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CROSS-BORDER COOPERATION IN THE MEDITERRANEAN

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4.1 Report on the state of the art of biodiversity

in the Mediterranean coastal areas analyzed by the GREAT Med project

September 2014

The present report was conducted in the context of the GREAT Med project by the project's partners: Sapienza University (Italy), University of Saint-Joseph (Lebanon), University of Sfax (Tunisia) and the IMBE – Aix-Marseille University (France). The report was coordinated by the IMBE and the University of Sfax. It represents the output **O4.1:** "Report on the **state of the art of biodiversity** in analysed coastal areas".

Contents

General Context

The aim of this report is to make a synthesis of the available information on biodiversity data within the four partner countries: Italy, France, Tunisia and Lebanon.

This state of the art of biodiversity data is an essential step for further work-packages of the ENPI-GREAT Med project in order to:

1) **Define** the level of biotic organization considered when referring to **biodiversity**. The term biodiversity may refer to a variety of organisms describing their complexity in different levels of biotic organization, from genes to ecosystem level. For the ENPI-GREAT Med project needs, this term will be used to define **coastal biodiversity** at the level of **plant species and habitats**. Given the data already available in all four countries and those that can be collected within a reasonable amount of time, data on plant species occurrence will be used. Phylogeny and plant functional traits will not be considered for the time being, since related data are not homogenously available in all partner countries.
2) **Define** adequate **biodiversity indicators,** indicating coastal vegetation fragmentation and vulnerability level. Selected indicators will be defined also according to the available data and/or feasibility of collecting new data in all partner countries. The methodology for quantifying coastal biodiversity through specific indicators is detailed in the "Biodiversity Indicators" section and the Summary Table.
3) Evaluate the **feasibility** of estimating biodiversity indicators for each partner country, according to the activities timetable, data availability and possibility of collecting additional data.
4) **Define** a suitable **spatial scale and resolution** to estimate selected biodiversity indicators. Disparities between countries regarding the type and accuracy of available data are presented and discussed in the following sections.
5) Identify possible **need for information or data** on biodiversity status and give **recommendations** for future activities.

Biodiversity indicators

The list of biodiversity indicators selected for this project aims at covering the multidimensionality encompassed by the term "biodiversity" (Noss 1990; Gaston 1996). The biodiversity aspects assessed are the following:

1. **Species richness (SR).** This indicator is the most commonly used. It represents the total number of species present in a spatial unit. In this report, SR will be referred to cells of several hundred meters or few kilometres size and will be used as a landscape-level indicator (see section "Data availability").
2. **Proportion of (local) richness out of regional richness.** This indicator measures the proportion of the total regional richness present in a given unit, and therefore it accounts for patterns of beta and gamma diversity. This indicator may be calculated in several ways. One metric could be referred to each cell, resulting from the division of the species richness in that cell (SR) by the total number of species found in all sites of the study region (see Figure 1 in the next section). It could be also calculated as the species richness in each study site, divided by the total number of species found in all sites of the study region. Species richness at regional scale is thus defined by all the plots inventoried in the region, although a complete list of species present in the coastal region containing all study sites could also be used.
3. **Richness of species with high conservation value out of the total species richness (HCSR/SR).** This indicator results from dividing the number of species with high conservation value in each cell by its total number of species. It represents, therefore, the proportion of species with high conservation value in each cell. By normalising it, this indicator can be compared among different cells and study sites. Species of high conservation value include the number of species that are of national/regional interest according to: global (IUCN), national and regional red lists, international Conventions and Directives (Habitats Directive,

Bern Convention, CITES), judgment of local plant experts (for instance, for narrow endemics or species with reduced population size).

4. **Richness of invasive species (ISR) out of total richness (ISR/SR).** This indicator results from dividing the number of invasive species in each cell by its total number of species. It represents, therefore, the proportion of invasive plant species in each cell, and is an indicator of conservation status. When an ecosystem is particularly rich of invasive species, it is often considered to have lower environmental quality. However, some invasive colonizing plants can provide ecosystem services where native species are absent (erosion, maintenance of pollinator communities).
5. **Floristic Quality.** This indicator represents the percentage of species that, because of their ecology and tolerance to disturbance, show a significant degree of fidelity to natural and semi-natural habitats (which, in the coastal regions, usually include beaches, dunes, coastal lakes and lagoons, saltmarshes, Mediterranean temporary ponds, Mediterranean maquis, etc.). Therefore, it is a measure of the degree of representativeness of flora. This indicator is helpful to evaluate species richness, which can be misleading when used in isolation (Fleishman et al., 2006), and to gain insights on the ecological integrity of habitats (in line with the ideas underlying the Floristic Quality Index, see Taft et al. 1997). The higher the proportion of representative species, the more natural and intact the habitats are. On the contrary, a low proportion of representative species can indicate polluted, disturbed or ruderalized areas.
6. **Diversity of natural and semi-natural ecosystems.** This indicator measures the number and relative abundance of natural and semi-natural ecosystems in a cell. It should be noted that land uses depending on a continuous input of human energy, as urban and agricultural areas, will be excluded. This index can be calculated through the Shannon index; it increases with the number of ecosystem types in the cell, while penalising the excessive dominance of one of them.

7. **Relative cover for habitats of high conservation value.** This indicator represents the percentage cover of all patches of high conservation value habitats in each cell. A list of ecosystems (or habitats) with high conservation value will be defined, following the criteria of endemicity and vulnerability and with reference to international and national policies, and judgement of local experts.

