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Plant assemblages and conservation status of habitats of Community interest (Directive 92/43/EEC): definitions and concepts

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Abstract: The article 17 of the 92/43/EEC Habitats Directive imposes to the Members States to produce periodic reports (every 6 years) on the conservation status of habitats and species at national level. In this context, in view of preparing the 4th National Report, the Italian National Institute for Environmental Protection and Research (ISPRA) drafted the national guidelines for habitats monitoring, focusing on data collection at site level. The intention of this paper is to provide an overview about the development, in Italy, on Habitat types monitoring methodologies, in particular detailing the current state-of-the-art for the parameter structure and functions, which is the most controversial among those required by the Habitats Directive for the assessment of conservation status. The paper concludes that, although habitat types monitoring programs could be carried out using individual species of fauna and/or flora, vegetation surveys represent the best choice as it allows to collect standardised and objective data, useful for the definition of more specific indicators, first of all the presence and abundance of typical species.

Keywords: Italy, habitat types, monitoring, typical species.

1. Introduction

Monitoring is an essential tool for the study of environmental systems, related to three main functions: to inform the conservationist when the system is receding from the desired state, to measure the success of management actions, and to detect the effects of perturbations and disturbances (Legg and Nagy, 2006). The problems related to habitats conservation are in general rather complex since they involve data recording on different components (vegetation, climate, geology, geographic region). Despite this complexity, a sustainable management of biological resources requires reliable scientific knowledge and accessible data. Therefore, it is necessary to identify proper conservation strategies and protocols aimed to the systematic collection of information on their ecological pattern. The extreme heterogeneity of availability and distribution of biodiversity data has led to the need to develop standardised observation systems. The European biodiversity observation network Eu-BON (http://www.eubon.eu/show/project_2731/), that is the European-level implementation of the global biodiversity observation network GEO-BON (http://geobon.org/), and the EuMon project (2004-2008) (http://eumon.ckff.si/media.php), with more specific pur-

poses, aim to improve such information and the overall work in the field of biodiversity.

In Europe, most of the Habitat types monitoring schemes concern the collection of data relating both to their species composition and their distribution. Among monitoring schemes that are collecting data on the species composition, in most cases (63%) data concern both the presence/absence and abundance of species, in 19% of cases data regard only abundance of selected species, and finally in 8% of cases data refer only to presence-absence of species (http://eumon.ckff.si/biomat).

This approach reflects the request of the European Guidelines for reporting art. 17 of Habitats Directive (Evans and Arvela, 2011), requiring to the Members States periodic reports on the conservation status of habitats and species.

Guidelines based the assessment of Habitat types on the following four parameters: 1) Range, 2) Area, 3) Structure and functions (including typical species), and 4) Future prospects (Evans and Arvela, 2011). The assessment is firstly carried out for each of these parameters and then combined to obtain an overall assessment. Currently, such data represent the most up-to-date and detailed information on conservation status of habitats and species at the European Union (EU) level and their main limitation concerns the difference of quality across Member States (Masante et al., 2015).

The problem of data quality and heterogeneity, as well as the differences in the specific methodologies used for the evaluation of critical parameters such as "Structure and functions" (actually mainly based on "expert judgement") represents one of the crucial points to be solved. The goal of the present paper is to give an overview about the current state of the art in the methodologies for monitoring the structure and functions of Habitat types in Italy, focusing on the use of plant assemblages as typical species for consistent and reliable monitoring program, able to provide consistent data and make the reports reliable and comparable in time and space.

2. The Italian context

In view of preparing the 4th National Report, the Italian National Institute for Environmental Protection and Research (ISPRA) drafted the national guidelines for habitat monitoring, and in particular for data collection at site level. Methods are described in 3 handbooks, two for species (Stoch and Genovesi, 2016; Ercole et al., 2016) and one for habitat types (Angelini et al., 2016). These handbooks aimed to promote the harmonized use of standard protocols addressed as official reference in EU (Evans and Arvela, 2011) at national level to ensure a pragmatic and efficient approach to habitat monitoring and collecting data. The development of monitoring and evaluation techniques for Habitat types is principally related to the parameter Structure and functions, including the evaluation of typical species. It represents a particular challenge because of the difficulty of transposing it into numerical terms, ensuring the comparability.

