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## **Assessing the conservation status of coastal habitats under Article 17 of the EU Habitats directive**

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Manuscrit accepté

# 1 **Assessing the conservation status of coastal habitats under Article** 2 **17 of the EU Habitats directive**

## 6 **Abstract**

7 Research on the habitats protected by the European Union's Habitats Directive (HD) has increased rapidly since  
8 its adoption in 1992. However, the methods and tools used to assess their conservation status are varied. In this  
9 context, we reviewed and summarized the scientific literature related to the coastal Natura 2000 habitats to list  
10 and sort parameters used to assess and map their conservation status. We found 225 papers that specifically  
11 focused on the assessment of conservation status of coastal habitats. An analysis of the papers was conducted  
12 based on the four parameters (range, area, structure and functions, future prospects) specified in the guidelines.  
13 Results highlight knowledge gaps regarding the availability of data and methods that measure the range, area,  
14 structure and functions and trends. Most of the papers focused on coastal dunes and were located in the  
15 Mediterranean biogeographic region. Therefore, the process of assessing the conservation status of coastal  
16 habitats remains complicated to implement because methodological approaches are mainly dominated by expert  
17 statements and all the procedures of the Habitats Directive are carried out within each member country and the  
18 final assessments are often the synthesis of these partial assessments. However, the multiscale approach and the  
19 use of innovative technologies (databases, remote sensing) can be particularly relevant to develop replicable  
20 approaches and facilitate monitoring and the implementation of management measures.

21 **Keywords:** conservation status, coastal habitats, Habitats Directive, Natura 2000, European review.

## 24 **1. Introduction**

25 Coastal habitats are amongst the most threatened habitats and are subject to natural (marine and wind  
26 erosion) and anthropogenic pressures (climate change, urbanization, agriculture, tourism, etc.) (Heslenfeld et al.,  
27 2004; Jackson et al., 2011; Janssen et al., 2016). At the same time, awareness of their fragility has been  
28 heightened by regulatory protection measures and numerous studies on the geomorphological and temporal  
29 changes of coastlines, their management and development have been published (Brown and McLachlan, 2002 ;  
30 Sterr, 2008). It is critically important to find suitable monitoring methods which enable accurate information  
31 with a reasonable sampling effort. The implementation of the EU directives on the conservation of natural  
32 habitats and of wild fauna and flora (92/43/EEC) and on the conservation of wild birds (79/409/EEC) constitutes  
33 an important step towards the harmonization of nature conservation in the European Union. The aim of the  
34 Habitats Directive is to contribute towards ensuring bio-diversity through the conservation of natural habitats  
35 and of wild fauna and flora in the European territory of the Member States to which the Treaty applies and to  
36 maintain or restore in a favourable conservation status, natural habitats and species of wild fauna and flora of  
37 Community interest (Art. 2). The Birds and Habitats Directives require Member States to adopt the measures in  
38 the Directive and to actively implement them. The corresponding conservation actions focus on the "Species of  
39 Community Interest" and "Habitats of Community Interest" listed in the Annexes to the Directives. More  
40 specifically, the Habitats Directive (HD) requires Member States to monitor the conservation status of the  
41 habitats and species listed in the Directive (Art. 11) and to report periodically (Art. 17): conservation status of  
42 habitats and species must be assessed in a report every six years at the biogeographical level.

43 However, the implementation of the HD has been problematic as fundamental concepts used for reporting  
44 (Favourable reference values in particular) and the four parameters used to assess Conservation Status ("Range",  
45 "Area", "Structure and functions", "Future prospects") which are still unclear. In addition, monitoring protocols  
46 are difficult to standardise at biogeographical level due to the difference in data available between European  
47 countries and between habitats of Community interest (Evans, 2006; Maciejewski et al., 2016; Bijlsma et al.,  
48 2019). The general aims of the HD have not yet been achieved (EEA, 2015) and it is not possible to predict  
49 when, or if, they will be fully achieved. However, it is clear that the situation of habitats conserved by the  
50 Directives would be significantly worse in its absence and that the conservation status of habitats improves when  
51 targeted actions on a sufficient scale are taken (European Commission, 2016; Tucker et al 2019). Further  
52 research on monitoring and assessment of the conservation status of habitats is necessary to improve monitoring  
53 protocols and clarify the definitions of reference states and conservation status parameters (Angelini et al., 2018;  
54 Ellwanger et al., 2018). The Commission will present in 2021 a proposal to set legally binding nature  
55 conservation targets for the EU with a view to restoring degraded ecosystems, in particular, it will ask the