Figure 1. View of the Italian case study of Chia (Gulf of Cagliari, Sardinia).

Data availability and feasibility

In this section, we aim at providing a synthesis about data availability based on the potential of harmonization/synchronization among countries. For instance, the sampling effort in most of the countries is not always adequate to evaluate local biodiversity indicators and estimate the impact of fragmentation and land-use change at landscape and regional scales. Such analyses would require high spatial resolution data at relative large spatial extents. Therefore, we suggest focusing on landscape-level indicators of biodiversity:

- Local scattered information (e.g. the raw data of species richness at a 100-m^2 plot) may be up-scaled at larger reference spatial units (e.g. species richness at a 1x1-km cell; see Figure 2), which will allow us to cover more extensive continuous areas (study sites).
- Variability at wider regional scales may be accounted for by considering several study sites (or groups of cells) within each region.
- Finally, data on islets' biodiversity could be considered, when available, as a potential reference of biodiversity levels in non-altered areas/habitats similar to the coastal zone in terms of biogeographical conditions.

The selection of biodiversity indicators was limited by the data availability needed for their calculation, or the feasibility of gathering original data within the ENPI GREAT Med project duration. The availability of biodiversity data in each study region depends on the spatial extent and resolution of the study, leading to a limiting choice of spatial scale. Thus, a trade-off is necessary between the choice of an adequate spatial scale for the specific ecological and human processes addressed here, and data availability at such scale. The need of harmonising biodiversity data among partner countries in order to obtain comparable results has further influenced the choice of biodiversity indicators and the spatial scale.

The information in this section, together with other relevant environmental and human-pressure criteria, would help in the selection of the number and extension of the study sites, size of aggregation units and area of the sampling plots in each region (see Figure 1 and Summary table).

In the following section, we discuss the availability and feasibility of the selected biodiversity indicators, and the range of spatial scales, in line with the study objectives and data availability (i.e. cell sizes of 500 m to 3 km, study sites of 4-10 km of coastal length by 2-10 km of distance landwards). All indicators will be reported at the cell level.

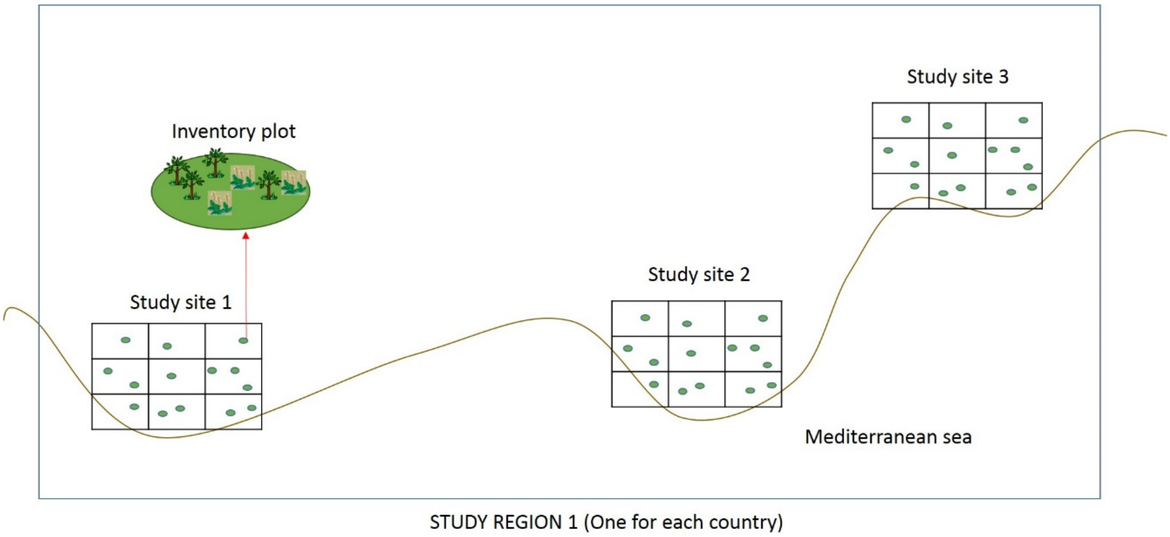

Figure 2. Scheme of the study design for each study region. The number of study sites varies in each region.

1. Species richness

The total number of species in a cell can be obtained from the field inventory. However, such up-scaling requires a minimum density of 1 sampling plot per grid cell, or ideally per habitat type within each grid cell. In the optimal case, the number of plots per grid cell should be proportional to the amount of non-urban and agricultural areas within each cell. Moreover, in order to estimate human pressure impacts, study sites should be embedded in landscape matrices of various urbanisation/fragmentation levels.

France: There are two potential plant databases in the coast region of Provence, SILENE database (www.silene.eu) and SIV database (an IMBE based research database of >1000 systematic floristic relevés in the study area).

We cannot use SIV database (area of about 16 km x 6 km) to answer questions on fragmentation, despite its systematic sampling design at every 500m, because it represents only a hardly fragmented landscape; however it is an important reference for continuous semi-natural areas.