As recommended by the European Guidelines, Structure and functions of Habitat types should be monitored by means of "typical species". Although the definition of typical species is not explicit in the Directive, European Commission has recently specified their definition: "*species which occur regularly in the habitat type (as opposed to occasionally occurring species) and are species which are good indicators of favourable habitat quality. The list of "typical species" chosen for the purpose of assessing conservation status should ideally remain stable over the medium to long term*" (DG Environment, 2017). This means that an adequate population of the typical species in the area covered by a Habitat type should be the confirmation of good condition of its structure and ecological functions.

During the last reporting cycle (2006-2012), Member States attempted to define and set up lists of typical species. The European complete list of typical species contains more than 10,000 species (http://cdr.eionet.europa.eu/help/habitats_art17) and indicates *Vaccinium myrtillus* as the absolute most utilized species. This species is represented by 187 records among 16 Member States for 43 Habitat types in 6 biogeographical regions. Another remarkable species in the list is *Plantago maritima*, used by 18 Member States for 15 habitat types in 9 Biogeographical regions, even if it is present in "only" 39 records. The reason of their great utilization is probably due to their wide distribution, both in terms of total area covered and local abundance, making the species easy to be detected and suitable as typical species "candidate", according to argumentation on typical species by Shaw and Wind (1997).

Despite the efforts done, some criticisms remain about this list due to both the heterogeneity of criteria used by the various Member States and the fact that often the choice seems to be driven more by the data availability than by formalized criteria. In many cases there are no clear specifications on criteria used, i.e. expert knowledge (EEA, 2015), while in others, species are chosen more using diagnostic criteria instead of ecological indicators. Moreover, some Member States chose to use as typical both flora and fauna species and in most cases species are chosen among those under protection as for them published Red Data exist (De Knijf and Paelinckx, 2012; Maciejewski et al., 2010; Oosterlynck et al., 2013).

3. The proposal from Italy

The Italian proposal focuses on data collection to overcome, at first, the criticism derived from the lack of standardised and reliable data. In particular, the technical solution identified is based on the use of plant assemblages, by means of variables such as floristic composition and species coverage. For the purposes of Habitat monitoring, data collection will be carried out using the method commonly adopted by the vegetation science (Braun-Blanquet, 1964; Poore, 1955), creating specific georeferenced floristic-vegetation archives. These archives will respond to precise procedural standards to ensure interoperability with the already existing floristic-vegetation databases at national and European level, on which a process of standardization and homogenization of data has been started and created for applications on different purposes such as the classifications of Habitat types on a European scale (Chytrý et al., 2016; www.euroveg.org). Well-structured archives also allow to develop predictive models for large-scale monitoring, to evaluate the real global changes taking place, and to define future trends (Attorre et al., 2014; De Cáceres et al., 2015). The use of vegetation surveys represents the best choice allowing the acquisition of objective data such as the presence and the abundance of typical species. The Italian manual for Habitat types monitoring (Angelini et al., 2016) defines typical species at national level and in some cases for the three biogeographical regions present in Italy (Alpine - ALP; Continental - CON; Mediterranean - MED) for the majority of Habitat Types (HT) (Tables 1-8). Criteria for their definition are based on analysis of structure and species richness of each Habitat type, identifying three main categories of typical species (Gigante et al., 2016). Tables 1-8 show different situation in the habitats categories. For grasslands, freshwater and rocky habitats, the choice of predetermined typical species is possible only for few HT (*Chara* ssp. and *Nitella* ssp. for HT 3140, *Myricaria germanica* for HT 3230, *Sedum* sp. pl. for HT 6110, and *Quercus suber*, *Q. Ilex* and *Q. coccifera* for HT 6310). For all the other HT, it is necessary to consider different species in different local environments, identifying typical species accordingly with the study of their functional traits (Maciejewski et al., 2016) and their ecological indicator value (i.e., referring to Landolt and/or Ellenberg systems adapted to Italy; Pignatti, 2005).