56 Member States to ensure that trends in conservation and ecological status of all habitats and species are not  
57 deteriorated by 2030 (in connection with art. 11 and art. 17 of the HD) (European Commission, 2020).

58 Furthermore, the difficulties in implementing the HD at the national scale have an impact on the assessment  
59 of the conservation status at the local scale (within and outside Natura 2000 sites) but also on the monitoring of  
60 habitats. Indeed, the disparity of available scientific data and the diversity of methodological approaches do not  
61 allow for the effective implementation of conservation policies by managers. Moreover, local data represent a  
62 valuable source of information for testing and improving the methodological approach (Bensettiti and  
63 Trouvilliez, 2009). In this way, a multi-scalar scientific approach would answer the need for research set out in  
64 Art. 2 of the HD on the definition of the favourable conservation status, in Art. 11 of the HD on the monitoring  
65 of the conservation status and in Art. 17 on the assessment of the conservation status.

66 In this context, we carried out a review of the scientific literature at the European level in order to answer  
67 these two research questions : Q1-"Why and due to which aspects the implementation of HD remains  
68 complicated today to assess and monitor the conservation status ?"; Q2-"what are the most relevant and objective  
69 parameters to be implemented in the protocols for assessing and monitoring the conservation status of coastal  
70 habitats ?". We aimed (i) to examine the extent to which European Union countries have built their methodology  
71 to assess and monitor conservation status of coastal habitats; (ii) to examine which parameters and categories  
72 have been taken into account to assess and monitor conservation status of coastal habitat. To achieve this, we  
73 focused our research on publications dealing with the concepts of reference state and favorable conservation  
74 status as well as the assessment of the four parameters (range, area, structure and functions, future prospects)  
75 recommended by the guidelines of all coastal habitats of Appendix 1 of the Habitats Directive (dune, cliff, salt  
76 marsh, salt steppe, estuary and lagoon). Our review discusses the development of conservation status assessment  
77 projects with the aim of improving monitoring and management protocols. This paper constitutes a state of the  
78 art based on a European synthesis of methods for assessing the conservation status of coastal habitats. Beyond  
79 this methodological aspect, this synthesis allows to better define the context in which these methodologies are  
80 implemented and to identify research perspectives on the conservation assessment of coastal habitats.

81

## 82 **2. Methods**

83 We reviewed the literature according to the analytical framework proposed by Higgins and Green (2011),  
84 which is based on a standard protocol. Our aim was to trace a history and identify the methods and tools used to  
85 assess the current conservation status of coastal habitats. We have deliberately focused on the peer-reviewed  
86 literature but have also taken into account documents in the "grey literature" at a European scale (e.g. EEA and  
87 European Commission reports). We are aware that the assessment of the conservation status of habitats at the  
88 scale of Natura 2000 sites is frequently addressed in the grey literature (technical reports or synthesis). A  
89 literature search on the conservation status of all coastal habitat was performed with the SciVerse Scopus engine,  
90 arguably the largest database of peer-reviewed research literature. We used the main keywords as "conservation  
91 status" AND "Habitats Directive" AND ["coastal vegetation" OR "coastal habitat"] OR "Natura 2000" AND  
92 "Biodiversity" AND "Habitat conservation" AND "Habitat management" AND "Habitat type"). Although these  
93 terms are only in English, we have translated them into the main European languages (Italian, Spanish, French,  
94 Portuguese and German) in order to compile as many publications as possible from the different countries. Our  
95 study focuses on coastal terrestrial habitats in Appendix I of the Habitats Directive (Tab. C.1. *in* Appendix C).  
96 and does not cover species or the habitats of associated species. It also does not take into account publications  
97 dealing with ecosystem services (Drius et al., 2019) because this concept refers to the value (monetary or non-  
98 monetary) of ecosystems. The final list of keywords contains the words most used in the literature and most  
99 representative, in order to collect the most records published on our subject of study. We conducted additional  
100 research on the assessment conservation status in different publication sources to obtain a maximum number of  
101 records. The time span of our search was 1992 – 2019 corresponding to the period since the Habitats Directive  
102 was adopted until now. Searches were carried out from March to May 2019.

