

VegDunes – a coastal dune vegetation database for the analysis of Italian EU habitats

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Abstract: In this paper we illustrate VegDunes (GIVD ID EU-IT-005), a vegetation database of Italian coastal dune EU habitats (sensu 92/43/EEC Habitats Directive). We explore general features of the data collected, in particular variation in plot size, time range of the relevés and geographical position accuracy. Then, we characterise and explore the spatial distribution of the different coastal dune habitats in the database, evidencing major biodiversity “hotspots” (areas with the highest number of habitats) at the national level. We collected previously published phytosociological information (2,666 phytosociological relevés) concerning Italian coastal dune vegetation (10 different EU habitats) that ranged from 1967 to 2011. Most relevés were recorded with a medium to high accuracy (from the exact GPS coordinates to a coastal length up to 5 km) and the plot size did not exceed 100 m². Habitats close to the sea-line were much more widespread along Italian coasts compared to more inland ones, possibly in relation with habitat loss caused by the intensification of human impact in back dune communities. Even though phytosociological databases are affected by preferential sampling issues, this kind of data is an important source of information for nature conservation, especially for threatened coastal environments. Overall, this information may be a powerful instrument for the future management of EU habitats from a conservation perspective.

Keywords: Coastal dune habitat; Habitats Directive; phytosociological database; psammophilous vegetation; UTM grid.

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Introduction

In Europe there is a long tradition of vegetation survey based on the classical phytosociological approach (Braun Blanquet 1964, Westhoff & van der Maarel 1973, Dierschke 1994, Dengler et al. 2008) which has proved to be a very useful methodological framework for local and regional overviews of vegetation types (Schaminée et al. 2009). In fact, the floristic-sociological approach makes it possible to describe and define characteristic vegetation groups in relatively small sample plots (usually between 1–100 m²) taking also environmental factors and biotic interactions into account (Botta-Dukát et al. 2007, Schaminée et al. 2007).

Millions of vegetation plots have been recorded for different purposes as well as a huge amount of metadata (Bekker et al. 2007). Nevertheless, the access to this massive but also scattered information was extremely limited prior to the advent of electronic database technologies and digital communication tools (Mucina & van der Maarel 1989, Dengler et al. 2011).

In Italy huge amounts of phytosociological relevés have been performed (estimated in 150,000 samples according to Schaminée et al. 2009), although this information is often unpublished and not yet widely available on digital archives. However, many efforts in this regard are currently being carried out (Venanzoni et al. 2012). The compilation of a national vegetation-plot database is particularly urgent for Italian coastal dune habitats. The second National Report about the implementation of the 92/43/EEC Directive (the so called “Habitats Directive”; EEC 1992) indicates that among all 130 habitats listed in the Annex I for Italy, coastal dunes are one of the few types that fall within the category “unfavourable conservation state” (European Commission 2008, La Posta et al. 2008; Fig. 1).

The critically poor conservation conditions make these habitats those with the highest risk level and requiring special management measures in the near future (La Posta et al. 2008). In fact, even though the great diversity of Italian coastal dune habitats is widely recognised (Biondi et al. 2009), they are highly endangered not only by the increase of hu-

man pressure on sandy littorals but also by massive coastal erosion coupled with missing space for natural coastal dynamics. Due to the combination of these factors dune habitats end up being compressed between the retreating coastline and the presence of human structures in the inland. Coupled with these phenomena are the effects of ongoing global climate change (Stanisci et al. 2004), which could cause alterations in the climate characteristics of the Mediterranean and changes in the sea-level, consequently affecting water resources, natural ecosystems (both terrestrial and marine), human activities (e.g. agriculture, recreation, tourism) and health (Giorgi & Lionello 2008). Overall, the most threatened habitats are embryonic shifting dunes (EU habitat 2110), shifting dunes along the shoreline with *Ammophila arenaria* (EU habitat 2120), coastal dunes with *Juniperus spp.* (EU priority habitat 2250*) and *Cisto-Lavanduletalia* dune sclerophyllous scrubs (EU habitat 2260) (European Commission 2008, La Posta et al. 2008).

On such a basis we built a vegetation database of Italian coastal dune EU habitats (sensu 92/43/EEC Habitats Directive;

EEC 1992), collecting previously published phytosociological information and georeferencing each relevé with a specified geographic accuracy level. Then we focused on the spatial distribution of the

different coastal dune habitats based on the information available in the database. In this paper we aim to 1) increase the visibility of the database illustrating its main characteristics and its potential fu-

ture uses, 2) highlighting likely biodiversity hotspots (areas with the highest number of habitats) for sandy coasts at the national level.

