCCS allows a more precise land cover class definition already at the third and fourth level of natural and semi-natural types, namely by using the simple *pure land cover classifiers*. For example, for the site IT4 the CLC class 3.2.3 - "Sclerophyllous vegetation" can be represented in LCCS by three different classes that can be distinguished for their leaf type (broadleaved, needle-leaved), leaf phenology (evergreen, deciduous), height (dwarf, medium, high) and cover (open, closed). These three LCCS classes provide more information than the CLC class and can be used to discriminate better different habitats. However, these classes are not yet habitat *sensu* Annex I. To achieve this kind of definition it is necessary to add additional information that, in the LCCS system, is provided through the so-called *environmental attributes* and *technical attributes*. For example, the LCCS class A4.A10.B3.D2.E1/B9 - "Needleaved evergreen medium / high closed shrubland (thickets)" provides detailed information on vegetation structure. However, to define the Annex I habitat 2250 (Coastal dunes with *Juniperus* spp.), additional environmental attributes are needed. We should know that we are on Mediterranean coastal dunes (soil and geomorphological information) and then we could deduce the Annex I habitat. By adding *floristic attributes* we achieve a precise definition (since Annex I habitats contain, in their description, floristic characters).

GHCs correspond (with a degree of approximation) to LCCS classes as defined in the *Modular-Hierarchical* phase at the level of *pure land cover classifiers.* GHCs contain, in themselves, information about life forms, height, leaf type and cycle. As an example, LHE (leafy hemicryptophytes) corresponds to "perennial medium tall forbs" in LCCS; or MPH/CON (mid phanerophytes/conifers) corresponds to "needledleaved evergreen - medium high thicket" in LCCS. However, some discrepancies have been observed. For example, ranges in height defined by GHC for chamaephytes and phanerophytes do not correspond exactly to the ranges defined by LCCS for trees and shrubs. In LCCS, ranges in height are defined for herbaceous; but these ranges are not considered in GHC.

At the level of land cover, LCCS classes seem to provide more details with respect to (land cover classes at the base of) GHCs, such as percentage of soil cover, height (for herbaceous), spatial distribution, stratification (if present) and water seasonality (only for aquatic/flooded).

By adding specific *attributes,* it is possible to obtain an LCCS description of land cover which is very close to habitat definition. It is worth noting that beside *classifiers* and *attributes*, in many cases the *phenology* of each type of plant community should be considered to achieve habitat description, whereas *agricultural practices* should be introduced to differentiate cultivated classes. However, at the moment, LCCS does not allow to include such inputs. Two examples are reported from the analysis of IT4 site. The first concerns the Annex I habitats 3170 and 1310 (see Table IT4_4b_Cesine). In particular, plant communities of habitat 3170 have maximum biomass in May/June and are dry in August. Plant communities of habitat 1310 grow later with maximum biomass in August. The second example is the Eunis habitat coded G2.91 represented by olive groves (in CORINE): information such as the presence/

absence of orientation as well as the number of orientations (i.e. two for olive groves as well as for orchard, one in the case of vineyard) and period might be useful to differentiate such classes.

*Phenology* and *agricultural practices* can be also useful for the discrimination of plant communities and cultivated classes from remote sensing observations at VHR [Sanz et al., 2006].

In other cases, e.g. the Eunis habitats D5.24 , D5.1 and D5.2 (see Table IT4_4b_Cesine), *in-field* campaigns for the detection of floristic (*technical*) attributes only can solve their discrimination.

To obtain habitats from GHCs, a variable number of different *qualifiers* has to be added to GHCs to let the process culminate (for natural vegetation) in the definition of habitat types. With regard to the Italian study sites, for all those natural and semi-natural (and artificial) habitat types not included in Annex I of Habitat Directive, the GHC types have to be defined (both Life Form and Non Life Form categories) during the project life time.