103 After the elimination of duplicates, our initial search resulted in 352 records that were combined using  
104 Zotero software. To assess the accuracy of our search, we made a comparison with the first 50 records retrieved  
105 by Google Scholar. We found that we had already compiled the 50 records found on Google Scholar. We have  
106 removed from our initial data (n = 352) those that do not deal with *sensu-stricto* research (in particular comments  
107 and supplements): (20), were not relevant to the Habitats Directive (45), concern species or the habitats of  
108 associated species (31), take into account publications dealing with ecosystem services (42), addressed areas  
109 outside the EU only (37), were not obtainable in full-text format (11), or did not fulfill our inclusion parameters  
110 for other reasons (duplicate publication (1)). The total number of papers retained for our analysis was 225  
111 (Appendix A).

112 A literature review was conducted to classify these 225 references retrieved during the search, and to extract  
113 the relevant information for testing our hypotheses. In order to assess the main references, parameters and  
114 criteria of the conservation status of coastal habitats, we read the whole text and for each paper we recorded the  
115 year of publications, type of research (quantitative and/or qualitative), biogeographical regions and countries  
116 where the study was conducted and their topic within predefined categories (Appendix B). First, we carried out a  
117 general characterization of the selected publications (typology used, type of habitat studied, spatial and temporal  
118 scale, types of surveys (quadrats, transects, phytosociological and/or landscape surveys...). Next, we carried out a  
119 content analysis to identify the methods and tools used in the literature to assess the status of the four parameters  
120 used to assess Conservation Status; "Range", "Area", "Structure and functions" and "Future prospects" (Evans &  
121 Arvela 2011, Bijlsma et al. 2019). We have listed the number of records that use these keywords most frequently.  
122 We also classified the records according to their publication date. In addition, we sorted the studies according to  
123 the country and biogeographic regions where they were conducted in order to highlight geographic trends. Our  
124 research focused on specific topics among the most frequently addressed in order to detect other approaches  
125 used.

126 Descriptive statistics were used to assess the temporal trends of published papers. The proportion of records  
127 in relation to the total number of published records per year was also plotted as smoothed curves between 1992  
128 (first record retrieved since adoption of the directive) and 2019. A Multiple Correspondence Analysis (MCA)  
129 was used to ordinate the similarities between the variables derived from our Literature review (Categories and  
130 classes – Tab. B.1. in Appendix B). In order to assess which methods have been used and at what scale, a MCA  
131 was applied to the categories "Types of surveys", "Spatial scale", "Range", "Area", "Structure and functions",  
132 and "Future prospects" (Tab. B.1. in Appendix B). Secondly and in view of the diversity of criteria used in the  
133 literature to assess the conservation status of the "Structure and functions" parameter, we sought to identify the  
134 proximities between the criteria and to count the records that take into account both one or more criteria using  
135 also MCA. All statistical procedures were conducted using the open source program R version 3.2.3 (R Core  
136 Team, 2014).