SILENE (System of Information and Localisation of native and invasive species) is a georeferenced database compiled by the National Mediterranean Botanical Conservatory (CBNMed) which contains more than one million records on plant species occurrences in the French Mediterranean region. Such information comes from very different sources (herbaria specimen, field data from different campaigns, etc.), and varies spatially in its sampling effort. IMBE is performing an analysis of spatial patterns of sampling completeness (Gotelli and Colwell 2001) in order to select well-sampled study sites (see Soberón et al. 2007) that represent different scenarios of human pressure and environmental conditions. We will use only cells with a relatively high degree of sampling completeness. For such cells, rarefied species richness will be interpolated from the species accumulation curve, or nonparametric estimator of species richness will be used (Gotelli and Colwell 2001). Based on current preliminary results, cells smaller than 3km x 3km may not have enough sampling completeness to obtain reliable indicators.

Tunisia: Sampling plots with information on plant community composition are not available but we have the possibility to do some fieldwork. During the autumn 2014 (October, November, December) field survey will be conducted in three different sites (Sfax, Gabès and Djerba) with different degree of disturbance. All three sites are situated in the Gulf of Gabès. This fieldwork concerns especially the observations on the present flora. The comparison of species richness observed in the field with the potential flora of different sites will give further species richness indicators.

Italy: We plan to create a floristic database based on a spatial grid of 0.25 km² or 1 km², by using data from published floristic or vegetation studies and original data from fieldwork. In June 2014 we carried out surveys based on a 500m x 500m grid and stratified systematic sampling. We plan to do another survey in early spring 2015, in order to complete our floristic database, if necessary.

Lebanon: We have two types of datasets: the literature data that contains information about the plant species present in Byblos and the new data obtained during the fieldwork for the project. The historical data are extracted from Mouterde (1966-1983), which provides information and description about species found in Lebanon and Syria, including their habitat. The second literature source is Tohmé & Tohmé (2014) which contains a list of plant species found in Lebanon in addition to their location and habitat and a small description of each. However, in both papers the exact GPS locations are not given. In the framework of the GREAT Med project, 35 plots were heterogeneously inventoried along 10 Km of the coastal area of Byblos from March to July 2014. Most of them are concentrated along 2 kilometers. We will try to do more fieldwork and choose the plots locations more homogeneously. On the other hand, the "Zireh island"(0.2 ha) was exhaustively inventoried in July 2013 (Vela & Vela 2015). The fiabile probability is of 95%. Regional endemic species are found in this island. There is also a study made by Talhouk *et alii* (2005) that recorded 441 species along a part of the coastline including Byblos area. It must be noted that non artificial areas or land surfaces unaffected by anthropogenic factors are very limited in the coastal area.

2. Proportion of cell (or site) richness with regard to regional richness

The relevance of this indicator depends on the scale used for the definition of the species pool (region), which may be chosen explicitly small or based on the coastline plus a minimal distance. This indicator requires defining the limits of the region and a value of the total number of species within the region. When data at a regional scale is not available, up-scaled information from study sites within the region may be used.

France: SILENE database can be easily used to calculate the number of species in the coastal region that includes all analyzed study sites. Due to the large spatial extent of the considered region, we believe that the sampling completeness is sufficient to calculate robust and reliable values of species richness.

Tunisia: Species richness of the selected sites, confirmed by field observations, will be compared with the regional pool, which characterizes the coastal part of southern Tunisia.

Italy: We can derive the total number of species along the coast in the Gulf of Cagliari (or the South of Sardinia) from floristic literature.

Lebanon: The study area is delimitated. Literature data and data obtained from fieldwork can be used.

3. Richness of species with high conservation value

This indicator is ideally based on regional (otherwise national, global) lists of endangered, endemic or rare species (e.g. red lists) and uses occurrence information from field plots i.e. the number of species of high priority for conservation within a plot. We need information on global (IUCN), national and regional red lists, international Conventions and Directives (Habitats Directive, Bern

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Convention, CITES), or judgment of local plant experts, to produce a list of species of interest for the study areas of the GREAT Med project.

France: There are lists of protected species at the national and regional level (in France and in the region PACA, where La Provence belongs). There are red lists using the IUCN criteria on the national (Olivier et al 1995) and regional level (CBN Med 2001 unpublished, CBN Med 2014 in prep.). These can be completed by the status of endemics, sub-endemics and otherwise geographically restricted species.

Tunisia: There is the red list of species, but also the national list of protected species. Among this list, we will note those species found within the Gulf of Gabès. Moreover, for this indicator, we will provide the Red List of endangered species, according to IUCN in the Gulf of Gabès.

Italy: We will refer to regional and national Red Lists (Conti et al. 1992, 1997; Rossi et al. 2013), but also to the lists from the CITES Convention, the Habitats Directive and the Convention of Bern. Furthermore, we could derive a georeferenced database of Corso-Sardinian endemics within the study sites, from literature data (Bacchetta, Mandis & Pontecorvo, 2007; Bacchetta et al., 2012a and 2012b; Fenu et al., 2014) and from original unpublished data, subject to the permission of the owner (Centro Conservazione Biodiversità, University of Cagliari).

Lebanon: There are no national red lists. However, our team is working on the first national red list focusing on endemic and rare species. Abi-Saleh *et alii* (1996) published lists of: endemic species of Lebanon (with information on abundance, local distribution and particular habitats); medicinal and main pastoral plants; threatened and endangered Lebanese species (stating type of threat, particular habitat, and local distribution). Mouterde (1966-1983) and Tohmé & Tohmé (2014) mention for some species if they are rare or common.

4. Richness of invasive species

Ideally, this indicator is based on regional (otherwise national, global) lists of invasive species. Sapienza has prepared an example of reference list of potentially invasive plant species in the coastal habitats of the Mediterranean Basin, derived from the EPPO lists (https://www.eppo.int) (see the Supplementary material section at the end of this report).