GIVD Database ID: EU-IT-005		Last update: 2012-07-08
VegDunes		
Scope: The database contains published and original phytosociological relevés of Italian coastal dunes. We considered only plant communities of Holocene dunes. Each vegetation plot is associated to a habitat of Community interest (sensu "Habitats Directive" 92/43/EEC)		
Status: ongoing capture		Period: 1967-2011
Database manager(s): Irene Prisco (iprisco@uniroma3.it)		
Owner: Laboratorio di Ecologia Vegetale, Dipartimento di Biologia Ambientale, Università Roma Tre, Rome, Italy		
Web address: [NA]		
Availability: according to a specific agreement	Online upload: [NA]	Online search: [NA]
Database format(s): Turboveg		Export format(s): Turboveg
Publication: Prisco I., Acosta A.T.R., Ercole S. (2012) An overview of the Italian coastal dune EU habitats. <i>Annali di Botanica</i> 2: 39-48.		
Plot type(s): normal plots		Plot-size range: 0.2-500 m ²
Non-overlapping plots: 2,666	Estimate of existing plots: [NA]	Completeness: [NA]
Total plot observations: 2,666	Number of sources: 71	Valid taxa: [NA]
Countries: IT: 100.0%		
Forest: 0% — Non-forest: aquatic: 0%; semi-aquatic: 0%; arctic-alpine: 0%; natural: 100%; semi-natural: 0%; anthropogenic: 0%		
Guilds: all vascular plants: 100%		
Environmental data: altitude: 5%; slope aspect: 1%; slope inclination: 3%		
Performance measure(s): cover: 100%		
Geographic localisation: GPS coordinates (precision 25 m or less): 2%; point coordinates less precise than GPS, up to 1 km: 34%; small grid (not coarser than 10 km): 39%; political units or only on a coarser scale (>10 km): 26%		
Sampling periods: 1960-1969: 0.8%; 1970-1979: 24.8%; 1980-1989: 31.8%; 1990-1999: 22.1%; 2000-2009: 18.6%; 2010-2019: 1.9%		
Information as of 2012-07-19; further details and future updates available from http://www.givd.info/ID/EU-IT-005		

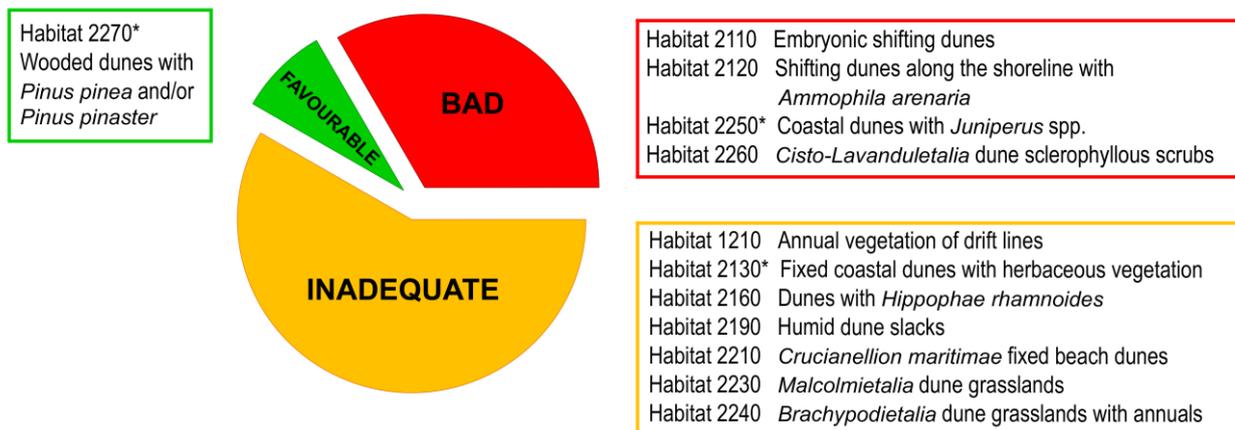


Fig. 1: Conservation state of "Coastal Sand Dunes" and "Inland Dunes" (La Posta et al. 2008). Dune habitats show a high percentage of inadequate (59%) and bad conservation state (33%). Only one habitat show a favourable conservation state. * = priority habitat.