Table 1. Typical species for Coastal habitats in Italy with specification, for some HT, for Biogeographical regions (Alpine - ALP; Continental - CON; Mediterranean - MED)

Coastal habitats		
code	**Habitat description**	**Typical species**
1150	Coastal lagoons	**CON**: *Ulva* sp. pl., *Chaetomorpha* sp. pl., *Cymodocea nodosa*, *Nanozostera noltii*, *Ruppia* sp. pl. **MED**: *Cymodocea nodosa*, *Ruppia maritima*, *Ulva* sp. pl., *Chaetomorpha* sp. pl.
1210	Annual vegetation of drift lines	*Cakile maritima* subsp. *maritima*, *Salsola kali*
1240	Vegetated sea cliffs of the Mediterranean coasts with endemic *Limonium* spp.	*Crithmum maritimum*, *Limonium* sp. pl.
1310	Salicornia and other annuals colonizing mud and sand	*Salicornia* sp. pl., *Suaeda* sp. pl.
1320	Spartina swards (*Spartinion maritimae*)	*Spartina maritima*
1340	Inland salt meadows	*Puccinellia fasciculata* (=*P. borreri*)
1410	Mediterranean salt meadows (*Juncetalia maritimi*)	*Juncus* sp. pl., *Arthrocnemum* sp. pl., *Sarcocornia* sp. pl., *Artemisia coerulescens*, *Carex extensa*, *Puccinellia festuciformis*, *Schoenus nigricans*
1420	Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*)	*Arthrocnemum* sp. pl., *Halocnemum* sp. pl., *Sarcocornia* sp. pl.
1510	Mediterranean salt steppes (*Limonietalia*)	*Limonium* sp. pl.

Table 2. Typical species for Dunes habitats in Italy with specification, for some HT, for Biogeographical regions (Alpine - ALP; Continental - CON; Mediterranean - MED)

Dunes habitats		
code	**Habitat description**	**Typical species**
2110	Embryonic shifting dunes	*Elymus farctus* subsp. *farctus* (= *Agropyron junceum, A. junceum* subsp. *mediterraneum*, *Elytrigia juncea, E. mediterranea*), *Otanthus maritimus* (= *Achillea maritima*)
2120	Shifting dunes along the shoreline with *Ammophila arenaria* ("white dunes")	*Ammophila arenaria* subsp. *arundinacea* (= *Ammophila arenaria* subsp. *australis*)
2130	Fixed coastal dunes with herbaceous vegetation („grey dunes")	*Carex liparocarpos, Fumana procumbens, Syntrichia ruralis* var. *ruraliformis*, *Pleurochaete squarrosa*
2160	Dunes with *Hippophaë rhamnoides*	*Hippophaë rhamnoides* subsp. *fluviatilis*, *Juniperus communis*
2210	*Crucianellion maritimae* fixed beach dunes	*Crucianella maritima*
2240	*Brachypodietalia* dune grasslands with annuals	*Brachypodium distachyum*
2250	Coastal dunes with *Juniperus* spp.	**CON**: *Juniperus communis*; **MED**: *Juniperus macrocarpa* (=*Juniperus oxycedrus* subsp. *macrocarpa*), *Juniperus phoenicea* subsp . *turbinata*; *Tortella flavovirens* var. *flavovirens*
2260	Cisto-Lavenduletalia dune sclerophyllous scrubs	**CON**: *Phillyrea media*; **MED**: *Phillyrea* sp. pl., *Pistacia lentiscus*
2270	Wooded dunes with *Pinus pinea* and/or *Pinus pinaster*	**CON**: *Pinus halepensis, Pinus pinaster, Pinus pinea*; **MED**: *Pinus halepensis, Pinus pinaster, Pinus pinea, Juniperus macrocarpa* (= *Juniperus oxycedrus* subsp. *macrocarpa*), *Juniperus phoenicea* subsp. *turbinata*
2330	Inland dunes with open Corynephorus and Agrostis grasslands	*Corynephorus canescens, Teesdalia nudicaulis, Aira caryophyllea*

Table 3. Typical species for Freshwater habitats in Italy

Freshwater habitats		
code	**Habitat description**	**Typical species**
3140	Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.	*Chara* sp., *Nitella* sp.
3230	Alpine rivers and their ligneous vegetation with *Myricaria germanica*	*Myricaria germanica*

Table 4. Typical species for Heath & scrub and Sclerophyllous scrubs in Italy with specification, for some HT, for Biogeographical regions (Alpine - ALP; Continental - CON; Mediterranean - MED) and in relationship with some sub-categories of Palaearctic classification (PAL: CLASS. 2001) (Devillers et al., 2001)