France: The National Mediterranean and Alpine Botanical Conservatories are currently elaborating an updated list of invasive species of the PACA region (Terrin et al. 2014). The study is almost finished and the list is almost definitive (and therefore will be available for the studies of the GREAT Med project), but it cannot be published in this document. For published list of invasive species of the PACA region, please refer to www.invmed.fr

Tunisia: For Tunisia, we will rely on invasive species, according to the report of the Bern Convention. In addition, based on the scheduled field visits, we will note the list of invasive species present today in the Gulf of Gabès. Finally, references will justify the source of our collected information.

Italy: There is a list of invasive plant species in Sardinia, based on recent publications at local and national scale (Celesti-Grapow et al., 2009 and 2010; Bacchetta et al. 2009, Podda et al. 2012), with notes on the invasion status in the region.

Lebanon: There are no lists of invasive species. However, studies were made about native and non-native invasive weeds in Bekaa and North Lebanon. We can also use the data obtained during the field inventory.

5. Floristic Quality

To simplify calculations, this indicator will consider the proportion of species with significant fidelity to natural and semi-natural habitats out of the total number of species in each study area (rather than in each cell). A value of the total number of species at each study site is then required, and some basic knowledge on the ecology of plant species.

France: A detailed list of species affinity to habitats in France is available by P. Julve (2014) and accessible from www.tela-botanica.org. It can be used to extract species with a high affinity to selected coastal habitats or to all habitats of high conservation value in the coastline within a restricted distance. This list can be completed by ecological information of several local to regional flora (e.g. Tison et al 2014).

Tunisia: In the case of Tunisia, this parameter can be calculated by the ratio of the number of species present on the site in relation to the species total number inventoried for the Gulf of Gabès according to the phytoecological map of Tunisia (Le Houérou 1959 & 1969).

Italy: The use of this indicator in the Italian study case is feasible. The Flora of Italy (Pignatti 1992) records the habitats that are more likely to host individual plant species according to their autoecology. Furthermore, specific literature on coastal vegetation at national and regional level provides adequate information on the affinity of plant species to particular habitats.

Lebanon: Species habitats are being extracted from Mouterde (1966-1983) and Tohmé & Tohmé (2014). It will be possible to know the species found in the Lebanese and Byblos coast and their habitats, and in which different types of habitats inventoried species were found.

6. Diversity of Habitats

The feasibility to calculate this indicator depends on the availability and quality of land use data. Ecological land classification (i.e. environmental stratification) could help to depict the spatial distribution of natural heterogeneity (due to physical factors) and determine the potential distribution of different habitat types.

France: We have a land use GIS layer at a spatial scale of 1:50 000, and a minimum mapping unit of 2.5 hectares (Occupation du sol PACA 2006, http://www.crige-paca.org, an extension of the European Corine Land cover). Note, however, that <15% of semi-natural patches in our region are smaller than 5 ha. Thus, a cell size of 25 ha (500m x 500m) may frequently contain only two or three patches with different habitats, and the spatial variability of this indicator would be too small. For this indicator, it is probably better to consider a minimum cell of 1km x 1km.

Tunisia: There is a non-digitalized phytosociological map of 1:500000 and patches do not seem to be bigger than 0.5 cm (2.5x2.5 km). Therefore, to have a significant measure of habitat diversity we would need a minimum cell size of 10x10 km.
It does not seem feasible to digitalize land-use data from satellite or aerial images for a large part of Tunisia, but this may be done for a restricted area (e.g. 10km^2 or less). Alternatively, the use of available global data may be considered.

Italy: There are two different land cover maps covering the Gulf of Cagliari: the 1:50000 “Map of Nature” (habitat-biotope level), with a minimum mapping unit of 1 ha; and the 1:25000 land cover map realized in 2008 by Sardinia Region (mmu 0.5 ha), which is more consistent with the field sampling scheme we have already adopted.

Lebanon: A land use map at a scale of 1:20000 is available.

7. Relative cover of high conservation habitats

The calculation of this indicator requires a map of habitats/land cover types and information about the conservation priority of habitats in order to calculate a quantitative variable (i.e. total surface covered by priority habitats in each cell).

In this regard, we should create a list of habitats with high conservation value in all study areas to define some priority habitats for conservation in the Mediterranean Basin. We recommend that each partner country produce a list of threatened, rare or biogeographically important habitats (describing the habitat, and explaining why it is important or exploring the habitat's current or potential threats) with the help of local plant experts. After that, we will harmonize the data in order to produce a common reference list. The following is an example of habitats currently selected in Italy and the reasons for their selection:

Country	Habitat description	Dominant or characteristic species	Threatened habitat	Rare habitat	Biogeographic importance	Source and notes
Italy	Sandy coastal vegetation	*Ammophila littoralis Elytrigia juncea*	X (land use change)	X		Habitats Directive
Italy	Halophytic vegetation	*Salicornia* sp., *Suaeda* sp.		X		Habitats Directive
Italy	Dune with *Juniperus* species		X	X		Habitats Directive
Italy	Maquis		X		Endemic species	Habitats Directive

France: We will select the relevant habitats according to the data of the European Habitats Directive (92/43/EEC), and the French interpretation manual, controlled by our own expert knowledge in the field. The land use and habitat map of the PACA region (1:50 000) has been adapted from Corine Land Cover and thus the typologies identified by the European Directive can be easily related with the habitats identified in the georeferenced layer.