137

### 138 3. Results

#### 139 3.1. Overview and trends about conservation status approaches

140 The conservation status of coastal habitats is a recent subject of study which has developed rapidly since the  
141 2000s and particularly since 2011 (Figure 1 - [A]). The assessment of the conservation status seems to have  
142 evolved with computer science and mapping advances during this decade although red listing of plant  
143 communities/habitats/biotopes developed earlier (Janssen et al., 2016). Despite the adoption of the Habitats  
144 Directive in 1992, publications on coastal habitats did not appear in any number until the early 2000s, were  
145 frequent in the early 2000s, with a rapid increase in papers on the assessment of the conservation status of  
146 coastal habitats in the mid-2010s. However, there were many papers on the directive and Natura 2000 network in  
147 the 1990's but many were very general (eg Pott, 1997). Our overview shows that, in general, records on  
148 conservation status are carried out in a monitoring context rather than assessment context (Figure 1, [B]). Indeed,  
149 most studies have a focus on defining the conservation status to help managers recommend management  
150 measures adapted to the conservation of coastal habitats. This is particularly the case for long-term multi-  
151 temporal analyses that have guided managers in planning conservation management strategies adapted to coastal  
152 dunes (Malavasi et al., 2013).

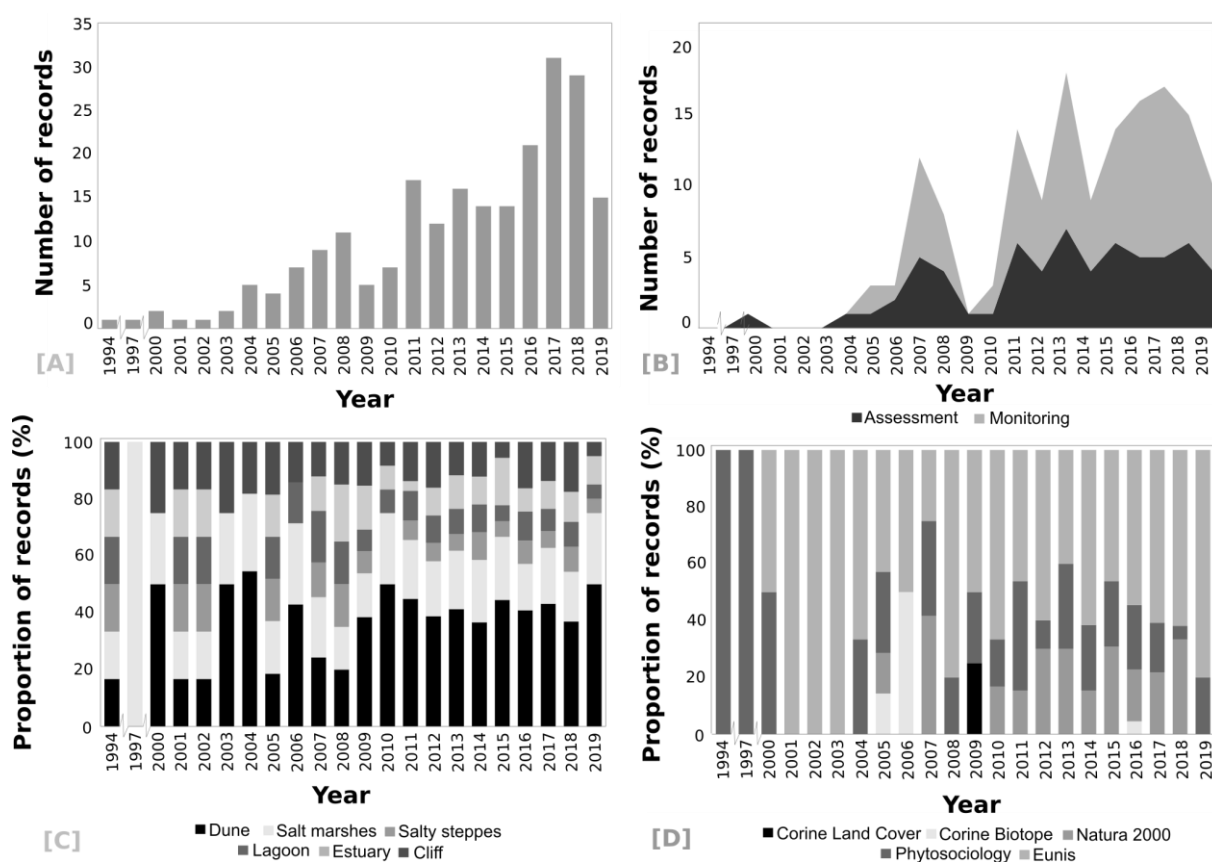
153 In general, the process of assessing the conservation status of coastal habitats remains difficult to implement  
154 for two reasons: on the one hand the methodological approach is mainly dominated by expert statements and on  
155 the other hand all the procedures of the Habitats Directive are carried out within each member country  
156 (individually) and the final assessments (at the biogeographic scale) are often the synthesis of these partial  
157 assessments. These aspects of the procedure imply disparities in the definition of the reference status, in the  
158 typologies used to describe the habitats to be assessed, and more broadly in the methods used to assess the  
159 conservation status according to coastal habitats (Bijlsma et al. 2019).