Heath & scrub and Sclerophyllous scrubs		
code	**Habitat description**	**Typical species**
4030	European dry heaths	**ALP**: *Calluna vulgaris*, *Cytisus nigricans* (= *Lembotropis nigricans*), *Cytisus scoparius*, *Erica* sp. pl., *Genista germanica*, *Genista pilosa*, *Genista tinctoria*, *Vaccinium myrtillus*. **CON, MED**: *Calluna vulgaris*, *Cytisus nigricans* (= *Lembotropis nigricans*), *Cytisus scoparius*, *Erica* sp. pl., *Genista germanica*, *Genista pilosa*, *Genista tinctoria*, *Vaccinium myrtillus*, *Ulex europaeus*
4060	Alpine and Boreal heaths	**ALP**: *Erica* sp. pl., *Rhododendron* sp. pl., *Vaccinium* sp. pl., *Rhodothamnus* sp. pl., *Loiseleuria* sp. pl., *Juniperus* sp. pl., *Genista* sp. pl., *Arctostaphylos* sp. pl., *Empetrum* sp. pl., *Cladina* sp. pl. (moss layer). **CON**: *Erica* sp. pl., *Rhododendron* sp. pl., *Vaccinium* sp. pl., *Juniperus* sp. pl., *Genista* sp. pl., *Arctostaphylos* sp. pl., *Empetrum* sp. pl. **MED**: *Rhododendron* sp. pl., *Vaccinium* sp. pl., *Juniperus* sp. pl., *Genista* sp. pl., *Arctostaphylos* sp. pl.
4070	Bushes with *Pinus mugo* and *Rhododendron hirsutum* (*Mugo-Rhododendretum hirsuti*)	*Pinus mugo* s.s., *Rhododendron hirsutum*
4080	Sub-Arctic *Salix* spp. scrub	*Salix appendiculata*, *Salix breviserrata* (= S. myrsinites s.s.), *Salix foetida*, *Salix glabra*, *Salix glaucosericea, Salix hastata, Salix helvetica, Salix pentandra, Salix waldsteiniana*
4090	Endemic oro-Mediterranean heaths with gorse	*Genista salzmannii*, *Genista pichi-sermolliana, Astragalus genargenteus, Genista desoleana, Genista toluensis* (PAL. CLASS. 2001: 31.75); *Astragalus siculus* (PAL. CLASS. 2001: 31.76); *Astragalus nebrodensis*; *Genista cupanii*, *Genista michelii*, *Astragalus parnassi* subsp. *calabricus*, *Genista sericea* (sottotipo PAL. CLASS. 2001: 31.77); *Astragalus sempervirens* subsp. *sempervirens*, *Astragalus sirinicus* (PAL. CLASS. 2001: 31.7E)
5110	Stable xerothermophilous formations with *Buxus sempervirens* on rock slopes (*Berberidion* p.p.)	*Buxus sempervirens*
5130	*Juniperus communis* formations on heaths or calcareous grasslands	*Juniperus communis*
5210	Arborescent matorral with *Juniperus* spp.	*Juniperus phoenicea* subsp. *phoenicea*, *Juniperus oxycedrus* subsp. *oxycedrus*, *Juniperus thurifera* **CON**: *Juniperus oxycedrus* subsp. *Oxycedrus* **MED**: *Juniperus phoenicea* subsp. *turbinata*, *Juniperus phoenicea* subsp. *phoenicea*, *Juniperus oxycedrus* subsp. *oxycedrus*
5220	Arborescent matorral with Zyziphus	*Ziziphus lotus, Rhus pentaphylla, Rhus tripartita*
5230	Arborescent matorral with *Laurus nobilis*	*Laurus nobilis*
5310	*Laurus nobilis* thickets	*Laurus nobilis*
5320	Low formations of Euphorbia close to cliffs	*Helichrysum* sp. pl., *Thymelaea* sp. pl., *Anthyllis barba-jovis*