Italy: We will use the list of habitats from the European Habitat Directives, with particular reference to the Italian Interpretation Manual of Habitats (http://vnr.unipg.it/habitat/index.jsp).

Tunisia: The feasibility of this indicator will depend on the feasibility of the indicator "Diversity of Habitats".

Lebanon: The list of habitats present in Lebanon or in the coastal area can be extracted from the literature (Mouterde 1966-1983; Tohmé & Tohmé 2014). Furthermore, we can work on the inventoried data. Abi-Saleh *et alii* (1996) have proposed the Lebanese vegetation classification that contains different levels (mother rock, vegetation series and evolution stage) but the information is very vague. However, a map of protected areas provided by the Lebanese Ministry of the Environment and the National Physical Master Plan described 7 reserves, each corresponding to different habitats.

Figure 3. Effect of tourism development in Djerba (Gulf of Gabès)

Summary tables

BIODIVERSITY INDICATORS	*FRANCE*	ITALY	*LEBANON*	*TUNISIA*
Species richness (SR)	Species richness will be based on SILENE database. We will use only those cells with relatively high degree of sampling completeness	Literature data are available, and a preliminary field survey was carried out in June 2014, resulting in 57 plots sampled (37 in the Chia-Santa Margherita di Pula study area, and 20 in the Poetto study area). Additional field survey is scheduled in spring 2015	Field survey was carried in a 4-month campaign in 2014. It resulted in 35 sampled plots. Literature data is also available but the information is not georeferenced. There is also a study made by Talhouk et alii (2005) that recorded 441 species along a part of the Lebanese coast including Byblos. Additional field work could be done if needed	Relevés will be conducted in November in the island of Djerba, additional field work programmed in other two sites during autumn
% local SR (at cell or site)/regional SR (ex:Province region or Gulf of Gabès)	We have information on species richness beyond the study sites, based on SILENE, and therefore the definition of the region is flexible	We have information on species richness in the study sites, based on field survey and literature data. We will use as regional species richness the total number of species recorded in the Gulf of Cagliari	We have literature information about species presence outside the study site	Species richness of the selected sites, confirmed by field observations will be compared with regional wealth that characterizes the coastal part of southern Tunisia
Richness of species with high conservation value (HCSR)	National and regional red lists are available; they will be combined with occurrence data from SILENE	National and regional red lists are available. A georeferenced database of Corso-Sardinian endemics could be created from the floristic literature and from unpublished data (depending on the permission of the data owner)	The status of endemic and rare species will be undertaken in the framework of a CEPF project. The first national red list is expected to be released in 2016. Some literature data mention if the species are rare or common. Abi-Saleh et alii (1996) created a list of endemic species, a list of threatened and endagered species, and lists of medicinal and pastoral species.	Official Journal of the Tunisian Republic, Red List, National Strategy of biodiversity conservation, etc.
Richness of invasive species (ISR)	A list of invasive species in the PACA region is currently being finished; it will be combined with occurrence data from SILENE	Data on alien species can be extracted from the literature. Unpublished georeferenced data could be used (but not disseminated) with the permission of the data owner	EPPO list+ available information in the floristic literature	Bern convention of alien species
Floristic quality	A list of species affinity to habitats in France is available; it can be complemented by several local to regional floras	A list of species affinity to habitats in Italy is available at the national scale, and can be complemented by several local to regional floras	It will be defined in the framework of this project.	The same as France
Diversity of habitats	Available from the land use and habitats map	Available from land use and habitat maps	A land-use map is available but not a habitat map	The feasibility will depend on the recruitment of a GIS specialist, which seems difficult
Cover of high conservation habitats	Available from the land use and habitats map	Available from land use and habitat maps	Land use map is available but not a habitat map. The habitat is mentioned in the literature data (Mouterde 1966-1983; Tohmé & Tohmé 2014)	Available only at the scale of each one of the three selected sites (ex. Djerba)