Methods

Data collection

We conducted a detailed research of the Italian phytosociological information by collecting accessible sources regarding Italian coastal dune vegetation, including mainly published literature (Appendix) but also some original data. We considered only plant communities of recent (Holocene) dunes: fore dune, mobile dune, transition dune, fixed and inland dune. Thus, only phytosociological associations regarding these communities were selected. Specifically, we lead our bibliographical research by consulting all available issues of Italian journals reporting phytosociological relevés from the 1980s (e.g. *Annali di Botanica*, *Informatore Botanico Italiano*, *Giornale Botanico Italiano*, *Fitosociologia*. See Appendix for the complete list) and screening for vegetation surveys of coastal dunes in Italy. Then we searched for specific bibliography for each habitat through dedicated references reported in two main sources: the Italian Interpretation Manual of the 92/43/EEC Directive habitats (<http://vnr.unipg.it/habitat/index.jsp>) and the List of Italian Syntaxonomic Literature (LISY) which stores all citations of syntaxa and related bibliographic references published since 1909 for the Italian territory (<http://www.scienzadellavegetazione.it/sisv/index.jsp>). Finally, the search was integrated by directly inquiring many experts on these environments. The database is continuously updated based on information and literature sources made available to us.

After a first analysis of the collected information we identified areas with sandy coasts where no or very few relevés were available and conducted original phytosociological relevés in the spring of 2010 and 2011. In total we realized ca. 50 relevés distributed in the regions Lazio, Campania, Abruzzo, Molise and Puglia (all details in the database).

Database construction and structure

The database was built using the software *Turboveg* (Hennekens & Schaminée 2001). Although bryophytes and lichens are often abundant on the grey dune habitats in northern Europe (Houston 2008), no data about these species were available

in the reference sources. We used as taxonomic reference list the species list of the *Flora d'Italia* (Pignatti 1982), the most commonly used in most of the relevés recorded. Cases of synonymy and taxonomical problems (see Jansen & Dengler 2010) were resolved by relying on Conti et al. (2005), which report an updated list of synonyms with reference to the *Flora d'Italia* (Pignatti 1982).

For each relevé we also registered all metadata available from the reference sources, in particular sampling year, plot size, geographical location and phytosociological association. For the phytosociological associations we reported the original nomenclature of the primary reference sources. Based on the phytosociological classification of vegetation types provided in the reference source, each relevé was assigned to an EU habitat type following the guide-lines of the Italian Interpretation Manual of the 92/43/EEC Directive habitats (Biondi et al. 2009) and the Interpretation Manual of European Union Habitats (European Commission 2007).

The geographical position of each relevé allowed us to infer the spatial distribution of habitats at national level. In this regard, we should note that the description of the local geographical position of relevés varied, according to the reference source, from the exact geographical coordinates measured by Global Positioning System (GPS) to a general toponymic name. We used this information to georeference the relevés in decimal degrees through Google Earth, taking care to also assign an accuracy level. To this end, we proposed a scale of geographic accuracy, ranging from the lowest level of accuracy (if the toponym referred to a coast with a length over 5 km), to a medium level (coast length between 3 and 5 km) and finally to the highest level of accuracy (relevés with GPS coordinates, river outlets and small beaches -less than 3 km-).

The database *VegDunes* is registered in the Global Index of Vegetation Database (GIVD, <http://www.givd.info>) with the code EU-IT-005. The GIVD is an on-line archive of metadata on vegetation databases whose primary goal is to facilitate the use of vegetation data through increasing its visibility and availability worldwide (Dengler et al. 2011).

Brief analysis of the information in VegDunes and spatial distribution of relevés and habitats

For comparison with other databases in GIVD, we briefly explored the variation in plot size, level of georeferentiation accuracy and time range of all relevés as of December 2011. We also characterised each EU habitat in terms of the number of relevés available, the plot size range, the most abundant species and the number of different phytosociological associations. To analyse the spatial distribution of Italian coastal EU habitats contained in *VegDunes*, the information associated with each relevé was transferred into a 10 km x 10 km UTM grid, which is the spatial resolution most commonly used in regional and national analyses (Hassall & Thompson 2010), using a GIS software (ESRI Inc. 2006). Grid squares are commonly used to analyse habitats and species distribution patterns because this simple method is applicable to any amount of data (Bombi et al. 2011). In fact, information on the habitat types and species listed in the Annexes of the Habitats Directive (EEC 1992) has been aggregated at European level and organised on the UTM grid (European Commission 2008). Thus, we first calculated the number of relevés in each 10 km x 10 km UTM grid square. Then, we produced grid distribution maps for each EU coastal dune habitat identified. Finally, with the aim of identifying diversity hotspots, we calculated the total number of EU habitats for each grid square.

Results

VegDunes – Database of Italian coastal dune vegetation

Overall, the coastal dune vegetation database includes 2,666 phytosociological relevés related to the Italian peninsula and islands, 2,618 being from published sources (Appendix) and 48 being original data. The oldest plot in the database is dated 1967, whereas the newest is dated 2011, although most of the data comes from the 1980s till present (75%; Fig. 2). Regarding the geographic accuracy of the database, it is worth noting that most relevés were recorded with a medium and high accuracy (74%) and only 26% had a coarser accuracy.