Heath & scrub and Sclerophyllous scrubs		
code	**Habitat description**	**Typical species**
5330	Thermo-Mediterranean and pre-desert scrub	*Euphorbia dendroides*, *Olea europaea* subsp. *oleaster* (PAL. CLASS. 2001*: 32.22); *Ampelodesmos mauritanicus* (PAL. CLASS. 2001: 32.23); *Chamaerops humilis, Pistacia lentiscus* (PAL. CLASS. 2001: 32.24); *Periploca angustifolia, Euphorbia dendroides* (PAL. CLASS. 2001: 32.25); Endemic species of Genista (PAL. CLASS. 2001: 32.26)
5410	West Mediterranean clifftop phryganas (*Astragalo-Plantaginetum subulatae*)	*Astragalus terraccianoi, Centaurea horrida*
5420	*Sarcopoterium spinosum* phryganas	*Sarcopoterium spinosum, Thymbra capitata*
5430	Endemic phryganas of the *Euphorbio-Verbascion*	*Hypericum aegypticum* (PAL: CLASS. 2001: 33.5), *Sarcopoterium spinosum* (PAL: CLASS. 2001: 33.6) *Genista* sp. pl. (PAL: CLASS. 2001: 33.7; 33.9); *Helichrysum saxatile* subsp. *errerae; Matthiola incana* subsp. *pulchella* (PAL: CLASS. 2001: 33.A)

* PAL. CLASS. 2001 = Palaearctic classification 2001

Table 5. Typical species for Grasslands in Italy

Grasslands		
code	**Habitat description**	**Typical species**
6110	Rupicolous calcareous or basophilic grasslands of the *Alysso-Sedion albi*	*Sedum* sp. pl.
6310	Dehesas with evergreen *Quercus* spp.	*Quercus suber*, *Q. ilex*, *Q. coccifera*

Table 6. Typical species for Bogs, mires & fens in Italy

Bogs, mires & fens		
code	**Habitat description**	**Typical species**
7110	Active raised bogs	*Sphagnum, Carex, Drosera, Vaccinium, Andromeda, Eriophorum*
7120	Degraded raised bogs still capable of natural regeneration	*Sphagnum, Carex, Drosera, Eriophorum, Andromeda, Utricularia*
7140	Transition mires and quaking bogs	*Carex*, *Rhynchospora*, *Eriophorum*, *Sphagnum*, *Drosera*
7150	Depressions on peat substrates of the *Rhynchosporion*	*Carex*, *Drosera*, *Rhyncospora*, *Utricularia*
7210	Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*	*Cladium mariscus*
7220	Petrifying springs with tufa formation (*Cratoneurion*)	*Palustriella commutata* (C*ratoneuron commutatum)*
7240	Alpine pioneer formations of *Caricion bicoloris-atrofuscae*	*Carex atrofusca*, *Carex bicolor*, *Carex maritima*, *Carex microglochin*, *Carex vaginata*, *Juncus arcticus*, *Juncus castaneus*, *Kobresia simpliciuscula*, *Tofieldia pusilla*, *Trichophorum pumilum*

Table 7. Typical species for Rocky habitats in Italy with specification, for some HT, for Biogeographical regions (Alpine - ALP; Continental - CON; Mediterranean - MED)