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STUDY AREA AND METHODS	FRANCE	ITALY	LEBANON	TUNISIA
Plot size	Our source of biodiversity data (SILENE database) has a variable size of inventory plots	Plots of 100 m² (except when the habitat to be sampled covers less); literature data refer to different plot sizes	For fieldwork, plot size is 9 m². There is not precise plot size for the literature data (Mouterde 1966-1983; Tohmé & Tohmé 2014)	100-128 m²
Reference spatial unit (cell)	The selection of the cell size in France depends on the analysis of sampling completeness of SILENE database. A trade-off between completeness, cell size and number of cells per study site will be used for selection	For fieldwork cells of 500m*500m. Data will be upscaled to 1km*1km	1km×1 km, with one or more empty cells. Fieldwork was concentrated along 2 km. Additional field work will be made more homogenously to try cover more plots and habitats in each cell	It depends on the resolution of the source satellite data, but probably 1 km²
Size and number of study sites	The selection of the size and number of study sites in France depends on the analysis of sampling completeness of SILENE database. A trade-off between completeness, cell size and number of cells per study site will be used for selection	2 sites, namely Chia-Santa Margherita di Pula and Poetto. The size of the first is about 12 km x 4 km, whereas the Poetto study area covers about 10km x 10 km (these sizes refer to the wider areas, we may distinguish between true coastal area -to be sampled- and wider extent for analysis of threats)	1 site, Byblos coastal area. The site size is 10 km long by 200 m wide. The data obtained by the latest inventory are finer than other data. The spatial resolution of literature data of Mouterde (1966-1983) and Tohmé & Tohmé (2014) is at regional level	3 sites (Sfax, Gabès and Djerba) will be selected on the coast of the Gulf of Gabès covering a total linear length of 10 km
Islets	We have additional list of plant species on the islets, that can be used as reference of well conserved study sites	We do not have additional data on islets	Zireh islet was fully inventoried in June 2013	We have additional data on islets, that can be used as reference of well conserved study sites
Maps available for ecological land classification (i.e. environmental stratification)	French topographic map 1:10000 (BD TOPO 2012; www.ign.fr); France vector-based geological map 1:1 000 000 (Bureau de Recherche Géologiques et Minières (BRGM France) 2010 http://onegeology-europe.brgm.fr/geoportal/viewer.jsp) Map of land use and habitats 1:50 000 (Occupation du sol PACA 2006, http://www.crige-paca.org) French Digital Elevation Model 25m (http://professionnels.ign.fr/bdalti)	Topographic map of Sardinia, 1:25000 (http://www.pcn.minambiente.it/PCNDYN/catalogowms.jsp?lan=it) Geology of Sardinia and Land cover map of Sardinia, 1:25000 (Regione Sardegna, 2008, (http://www.sardegnageoportale.it/) Map of the Nature (habitat-biotope level) 1:50000 (ISPRA 2011, http://www.isprambiente.gov.it)	Administrative and ancillary data, including contour lines (Directorate of Geographic Affairs_DGA, Lebanese Army). Topographic maps of Lebanon (GGA, 1965) at 1:20,000 scale. Land Use Land Cover Maps: FAO + MoA (2002), based on satellite imagery of 1998; CNRS (2010), based on IKONOS satellite imagery of 2005 (The two maps adopt similar classifications, and differ especially for the definition and identification of shrubland and grasslands). 1:50000 Geological map (Dubertret 1955). Forest cover maps 1965 and 2005 for Forest Resource Assessment (FRA). Vegetation map: Dr. S. Saifi and Dr. B. Abi Saleh Saleh provides a vision of the distribution of vegetation. Carte lithologique du Liban, Geze 1956, CNRS, 2005 (scales 1:200000 and 1:50000)	Ecological map of central and southern Tunisia (according Le Houérou 1969)

Discussion

- In some cases, species richness is positively related to disturbance, due to the colonization by early successional species and may occur at the expense of specialist species (e.g. Gilliam et al. 1995, González-Alday et al. 2009). Therefore, additional indicators considering species composition should also be considered. The ratios of invasive and endangered species on the total number of species are used in that sense, as well as the "floristic quality" indicator.
- Some human pressures may have impacts at smaller spatial resolution than 1km x 1km. For example, oil spill and sea level rise may influence a narrower band in the coast, and its impact will depend on the spatial distribution of more vulnerable habitats and on their topography. However, other pressures, such as urbanization, agricultural lands and nurseries act at a larger scale. Thus, selected spatial resolution should enable considering different sources of pressure for coastal ecosystems.
- The indicators quantifying the number of species, or cover of habitats, with high conservation value, due to their endemicity to the region, are the most important for assessing biodiversity vulnerability to the analysed human pressures. Indeed, such indicators will be useful in order to identify areas of high conservation interest whose protection can be compromised by existing human pressure.
- Indicators on invasive species can be also informative on the vulnerability of the communities. In general, as the ratio of invasive species out of the region's total richness increases, ecosystems' functioning might be compromised. Therefore, we will consider the ratio of invasive species as an indicator of human impacts.

Conclusions and recommendations

For the French case study (Provence region), extensive data on species occurrences exist and are available (mainly through the SILENE database). However, preliminary harmonisation analyses were inevitable in order to use these data, as they result from different field protocols. Problems connected to sampling bias are now estimated and corrected. Thus, biodiversity indicators presented in this report are feasible for the Provence region. Nonetheless, as sampling bias can be important at fine resolution scales (ex. in 1x1km grid cells), biodiversity indicators might be estimated at a 3x3km grid resolution.

In the case of Tunisia, generally all the proposed indicators can be determined. However, it could be difficult to assess habitat fragmentation due to the lack of a GIS specialist. Therefore, we must define which methodological approach to apply to estimate broadly this indicator.

For the Italian study area (Gulf of Cagliari), there is a great amount of information on plant species and communities, which is however not organized in a spatially explicit, easily queryable and update database. Within this project, data from literature and previous field studies, as well as original data (gathered through ad hoc field surveys), will be combined to produce a well-structure database of plant biodiversity in the study area. Field surveys were carried out in June 2014, and will be repeated in 2015 to complete the floristic inventory and to refine sampling, if needed. All these tasks are feasible within the time schedule of the project's activities.

For the Lebanese case (Byblos coastal area), different sources of data are available. However, the data obtained from the field inventory made for the GREAT Med project is more refined as the exact location of the species and the percentage of occupancy (inside the plots) and presence (near the plots) are noted. The literature data obtained from Mouterde (1966-1983) and Tohme & Tohmé (2014) only states the region where the species were seen or found and their habitats, but the data concerns all the country. An important part of the coast is destroyed due to anthropogenic factors like urbanization, thus narrowing the width of the coastal area (e.g. three plots were totally destructed within two or three month). In some cases the inaccessibility to the coastal area, in addition to the absence of vegetation in different zones, makes it very hard to sample some localities. Additional fieldwork could be undertaken if necessary.