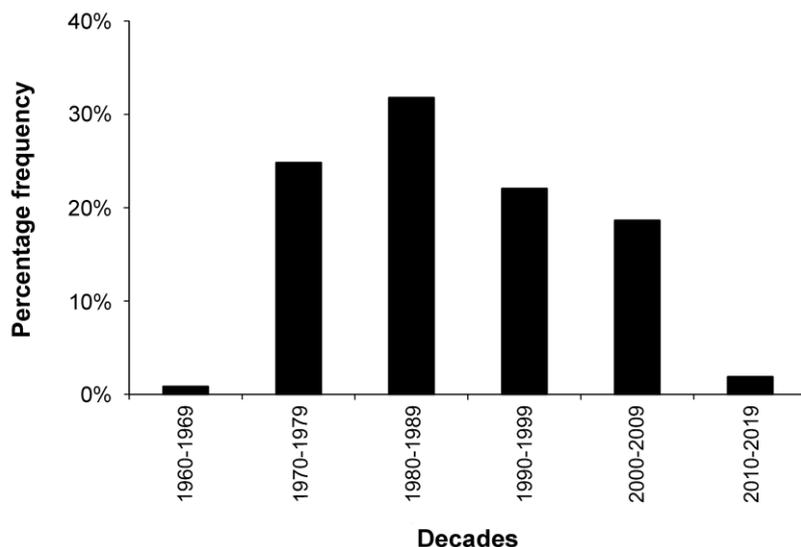


Fig. 2: Proportion of relevés recorded in each decade. We observed that most of relevés have been conducted since the 1980s to the present (75%), so we could affirm that the information in the database is relatively recent.

We noted that geographic accuracy increased slightly from the year 2000 up to the present (probably due to the recent widespread use of precision instruments as the GPS); however, relevés with a high geographic accuracy were available for the whole time range covered by the database. Sampling size varied from 1 to 300 m², but in most cases sampling plots were not larger than 100 m² (70%; Fig. 3). In particular, fore dune herbaceous vegetation (e.g. EU habitat 1210, 2110, 2120) was usually sampled in plots up to 100 m², whereas in fixed dune perennial vegetation (e.g. EU habitat 2250*, 9340) plots could reach up to 300 m². We observed that in recent years relevés have tended to be smaller (they do not exceed 100 m² after 2000).

Coastal dune EU habitats

Coastal dune relevés were distributed in 10 different EU habitats (Tab. 1). In the original sources 90 phytosociological associations have been described, however some of them probably include many synonyms, so the number of associations could be overestimated. Habitats concerning mobile dune and transition dune (EU habitat 2110, 2120, 2210) have the highest number of records, followed by fore dune and fixed dune habitats (EU habitat 1210, 2230, 2250*).

Regarding habitats' spatial distribution, we should note that fore dune, mobile dune and transition dune habitats (EU habitat 1210, 2110, 2120, 2210, 2230) were widespread but scattered along the Italian sandy coasts, while fixed and inland dune habitats (EU habitat 2130*, 2240, 2250*, 2260, 9340) showed a more restricted spatial distribution (Fig. 4). We should evidence that the EU priority habitat 2130* (grey dunes) is quite rare in Italy and localised only in the northern Adriatic Sea, but it is characterised by a relevant number of plant species (Tab. 1). This particular EU habitat corresponds to a Mediterranean sub-type of the more widely distributed "Atlantic 2130 habitat", extending from the Strait of Gibraltar to the North and the Baltic Sea (Houston 2008).

Even though relevés were widely distributed throughout the Italian coasts (Fig. 5a), the total number of habitats was higher in Central Italy (including both Tyrrhenian and Adriatic coasts) and in the major islands, Sicily and Sardinia. Furthermore, we identified some small localised hotspots along the North Adriatic and Ionic Sea (Fig. 5b).

Discussion

First of all, we should emphasize that this is the first attempt to produce an Italian

database focused on coastal dune vegetation. A national database for botanical data is currently being assembled (VegItaly, Venanzoni et al. 2012): this is an ambitious project collecting not only vegetation plots, but also information about Italian flora, taxonomy and herbarium records (<http://www.anarchive.it/anArchive/index.jsp>). VegDunes instead concentrates exclusively on coastal sand dunes habitats, aiming to a detailed characterisation of the vegetation of these threatened environments. At the moment VegDunes already includes almost 3,000 records distributed in a limited number of vegetation types (10 EU habitats) most of them with a consistent number of samples. In particular, we found that those habitats close to the sea-line were much more widespread compared to more inland ones. One possible explanation is that inland dune habitats have been less preserved as they have been often transformed into areas suitable for agriculture activities or urban development. The intensification of human presence in back dune communities has led to the increase of water catchment, pine plantation and tourist activities (Acosta et al. 2000, 2006), with the consequent decrease of more inland coastal dune habitats.