Rocky habitats		
code	**Habitat description**	**Typical species**
8230	Siliceous rock with pioneer vegetation of the *Sedo-Scleranthion* or of the *Sedo albi-Veronicion dillenii*	**ALP**: *Arabidopsis thaliana*, *Cerastium arvense* subsp. *strictum*, *Jovibarba allionii*, *Scleranthus perennis* subsp. *perennis*, *Sempervivum grandiflorum*, *Sempervivum wulfenii*, *Silene saxifraga*, *Veronica dillenii*, *Veronica fruticans*, *Arenaria marschlinsii*, *Sedum monregalense*, *Sedum hirsutum*, *Filago minima*, *Veronica verna*; **CON**: *Arabidopsis thaliana*, *Gagea bohemica*, *Scleranthus perennis*, *Sedum monregalense*, *Silene saxifraga*, *Veronica dillenii*, *Veronica fruticans*, *Filago minima*, *Veronica verna*; **MED**: *Allium montanum, Ceratodon purpureus, Gagea bohemica, Polytrichum piliferum*, *Scleranthus perennis, Veronica dillenii, Veronica fruticans, Veronica verna*
8310	Caves not open to the public	**ALP:** *Niphargus strouhali*, *N. ruffoi*, *Ischyropsalis* spp., *Anophthalmus* spp., *Pseudoboldoria* spp. and, for Ligurian Alps, *Duvalius* spp., *Agostinia* spp. and *Parabathyscia* spp; **CON:** *Limnosbaena finki*, *Titanethes albus*, *Illyrionethes strasseri*, *Androniscus stygius*, *Asellus kosswigi*, *Sphaeromides virei*, *Niphargus stygius*, *Troglocaris planinensis*, *T. anophthalmus sonticus*, *Anophthalmus mayeri*, *Leptodirus hochenwartii*, *Proteus anguinus* (Dinaric Karst); *Monolistra* spp., *Niphargus* spp., *Italaphaenops dimaioi*, *Lessinodytes caoduroi*, *L. pivai*, *Orotrechus* spp., *Anophthalmus* spp. (Prealps); *Niphargus* spp. gr. *speziae*, *Duvalius* spp., *Bathysciola* spp. (Northern Apennine) **MED:** *Stenasellus racovitzai*, *Tethysbaena argentarii* (Tuscany); *Hadzia* minuta, *Metaingolfiella mirabilis*, *Monodella stygicola*, *Spelaeomysis bottazzii*, *Stygiomysis hidruntina*, *Typhlocaris salentina*, *Italodytes stammeri* (Apulia); *Tyrrhenogammarus catacumbae*, *Pseudoniphargus sodalis* (Sicily); endemic species of *Scotoniscus*, *Catalauniscus*, *Oritoniscus*, *Stenasellus*, *Speomolops*, *Sardaphaenops*, *Ovobathysciola*, *Patriziella* (Sardinina)
8340	Permanent glaciers	Other (Permanent glaciers)

Table 8. Typical species for Forests in Italy with specification, for some HT, for Biogeographical regions (Alpine - ALP; Continental - CON; Mediterranean - MED)

Forests		
code	**Habitat description**	**Typical species**
9110	*Luzulo-Fagetum* beech forests	*Fagus sylvatica, Luzula* sp. pl.*, Vaccinium* sp. pl.
9120	Atlantic acidophilous beech forests with Ilex and sometimes also *Taxus* in the shrublayer (*Quercion robori-petraeae* or *Ilici-Fagenion*)	*Fagus sylvatica, Taxus baccata, Ilex aquifolium*
9130	*Asperulo-Fagetum* beech forests	*Fagus sylvatica, Abies alba, Galium odoratum* (*=Asperula odorata), Cardamine* sp. pl. (subgen. *Dentaria)*
9140	Medio-European subalpine beech woods with *Acer* and *Rumex arifolius*	*Fagus sylvatica, Acer pseudoplatanus, Acer platanoides, Laburnum alpinum, Sorbus aucuparia, Alnus viridis, Abies alba, Picea abies*