# 8. Appendix 1. Acronym List

| | |
|---|---|
| **AB** | **Advisory Board** |
| **ABERY** | **University of Aberystwyth – Inst. of Geography And Earth Sciences** |
| **AI** | **Altamira Information** |
| **ANSI** | **American National Standards Institute** |
| **APAT** | **Agenzia per la Protezione dell'Ambiente e per i servizi Tecnici (Italian Agency for Environment)** |
| **ASI** | **Agenzia Spaziale Italiana** |
| **ATREE** | **Ashoka Trust for Research in Ecology and the Environment – India** |
| **BACRES** | **Baraldi Consultancy in Remote Sensing** |
| **BIOHab** | **Acronym description: a framework for the coordination of BIOdiversity and Habitats** |
| **BIOPRESS** | **Acronym description: linking pan-European land cover change to pressures on biodiversity** |
| **BIO_SOS** | **Biodiversity Multi-Source MOnitoring System: From Space To Species** |
| **CBD** | **Convention of Biological Diversity** |
| **CCW** | **Countryside Council for Wales** |
| **CEC-EEA** | **Commission of the European Communities - European Environmental Agency** |
| **CERTH** | **Informatics And Telematics Institute Of The Centre For Research And Technology – Greece** |
| **CIBIO** | **Biodiversity & Conservation Ecology Group – Portugal** |
| **CLC** | **CORINE Land Cover** |
| **CNR** | **Consiglio Nazionale delle Ricerche** |
| **CNR-IAC** | **Istituto per le Applicazioni del Calcolo - CNR** |
| **CNR-IGV** | **Istituto di Genetica Vegetale – CNR** |
| **CNR-IRPI** | **Istituto di Ricerca per la Protezione Idrogeologica – CNR** |
| **CNR-ISSIA** | **Istituto di Studi sui Sistemi Intelligenti per l'Automazione - CNR** |
| **CORINE** | **COoRdination of INformation on the Environment** |
| **DG ENV** | **Directorate-General for the Environment** |
| **DOPA** | **Digital Observatory for Protected Areas** |
| **EEA** | **European Environmental Agency** |
| **EEC** | **European Economic Community** |
| **EBONE** | **European Biodiversity Observation Network** |
| **EC** | **European Community** |
| **ECNC** | **European Centre for Nature Conservation** |
| **EIONET** | **European Environmental Information Observation Network** |

| | |
|---|---|
| **ENCA** | **European Nature Conservation Agencies** |
| **ENM** | **Ecological Niche Models** |
| **EO** | **Earth Observation** |
| **EODHaM** | **EO Data for Habitat Monitoring** |
| **ESA** | **European Space Agency** |
| **ETCBD** | **European Topic Centre on Biological Diversity** |
| **ETC/NPB** | **European Topic Centre for Nature Protection and Biodiversity** |
| **EU** | **European Union** |
| **EUNIS** | **European Nature Information System** |
| **FAO** | **Food and Agriculture Organization** |
| **FAO-LCCS** | **FAO - Land Cover Classification System** |
| **FP7** | **Seventh Framework Program** |
| **GEO-BON** | **Group on Earth Observations Biodiversity Observation Network** |
| **GEOLAND** | **Acronym Description: geoland - Integrated GMES Project on Landcover and Vegetation** |
| **GIS** | **Geographic Information System** |
| **GLC** | **Global Land Cover** |
| **GLOBCOVER** | **Global Land Cover Map** |
| **GMES** | **Global Monitoring for the Environment and Security** |
| **HR** | **High Resolution** |
| **ICETA** | **Instituto de Ciências e Tecnologias Agrárias e AgroAlimentares** |
| **ICNB** | **Instituto da Conservação da Natureza e da Biodiversidade** |
| **ICONA** | **National Institute for the Conservation of Nature** |
| **ICPC** | **International Cooperation Partner Country** |
| **IES** | **Institute for Environment and Sustainability** |
| **IGBP** | **International Global Biosphere Programme** |
| **IGPB-DISCover** | **IGBP -Data and Information System Cover** |
| **IRD** | **Institut de Récherche pour le Développement - France** |
| **ISPRA** | **Istituto Superiore per la Protezione e la Ricerca Ambientale** |
| **JRC** | **Joint Research Centre** |
| **JRC-EEA** | **Joint Research Centre - European Environmental Agency** |
| **LACOAST** | **Land cover changes in COASTal zones** |
| **LC** | **Land Cover** |
| **LCC** | **Land Cover Change** |
| **LCCS** | **Land Cover Classification System** |
| **NGO** | **Non Governmental Organization** |
| **OGC** | **Open Geospatial Consortium** |

| | |
|---|---|
| **PKH** | **Planetek Hellas** |
| **PKI** | **Planetek Italia** |
| **RS-IUS** | **Remote Sensing Image Understanding System** |
| **UNEP** | **United Nations Environment Programme** |
| **UOI** | **University of Ioannina** |
| **VHR** | **Very High Resolution** |
| **WP** | **Work Package** |
| **WPL** | **Work Package Leader** |

# References

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