Considering all habitats together, based on the information contained in VegDunes, we can identify areas of high biodiversity, which are likely to be the most important for conservation purposes. Specifically, we highlighted that central Italy and the major islands seem to have the highest concentration of coastal dune habitats. These "hotspots" are possibly related to particularly well-preserved coastal dune vegetation systems (Brullo et al. 2001). The inclusion of such areas in the national reserve network or in conservation programs can be of fundamental importance for the ability of protecting these habitats and all the organisms that they harbour on the long-term.

Several biases typically influence the patterns highlighted by means of large electronic vegetation databases. As these databases are compiled using numerous literature sources, phytosociological relevés are usually unevenly distributed over time and space, and in terms of authorship (Haveman & Janssen 2008). Most common sources of heterogeneity include: geographic positioning accuracy, plot size, sampling effort and the time range covered by all relevés in the database.



Plate: Vegetation types featured by the vegetation-plot database GIVD EU-IT-005:

A: Shifting dunes along the shoreline with *Ammophila arenaria* (EU habitat 2120) in Punta Aderci (Vasto, Abruzzo).

B: *Malcolmietalia* dune grasslands (EU habitat 2230) in Tarquinia (Rome, Lazio).

C: Coastal dunes with *Juniperus* spp. (EU priority habitat 2250*) at Circeo National Park (Latina, Lazio)



Table 1: Summary of the 10 coastal EU habitats (* = priority habitat) within the database. For each habitat was reported information regarding relevés, most frequent species and phytosociological associations. Species names were updated according to the recent checklist of the Italian Flora (Conti et al. 2005).