160 The fact that the EU Habitats Directive asks each country to define its reference states and its own criteria  
161 makes the standardization of protocols almost impossible: each country has its own protocols with the result that  
162 the approach differs from one country to another and by habitat type (Ellwanger et al., 2018). Definitions and  
163 concepts relating to the conservation status are still being debated in the scientific community today. There is no  
164 agreement on how to select typical species (of a habitat) (Gigante et al., 2018). This is reflected in our analyses  
165 by a small number of records published at European level (10%). Generally speaking, the assessment of the  
166 conservation status is carried out at the local level (47%) and very little at the national level (25%). In some  
167 countries, the assessment of the conservation status at the national level is carried out by aggregating local data  
168 (within and outside N2000 sites) at the biogeographic level (Angelini et al., 2018).

169 Numerous studies have been carried out to identify the components of coastal habitats using different  
 170 typologies (Phytosociological typology, CORINE biotopes, EUNIS, EUR 28) (Figure 1, [D]). Braun-  
 171 Blanquetienne sigmatist phytosociology is the most widely used method to characterize their floristic  
 172 composition and abiotic conditions for habitats (Dengler et al., 2008). However, this method remains based on  
 173 experts' statements, which raises questions about the objectivity of the methodological approach.

174 Among coastal habitats, dune systems have been the subject of the largest number of studies (Fig. C.1. *in*  
 175 Appendix C). Our analysis reveals a disparity in records between dunes and other coastal environments (eg  
 176 cliffs, shingle, marshes and salt meadows) within Atlantic and Mediterranean biogeographic regions (Fig. C.1. *in*  
 177 Appendix C). This is linked to the geomorphological context of this environment and the anthropogenic  
 178 pressures (tourism, frequentation, trampling and urbanization) that make them very vulnerable (EEA, 2009; Ley  
 179 de la Vega, 2012). In the other biogeographic regions, habitats are dealt with fairly equally. The analysis by  
 180 country shows that dunes and salt meadows remain the most studied habitats. This analysis also shows that Italy  
 181 and France are the two countries that have carried out the most studies on the assessment of the conservation  
 182 status of coastal habitats (Fig. C.2. *in* Appendix C).

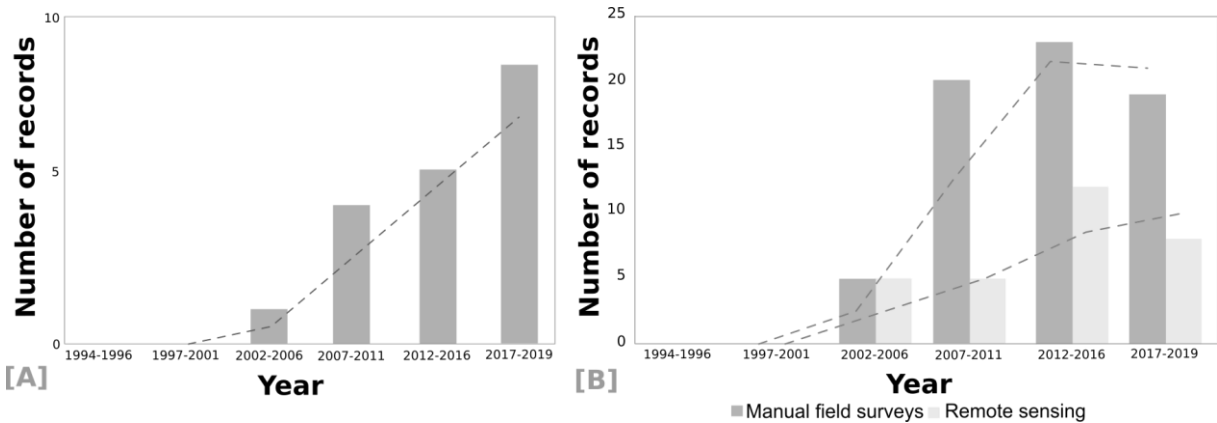
183 Even if today many techniques, such as numerical classifications or remote sensing represent relevant tools to  
 184 standardize and objectify the process of assessing the conservation status of coastal habitats, they do not yet  
 185 seem to be accepted by the procedure currently implemented.