Supplementary material

S1. Preliminary table of alien plant species (only neophytes, introduced after 1500) in the coastal landscapes of the Mediterranean Basin. The list is derived from the EPPO lists of alien plant species that colonize coasts or water habitats (that could occur along the coasts), and from regional knowledge. This table should be completed by each country/partner, by adding two columns, one for the presence and status (CAS= casual, NAT= natural, INV= invasive) and one for the source of reference.

Species	COAST	EPPO-LISTS	c_SAR	SOURCE_SAR
Aloe caesia	x		NAT	Bacchetta et al_2009
Aloe saponaria	x		CAS	Celesti-Grapow et al_2009
Alternanthera philoxeroides	water	INVASIVE		EPPO
Alternanthera pungens	water	OTHER		EPPO
Alternanthera sessilis	water	OTHER		EPPO
Amaranthus crispus	x		CAS	Celesti-Grapow et al_2009
Amaranthus cruentus L.	x		INV	Celesti-Grapow et al_2009
Ambrosia artemisiifolia	?	INVASIVE		EPPO
Ambrosia confertiflora	water	ALERT		EPPO
Ambrosia psilostachya	x	OTHER		EPPO
Ambrosia trifida	water	OTHER		EPPO
Amelanchier spicata		INVASIVE		EPPO
Amorpha fruticosa	water	INVASIVE		EPPO
Andropogon virginicus	water	ALERT		EPPO
Araujia sericifera	water	OBSERVATION		EPPO
Arctotheca calendula	?	ALERT		EPPO
Asclepias fruticosa	x		INV	Celesti-Grapow et al_2009
Asparagus asparagoides	x	OBSERVATION		EPPO
Azolla filiculoides Lam.	water	OBSERVATION	NAT	Celesti-Grapow et al_2009
Baccharis halimifolia	x	PEST(A2)		EPPO
Bidens frondosa	water	OBSERVATION		EPPO
Buddleja davidii		INVASIVE		EPPO
Cabomba caroliniana	water	INVASIVE		EPPO
Cardiospermum grandiflorum	water	INVASIVE		EPPO
Carpobrotus acinaciformis	x	INVASIVE	INV	Celesti-Grapow et al_2009
Carpobrotus edulis	x	INVASIVE	INV	Celesti-Grapow et al_2009

Species	COAST	EPPO-LISTS	c_SAR	SOURCE_SAR
Cenchrus incertus	x	OBSERVATION		EPPO
Chasmanthe aethiopica	x		INV	Celesti-Grapow et al_2009
Cornus sericea	water	INVASIVE		EPPO
Cortaderia selloana	x	INVASIVE	INV	Celesti-Grapow et al_2009
Cotula coronopifolia	x	OTHER	INV	Celesti-Grapow et al_2009
Cotyledon orbiculata	x		CAS	Celesti-Grapow et al_2009
Crassula helmsii	water	PEST(A2)		EPPO
Crassula lycopodioides	x		NAT	Bacchetta et al_2009
Cuscuta spp.	?	OTHER		EPPO
Cyperus difformis	x		NAT	Celesti-Grapow et al_2009
Cyperus eragrostis	x		NAT	Celesti-Grapow et al_2009
Cyperus esculentus	water	INVASIVE		EPPO
Delairea odorata	x	INVASIVE		EPPO
Drosanthemum floribundum	x		INV	Bacchetta et al_2009
Egeria densa	water	INVASIVE		EPPO
Eichhornia crassipes	water	PEST(A2)		EPPO
Elodea nuttallii	water	INVASIVE		EPPO
Eragrostis curvula	water	OBSERVATION		EPPO
Erigeron bonariensis	x		INV	Celesti-Grapow et al_2009
Erigeron canadensis	x		INV	Celesti-Grapow et al_2009
Eriocephalus africanus	x		CAS	Bacchetta et al_2009
Eriochloa villosa	water	OBSERVATION		EPPO
Eucalyptus camaldulensis	x		CAS	Celesti-Grapow et al_2009
Euonymus japonicus	x		CAS	Celesti-Grapow et al_2009
Fallopia baldschuanica		INVASIVE		EPPO
Fallopia japonica		INVASIVE		EPPO
Fallopia sachalinensis		INVASIVE		EPPO
Fallopia x bohemica		INVASIVE		EPPO
Gazania linearis	x		NAT	Celesti-Grapow et al_2009
Glinus lotoides	x		NAT	Celesti-Grapow et al_2009
Guizotia abyssinica	x		CAS	Celesti-Grapow et al_2009
Gunnera tinctoria	water	ALERT		EPPO
Gymnocoronis spilanthoides	water	OBSERVATION		EPPO
Hakea sericea	x	INVASIVE		EPPO
Helianthus tuberosus	water	INVASIVE		EPPO
Heliotropium curassavicum	x		NAT	Celesti-Grapow et al_2009
Heracleum mantegazzianum		INVASIVE		EPPO