Forests		
code	**Habitat description**	**Typical species**
9150	Medio-European limestone beech forests of the *Cephalanthero-Fagion*	*Fagus sylvatica, Cephalanthera* sp. pl.
9160	Sub-Atlantic and medio-European oak or oak-hornbeam forests of the *Carpinion betuli*	*Quercus robur, Quercus petraea, Carpinus betulus*
9170	*Galio-Carpinetum* oak-hornbeam forests	*Quercus petraea, Carpinus betulus*
9180	*Tilio-Acerion* forests of slopes, screes and ravines	**ALP, CON**: *Tilia cordata, Tilia platyphyllos, Ulmus glabra, Fraxinus excelsior, Acer platanoides, Acer pseudoplatanus, Acer cappadocicum* subsp. *lobelii localmente, Acer opalus* subsp. *Obtusatum* **MED**: *Tilia cordata, Tilia platyphyllos, Ulmus glabra, Fraxinus excelsior, Acer platanoides, Acer pseudoplatanus, Acer cappadocicum* subsp. *lobelii (locally), Taxus baccata, Acer opalus* subsp. *obtusatum*
9190	Old acidophilous oak woods with *Quercus robur* on sandy plains	*Betula pendula, Quercus petraea, Quercus robur, Populus tremula, Pinus sylvestris*
91AA	Eastern white oak woods	*Quercus pubescens* s.l., *Fraxinus ornus, Carpinus orientalis*
91B0	Thermophilous *Fraxinus angustifolia* woods	*Fraxinus angustifolia* s.l.
91D0	Bog woodland	*Pinus mugo, Pinus sylvestris, Betula pubescens, Picea abies, Sphagnum* sp. pl. *in particular: Sphagnum capillifolium, Sphagnum centrale, Sphagnum magellanicum, Sphagnum fuscum, Sphagnum papillosum, Sphagnum rubellum*
91E0	Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*)	*Alnus glutinosa, Alnus incana, Salix* sp. pl., *Fraxinus excelsior, Fraxinus angustifolia* subsp. *oxycarpa, Populus* sp. pl.
91F0	Riparian mixed forests of *Quercus robur*, *Ulmus laevis* and *Ulmus minor*, *Fraxinus excelsior* or *Fraxinus angustifolia*, along the great rivers (*Ulmenion minoris*)	**ALP**: *Quercus robur, Ulmus* sp. pl., *Fraxinus angustifolia, Fraxinus excelsior, Alnus glutinosa* **CON**: *Quercus robur, Ulmus* sp. pl., *Fraxinus angustifolia, Fraxinus excelsior, Alnus glutinosa, Populus nigra, Populus canescens;* MED: *Quercus robur, Quercus robur* subsp. *brutia, Ulmus* sp. pl., *Fraxinus angustifolia, Fraxinus excelsior, Alnus glutinosa, Alnus cordata, Populus nigra, Populus canescens*
91H0	Pannonian woods with *Quercus pubescens*	*Quercus pubescens, Fraxinus ornus, Ostrya carpinifolia, Pinus sylvestris*
91K0	Illyrian *Fagus sylvatica* forests *(Aremonio-Fagion*)	*Fagus sylvatica, Aremonia agrimonioides*
91L0	Illyrian oak-hornbeam forests (*Erythronio-Carpinion*)	*Carpinus betulus, Quercus robur, Quercus petraea, Quercus cerris*
91M0	Pannonian-Balkanic turkey oak-sessile oak forests	*Quercus cerris, Quercus frainetto, Quercus petraea*
9210	Apennine beech forests with *Taxus* and *Ilex*	*Fagus sylvatica, Taxus baccata, Ilex aquifolium*

Forests		
code	**Habitat description**	**Typical species**
9220	Apennine beech forests with *Abies alba* and beech forests with *Abies nebrodensis*	**ALP, CON**: *Abies alba* subsp. *alba, Fagus sylvatica, Acer platanoides, Acer pseudoplatanus, Sorbus aucuparia* subsp. *Aucuparia* **MED**: *Abies alba* subsp. *alba, Abies alba* subsp. *apennina, Abies nebrodensis, Fagus sylvatica, Acer platanoides, Acer pseudoplatanus, Acer cappadocicum* subsp. *lobelii, Sorbus aucuparia* subsp. *aucuparia*
9250	*Quercus trojana* woods	*Quercus trojana*
9260	*Castanea sativa* woods	*Castanea sativa*
92A0	*Salix alba* and *Populus alba* galleries	**ALP, CON**: *Salix alba, Populus alba, Populus nigra, Populus tremula* **MED**: *Salix alba, Populus alba, Populus nigra, Populus tremula, Populus canescens*
92C0	*Platanus orientalis* and *Liquidambar orientalis* woods (*Platanion orientalis*)	*Platanus orientalis*
92D0	Southern riparian galleries and thickets (*Nerio-Tamaricetea* and *Securinegion tinctoriae*)	*Nerium oleander, Vitex agnus-castus, Tamarix gallica, T. africana, T. arborea, T. canariensis*
9320	*Olea* and *Ceratonia* forests	*Olea europaea* subsp. *sylvestris, Ceratonia siliqua*
9330	*Quercus suber* forests	*Quercus suber*
9340	*Quercus ilex* and *Quercus rotundifolia* forests	*Quercus ilex*
9350	*Quercus macrolepis* forests	*Quercus macrolepis (= Quercus ithaburensis* subsp. *macrolepis)*
9380	Forests of *Ilex aquifolium*	*Ilex aquifolium*
9410	Acidophilous *Picea* forests of the montane to alpine levels (*Vaccinio-Piceetea*)	*Picea abies, Vaccinium sp. pl., Larix decidua, Pinus cembra, Pinus mugo*
9420	Alpine *Larix decidua* and/or *Pinus cembra* forests	*Larix decidua, Pinus cembra*
9430	Subalpine and montane *Pinus uncinata* forests (* if on gypsum or limestone)	*Pinus mugo* subsp. *uncinata (=Pinus uncinata)*
9510	Southern Apennine *Abies alba* forests	*Abies alba, Juniperus hemisphaerica*
9530	(Sub-) Mediterranean pine forests with endemic black pines	**ALP, CON**: P*inus nigra* subsp. *Nigra* **MED**: *Pinus nigra* subsp. *nigra, Pinus nigra* subsp. *calabrica*
9540	Mediterranean pine forests with endemic Mesogean pines	*Pinus halepensis, Pinus pinaster* subsp. *pinaster, Pinus pinaster* subsp. *hamiltoni (=Pinus pinaster* subsp. *escarena), Pinus pinea*
9560	Endemic forests with *Juniperus* spp.	*Juniperus thurifera*
9580	Mediterranean *Taxus baccata* woods	*Taxus baccata*
95A0	High oro-Mediterranean pine forests	*Pinus leucodermis (=Pinus heldreichii* var. *leucodermis)*