186  
 187  
 188 **Figure 1.** Temporal trends in the number of published records: (a) number of records concerning conservation status of  
 189 coastal habitats ; (b) based on whether the studies focused on assessment of conservation status or on monitoring of  
 190 conservation status ; (c) based on coastal habitats studied ; (d) based on typologies used to describe coastal habitats. Time  
 191 frame: between 1994 (first record retrieved by our search) and 2019. The proportion of records of each classification in  
 192 relation to the total number of published records per year was represented as column plots.  
 193

194 18 records deal with the use of databases to compile data for assessing conservation status (8%). The use of  
 195 databases has really developed since 2007 (Figure 2, [A]) with the aim of providing a tool for data processing  
 196 using modern, digital methods for the phytosociological classification of vegetation. 98 records discuss mapping  
 197 by field surveys and remote sensing (43%). As in the case of databases, the use of GIS and remote sensing data  
 198 has developed strongly since 2007 (Figure 2, [B]).

199



200

201 **Figure 2.** Temporal trends in the number of published records: (a) number of records using databases to assess conservation  
 202 status of coastal habitats ; (b) based on whether the studies focused on assessment of conservation status using mapping and  
 203 remote sensing approaches. For the outcomes of the literature review, the total number of records per year class [every 4  
 204 years] for each category was represented by line plots with smoothing curves for the period between 1994 (the first record  
 205 retrieved by our search) and 2019.