Species	COAST	EPPO-LISTS	c_SAR	SOURCE_SAR
Heracleum persicum		PEST(A2)		EPPO
Heracleum sosnowskyi		PEST(A2)		EPPO
Humulus japonicus	water	INVASIVE		EPPO
Hydrilla verticillata	water	INVASIVE		EPPO
Hydrocotyle ranunculoides	water	PEST(A2)	LOC	Celesti-Grapow et al_2009
Hygrophila polysperma	water	INVASIVE		EPPO
Impatiens glandulifera		INVASIVE		EPPO
Impatiens parviflora		OTHER		EPPO
Iva axillaris		OTHER		EPPO
Kalanchoë × houghtonii	x		CAS	PODDA et al_2012
Kochia scoparia	x		NAT	Celesti-Grapow et al_2009
Lagarosiphon major	water	INVASIVE		EPPO
Limnophila sessiliflora	water	OBSERVATION		EPPO
Ludwigia grandiflora	water	PEST(A2)		EPPO
Ludwigia peploides	water	PEST(A2)		EPPO
Lupinus polyphyllus		OBSERVATION		EPPO
Lysichiton americanus	water	OBSERVATION		EPPO
Malephora crocea	x		INV	Bacchetta et al_2009
Malephora lutea Schwantes	x		CAS	Celesti-Grapow et al_2009
Malephora uitenhagensis	x		CAS	Celesti-Grapow et al_2009
Mesembryanthemum cordifolium	x		CAS	Celesti-Grapow et al_2009
Microstegium vimineum	water	INVASIVE		EPPO
Miscanthus sinensis	water	ALERT		EPPO
Myoporum insulare	x		CAS	PODDA et al_2012
Myoporum tenuifolium	x		CAS	Celesti-Grapow et al_2009
Myriophyllum aquaticum	water	INVASIVE		EPPO
Myriophyllum heterophyllum	water	INVASIVE		EPPO
Nicotiana glauca	x		INV	Celesti-Grapow et al_2009
Opuntia ficus-indica	x		INV	Celesti-Grapow et al_2009
Opuntia puberula	x		NAT	Bacchetta et al_2009
Opuntia tomentosa	x		NAT	Bacchetta et al_2009
Oxalis pes-caprae	x	INVASIVE	INV	Celesti-Grapow et al_2009
Paraserianthes lophantha	x		NAT	Celesti-Grapow et al_2009
Parthenium hysterophorus	water	ALERT		EPPO
Paspalum dilatatum	x		NAT	Celesti-Grapow et al_2009
Paspalum distichum	water	INVASIVE	INV	Celesti-Grapow et al_2009
Paspalum vaginatum	x		NAT	Celesti-Grapow et al_2009

Species	COAST	EPPO-LISTS	c_SAR	SOURCE_SAR
Pennisetum setaceum	x	INVASIVE	NAT	Celesti-Grapow et al_2009
Pennisetum villosum	x		NAT	Celesti-Grapow et al_2009
Phalaris canariensis	x		NAT	Celesti-Grapow et al_2009
Pistia stratiotes	water	INVASIVE		EPPO
Pittosporum tobira	x		CAS	Celesti-Grapow et al_2009
Polygonum perfoliatum		PEST(A2)		EPPO
Prunus serotina		INVASIVE		EPPO
Pueraria lobata		PEST(A2)		EPPO
Rhododendron ponticum		OBSERVATION		EPPO
Rudbeckia laciniata	water	OTHER		EPPO
Ruschia tumidula	x		NAT	Celesti-Grapow et al_2009
Salvinia molesta	water	INVASIVE		EPPO
Senecio angulatus	x		CAS	Celesti-Grapow et al_2009
Senecio inaequidens	x	INVASIVE		EPPO
Sesbania punicea	x	OBSERVATION	CAS	Celesti-Grapow et al_2009
Sicyos angulatus	water	INVASIVE		EPPO
Sida spinosa		OTHER		EPPO
Solanum carolinense		OTHER		EPPO
Solanum elaeagnifolium	x	PEST(A2)	NAT	Celesti-Grapow et al_2009
Solanum rostratum		OTHER		EPPO
Solanum sisymbrifolium	x		INV	Celesti-Grapow et al_2009
Solanum triflorum		OTHER		EPPO
Solidago canadensis		INVASIVE		EPPO
Solidago gigantea		INVASIVE		EPPO
Solidago nemoralis	x	OBSERVATION		EPPO
Spirea alba	water	OTHER		EPPO
Spirea douglasii	x	OTHER		EPPO
Spirea tomentosa	x	OTHER		EPPO
Stipa neesiana	water	OBSERVATION		EPPO
Stipa tenuissima	water	OBSERVATION		EPPO
Stipa trichotoma		OBSERVATION		EPPO
Symphyotrichum squamatum	x		INV	Celesti-Grapow et al_2009
Vachellia karroo	x		NAT	Celesti-Grapow et al_2009
Verbesina encelioides		OBSERVATION		EPPO
Xanthium orientale italicum	x		NAT	Celesti-Grapow et al_2009
Yucca aloifolia	x		CAS	Celesti-Grapow et al_2009
Yucca gloriosa	x		CAS	Celesti-Grapow et al_2009

Species	COAST	EPPO-LISTS	c_SAR	SOURCE_SAR
Zantedeschia aethiopica	x		CAS	Celesti-Grapow et al_2009
Acacia dealbata	x	INVASIVE		EPPO
Acacia retinodes	x		INV	Celesti-Grapow et al_2009
Acacia saligna	x		INV	Celesti-Grapow et al_2009
Acroptilon repens		INVASIVE		EPPO
Agave americana L.	x		INV	Celesti-Grapow et al_2009
Agave attenuata	x		NAT	Celesti-Grapow et al_2009
Agave fourcroydes	x		INV	Bacchetta et al_2009
Agave ingens var. picta	x		INV	Bacchetta et al_2009
Ailanthus altissima	x	INVASIVE	INV	Celesti-Grapow et al_2009
Akebia quinata	water	OBSERVATION		EPPO
Aloe arborescens	x		CAS	Celesti-Grapow et al_2009

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