Habitat	Relevés		Species		Phytosociological associations	
	Tot n°	% of Tot.	Tot n°	Most abundant (frequency > 40%)	Tot n°	Most frequent
1210 Annual vegetation of drift lines	376	14.10%	123	<i>Cakile maritima</i> , <i>Salsola kali</i> , <i>Xanthium orientale</i>	10	<i>Salsola kali-Cakiletum maritimae</i> , <i>Salsola kali-Euphorbietum peplis</i> , <i>Cakiletum maritimae-Xanthietum italicum</i>
2110 Embryonic shifting dunes	568	21.30%	168	<i>Elymus farctus</i> , <i>Eryngium maritimum</i> , <i>Echinophora spinosa</i> , <i>Cakile maritima</i> , <i>Medicago marina</i> , <i>Otanthus maritimus</i> , <i>Sporobolus virginicus</i> , <i>Pancratium maritimum</i>	9	<i>Elymetum farcti</i> , <i>Echinophoro spinosae-Elymetum farcti</i> , <i>Sporobolo arenarii-Elymetum farcti</i>
2120 Shifting dunes along the shoreline with <i>Ammophila arenaria</i> (white dunes)	506	19.00%	241	<i>Ammophila arenaria</i> , <i>Eryngium maritimum</i> , <i>Echinophora spinosa</i> , <i>Elymus farctus</i> , <i>Euphorbia paralias</i>	6	<i>Ammophiletum arundinaceae</i> , <i>Echinophoro spinosae-Ammophiletum arundinaceae</i>
2130* Fixed coastal dunes with herbaceous vegetation (grey dunes)	21	0.80%	74	<i>Fumana procumbens</i> , <i>Oenothera biennis</i> , <i>Scabiosa argentea</i> , <i>Teucrium chamaedrys</i> , <i>Teucrium polium</i> , <i>Cyperus kalli</i> , <i>Silene vulgaris</i> , <i>Ammophila littoralis</i> , <i>Koeleria macrantha</i> , <i>Petrorhagia saxifraga</i> , <i>Stachys recta</i> , <i>Helianthemum jonium</i> , <i>Hypochoeris radicata</i> , <i>Tortula ruraliformis</i> , <i>Ambrosia maritima</i> , <i>Calystegia soldanella</i> , <i>Silene otites</i> , <i>Dactylis glomerata</i> , <i>Helichrysum italicum</i> , <i>Sanguisorba minor</i> , <i>Phleum arenarium</i>	1	<i>Tortulo-Scabiosetum</i>
2210 <i>Crucianellion maritimae</i> fixed beach dunes	462	17.30%	289	<i>Crucianella maritima</i> , <i>Pancratium maritimum</i> , <i>Helichrysum italicum</i> , <i>Lotus cytisoides</i>	19	<i>Crucianelletum maritimae</i> , <i>Centaureo sphaerocephalae-Ononidetum ramosissimae</i> , <i>Helichryso microphylli-Crucianelletum maritimae</i> , <i>Pycnocomo rutifolii-Crucianelletum maritimae</i>
2230 <i>Malcolmietalia</i> dune grasslands	333	12.50%	361	<i>Vulpia fasciculata</i> , <i>Lagurus ovatus</i> , <i>Silene colorata</i> , <i>Rumex bucephalophorus</i> , <i>Medicago litoralis</i>	20	<i>Vulpio-leopoldietum gussonei</i> , <i>Sileno coloratae-Vulpietum membranaceae</i> , <i>Sileno coloratae-Ononidetum variegatae</i> , <i>Glaucio flavi-Matthioletum tricuspidatae</i>
2240 <i>Brachypodietalia</i> dune grasslands with annuals	23	0.90%	109	<i>Rumex bucephalophorus</i> , <i>Lotus angustissimus</i> , <i>Coleostephus myconis</i> , <i>Tuberaria guttata</i>	3	<i>Euphorbio terracinae-Hyparrhenietum hirtae</i> , <i>Moenchio-Tuberarietum guttati</i> , <i>Psiluro-Crassuletum tillaeae</i>
2250* Coastal dunes with <i>Juniperus</i> spp.	238	8.90%	254	<i>Juniperus oxycedrus</i> , <i>Pistacia lentiscus</i> , <i>Rubia peregrina</i> , <i>Smilax aspera</i> , <i>Asparagus acutifolius</i> , <i>Phillyrea angustifolia</i> , <i>Juniperus phoenicea</i>	9	<i>Asparago acutifolii-Juniperetum macrocarpae</i> , <i>Pistacio lentisci-Juniperetum macrocarpae</i> , <i>Junipero-Quercetum calliprini</i> , <i>Phillyreo angustifoliae-Juniperetum turbinatae</i>
2260 <i>Cisto-Lavanduletalia</i> dune sclerophyllous scrubs	100	3.75%	225	<i>Rubia peregrina</i> , <i>Asparagus acutifolius</i> , <i>Pistacia lentiscus</i> , <i>Cistus salvifolius</i> , <i>Phillyrea latifolia</i> , <i>Sixalix atroporpurea</i> , <i>Smilax aspera</i>	9	<i>Phillyreo latifoliae-Ericetum scopariae</i> , <i>Loto-Thymetum capitati</i>
9340 <i>Quercus ilex</i> and <i>Quercus rotundifolia</i> forests	39	1.45%	92	<i>Smilax aspera</i> , <i>Quercus ilex</i> , <i>Pistacia lentiscus</i> , <i>Rubia peregrina</i> , <i>Asparagus acutifolius</i> , <i>Phillyrea angustifolia</i> , <i>Lonicera implexa</i> , <i>Clematis flammula</i> , <i>Arbutus unedo</i> , <i>Hedera helix</i> , <i>Myrtus communis</i> , <i>Phillyrea latifolia</i> , <i>Ruscus aculeatus</i>	4	<i>Phillyreo angustifoliae-Ericetum multiflorae</i> , <i>Quercetum ilicis</i> , <i>Pistacio lentisci-Rhamnetum alaterni</i>

Most relevés in the database are registered with a medium-high geographic accuracy. We show here that relevés with this accuracy level can easily be transferred into a 10 km x 10 km UTM grid. This procedure not only allows a clear presentation of their spatial distribution at national scale but can also contribute to avoid the influence of small position errors of relevés. As far as plot size is concerned, variation in dimensions is well-known in phytosociological surveys (Chytrý & Otýpková 2003). As van der Maarel (1975) pointed out, phytosociological relevés extension depend on the type of sampled vegetation. The largest plots (25–200 m²) are usually used for woodlands, scrubs or for species-poor or very open vegetation types, whereas for herbaceous and grasslands vegetation smaller plots are usually used (5–50 m²) (Westhoff & van der Maarel 1973, Dierschke 1994, Chytrý 2001). The plot size variations in our database reflect this general rule: smaller plots for fore dune and mobile dune and larger ones for woody vegetation on fixed dunes. Regarding sampling effort, results could be influenced by the different phytosociological traditions developed in the different regions, as some areas could have been traditionally more studied than others. Field researchers could also be hindered by time availability and budget (Kueper et al. 2006). In our case, visual inspection of the number of relevés per grid square shows that some squares have received greater sampling effort, but these are quite scattered throughout the peninsula and not concentrated in few specific regions. Besides, these more thoroughly sampled squares overlap only partially with the areas identified as diversity hotspots, suggesting that differences in sampling effort have limited influence on the distribution patterns highlighted. Despite the wide time range of the relevés we observed that most of them have been conducted since the 1980s to the present. Thus, the information is relatively recent and it probably reflects current knowledge concerning the Italian coastal dune vegetation. However, we are conscious that some habitats could have been overestimated in some areas due to a more recent habitat loss while others could have been underestimated.