4. Discussion and Conclusions

In the context of art. 17 reporting cycles, experiences from different Member States are mostly addressed at interpretation and description of habitats rather than defining an effective and appropriate methodology for site-level data collection and a subsequent planning of real monitoring programs on the conservation status of HT.

Despite the importance of HT interpretation, decades after the enactment of the Directive, it is necessary to take a step forward, focusing on actual monitoring programs.

The Italian choice to use plant assemblages as target of monitoring programs rather than individual species of fauna and/or flora derives from the following considerations:

(1) The majority of HT can be linked to one or more vegetational syntaxa, either by their name or by their description, and only 37% have no clear link to a syntaxon (Evans, 2010).

(2) The national handbooks or guidance for the interpretation of HT drafted by the majority of Member States use a phytosociological framework creating a well-built link between HT and vegetation science.

(3) Although some Members States indicate some invertebrates as typical species, their employ as ecological indicators, although appealing, is only the best alternative to evaluate local ecological modifications (Dufrêne and Legendre, 1997) rather than the substantial changes at biogeographic level, as required by the Directive.

The use of vegetation science as essential basis for habitat monitoring is a clear choice aiming to make reliable and comparable monitoring data across Europe (Agrillo et al., 2018). In this sense, we consider a fundamental step forward the drafting of national guidelines for habitat monitoring with a focus on data collection, at site level, of plant assemblages.

Techniques commonly adopted by the vegetation science for field data collection result at the same time detailed and highly representative of the status of a HT. Through the use of classes of abundance-dominance, they allow to effectively describe the social behaviour of each species providing objective data of "typical" member of the community, highlighting possible variations over time.

To make efficient and functional all the monitoring system, it is essential to adequately implement the nationwide sampling strategy, and to obtain statistically representative and replicable field data at the biogeographical level. This because the increasing of information obtained from a monitoring project not always can be directly translated into benefits for nature conservation (McDonald-Madden et al., 2010).

To achieve this goal in the national context, regional initiatives for creating data archives as the "database concerning the phytosociological relevés about habitats of Community interest (Directive 92/43/EEC)" in Lombardy (Brusa et al., 2017) are valuable contributions.

The implementation of a nationwide sampling strategy should be efficient and effective, statistically representative, and reliable and repeatable. A crucial issue is the achievement of a reliable sampling design. For occasional HT with a small total area is not difficult to have information for every occurrence, but for most HT some forms of sampling will be required, being impossible to obtain information on all the areas of occurrence. The sampling should be based on statistical principles, for example stratified random sampling. A proposal based on this sampling criterion was formulated by Brus et al. (2011) within the design of a European-wide monitoring network.

To ensure sufficiently useful data collecting during the monitoring program, it will be also necessary to pay special attention to the construction of an adequate design of vegetation surveys, planned considering the crucial step of implementing an appropriate balance between sampling effort (generally the most expensive part of the monitoring plans) and types of information obtained.

Future challenges will encompass the development of reliable strategies to transpose field data to larger spatial areas, such as biogeographical level, and to provide consistent reference values.

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