The application of the phytosociological approach provides advantages and disadvantages, as pointed out by several authors (Botta-Dukák et al. 2007, Chiarucci 2007, Diekmann et al. 2007, Hédl

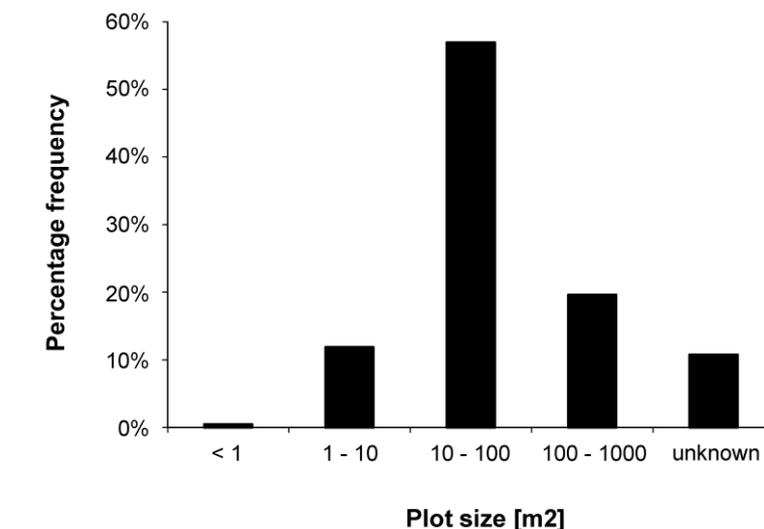


Fig. 3: Plot size distribution of the relevés in the database. In most cases sampling plots were not larger than 100 m² (70%). Larger plots were usually used for back and inland dunes habitats.

2007, Lájér 2007, Roleček et al. 2007, Michalcová et al. 2011). Subjective field selection, that characterises phytosociological relevés, is probably the best strategy for capturing diverse sites (local “hotspots”) which are usually of a very small extent (Hédl 2007), in particular considering the localised habitats of coastal dunes. In this situation random sampling may miss some vegetation types. An often mentioned drawback of phytosociology is the difficulty (or even the impossibility) of not to under- or oversample some particular vegetation types (Hédl 2007). Moreover, preferential sampling may lead to biased results due to violation of statistical assumptions of randomness and independence of observations (Kershaw & Looney 1985, Chiarucci 2007, Lájér 2007). Therefore, the frequency and distribution of habitat types we report on the basis of the information stored in VegDunes should serve as a general indication rather than a precise account of the current distribution. The use of habitat distribution modelling can potentially help overcome these drawbacks in the future (Bittner et al. 2011).

In conclusion, the information derived from this database gives an excellent account of the diversity of Italian coastal dune habitat types, and thereby serves as an important tool for nature conservation.

In particular, this information may be useful for the future management of EU habitats from a conservation perspective. In fact, large vegetation databases could be relevant for the effective implementation of the Natura 2000 Network (Shaminée et al. 2011). Information derived from this database could be overlapped with the Natura 2000 Network with the aim of identifying major gaps. By contrast, the identification of areas with the highest concentration of habitats may constitute the first step to proposing new protected areas in cases where such areas have not yet been demarcated.

Finally, the information contained in VegDunes database could be used for several further scopes. For example, it could be combined with information on morpho-functional traits (e.g. SynBioSys Europe; Schaminée et al. 2007) or with abiotic data such as climatic, geomorphological or edaphic strata (Coudun & Gégout 2007) to highlight possible causes of present day distribution patterns. This information would also help to evaluate the response of coastal dune habitats to different global change scenarios (Ozinga et al. 2005) and to estimate future possible range shifts for long-term conservation efforts (Elith & Leathwick 2009, Seo et al. 2009).

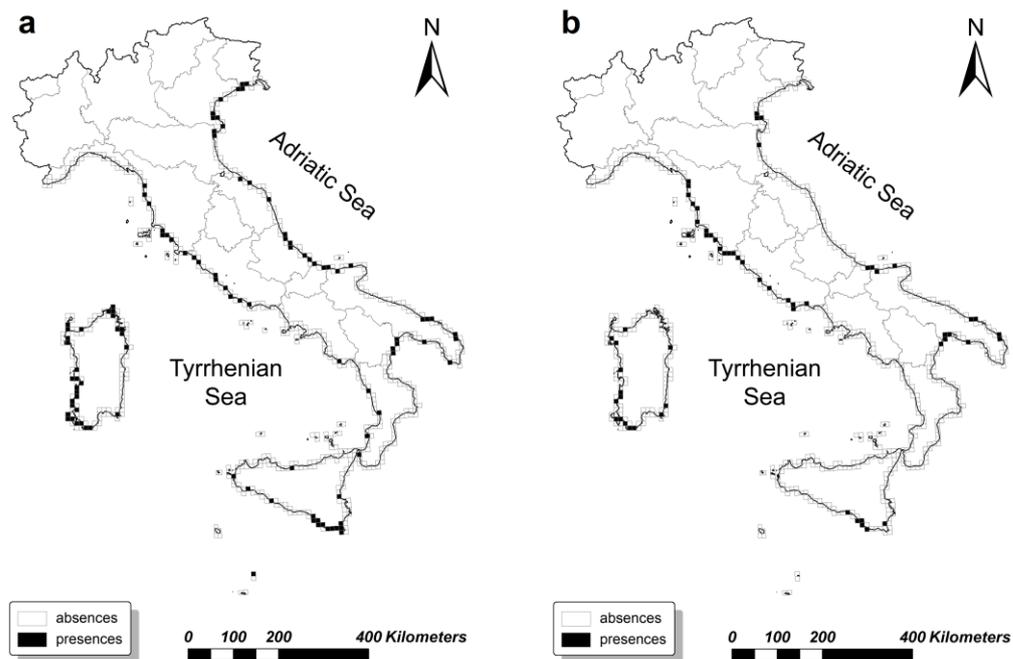


Fig. 4: Comparison between the geographical distribution of (a) a fore dune habitat 2120 Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes) and (b) a back dune habitat 2250* Coastal dunes with *Juniperus* spp.. We found that habitats close to the sea-line were much more widespread compared to more inland ones.

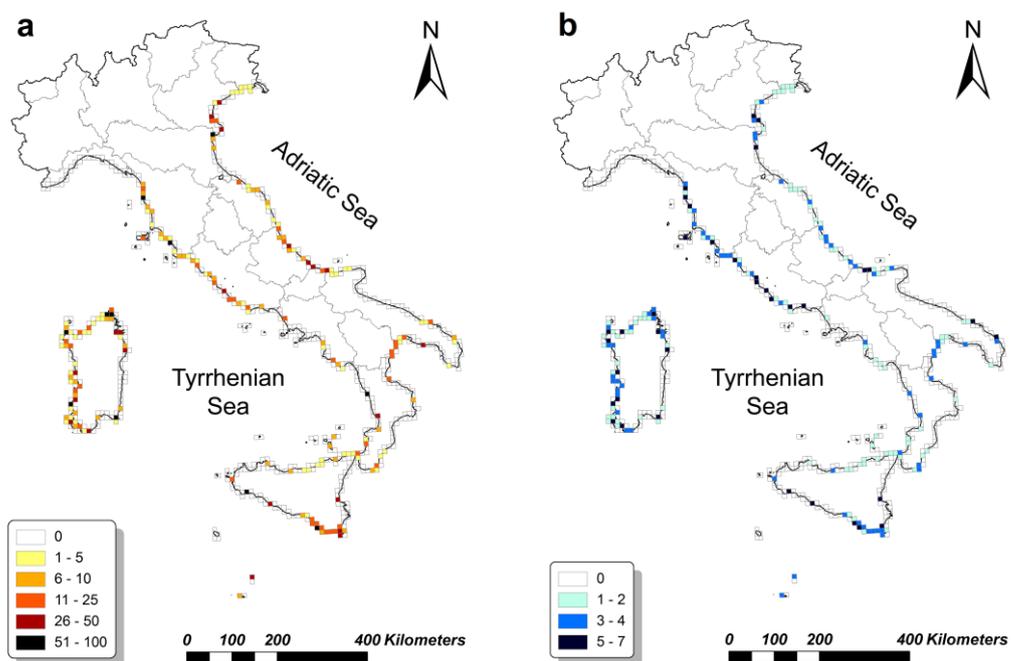


Fig. 5: (a) Total number of relevés and (b) number of EU habitats in each grid square (UTM grid 10 km x 10 km). Although relevés were widely distributed throughout the Italian coasts, we localised areas with high concentration of habitats, particularly in central Italy (including both Tyrrhenian and Adriatic coasts), in the two major islands (Sicily and Sardinia) and along the North Adriatic Sea.

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