### 206 3.2. Trends in assessing the conservation status of parameters

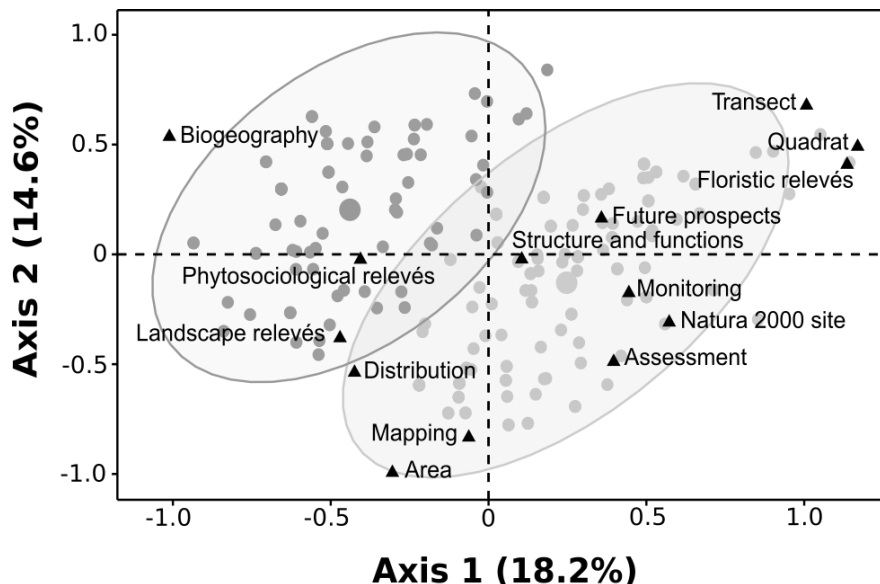
207

208 Since 2007, there has been a significant increase in the number of records on tools and methods to evaluate these  
 209 parameters (Fig. D.1. in Appendix D). 216 publications deal with the assessment of at least one of the 4  
 210 parameters defined in Art. 17 of the HD. 81 records discuss "Area," 114 records deal with "Range," 196 records  
 211 focus on "Structure and functions," and 134 discuss "Future prospects." "Structure and functions" is the parameter  
 212 with the most records since 2006 while "Future prospects" has been the subject of more publications since 2011.  
 213 On the other hand, the number of publications concerning the parameters "Range" and "Area" has shown a less  
 214 significant increase since 2010: "Range" is discussed in an average of 15 publications per year and "Area" in 6  
 215 publications per year. This result contrasts with the other two parameters which are discussed on average in 25  
 216 publications per year for "Future prospects" and 38 publications per year for "Structure and functions".

217

218 Figure 3 show the main methodological approaches and study scales are used to assess and monitor the  
 219 conservation status of coastal habitats.

220



221

222 **Figure 3.** Ordination of methodological approaches and scales used to assess the conservation status of coastal habitats.  
 223 Multiple Correspondence Analysis (MCA) of the records classified according to "Spatial Scale" [Natura 2000 site,  
 224 Biogeography], "Types of surveys" [Quadrat, Transect, Floristic relevés, Phytosociological relevés, Landscape relevés,  
 225 Mapping], "Parameters [Range, Area, Structure and functions and Future prospects] and "type of contribution" [Assessment,  
 226 Monitoring]. Time-period: 1994-2019. Number of records: 225. Values in brackets refer to the amount of variance explained  
 227 by MCA axes 1 and 2.

228 Two approaches with different characteristics are highlighted (Figure 4). Each approach corresponds to  
229 an ellipse: the first ellipse (leftmost) represents an approach at the regional scale based on phytosociological and  
230 landscape relevés; the second ellipse represents an approach at the local scale in a context of monitoring and  
231 management of coastal habitats. This second ellipse (rightmost) highlights a diversity of survey types to assess  
232 the conservation status of the four parameters: mapping is used to assess the "Range" and "Area" parameters,  
233 while quadrats, transects and floristic relevés are used to assess the "Structure and functions" and "Future  
234 prospects" criteria. Early studies focused on reflections on assessment systems and more specifically on the  
235 criteria that could be taken into account to evaluate the degree of artificialization and naturalness (e.g. Loidi,  
236 1994). Nowadays, methodological approaches are more oriented towards numerical and statistical models to  
237 assess the conservation status of coastal habitats. This is particularly the case on the Adriatic coast where  
238 mapping data and analyses of floristic and phylogenetic composition have been carried out to understand the  
239 impact of tourism on dune habitats (e.g. Šilc et al., 2019).

240 Range represents the envelope within which the areas actually occupied by a habitat type occur. The  
241 aim of this parameter is to describe and detect changes in the extent of the distribution. 114 records discuss  
242 range: 42% (48 records) focus on the biogeographic level and 58% (67 records) of them at the Natura 2000 site  
243 level. The most commonly used method for obtaining habitat range maps is geo-referenced phytosociological  
244 relevés (52% - 60 publications) followed by mapping methods (Habitat maps and remote sensing; 36% - 41  
245 records). From our research, 55% of the records (63 records) use the EUNIS typology, followed by Annex I  
246 (17.5% - 20 records) and syntaxonomic (16.6% - 19 records) typologies. Dune systems (80% - 92 records), salt  
247 meadows (61 records) and cliffs (44 records) are the coastal habitats most frequently studied. This parameter has  
248 to be assessed at the biogeographic scale (Del Vecchio et al., 2017). Our results showed that the methods for  
249 assessing the Favourable Reference Range of coastal habitats are based on two approaches: (i) an historical  
250 approach based on diachronic analysis. This approach studies the historical range of a habitat at a time when it  
251 was supposed to be in a favourable conservation status. (ii) A modeling approach based on "species range  
252 models" (SDMs). This approach allows the relationship between habitats and abiotic variables to be analyzed to  
253 predict their range where in situ data are missing.

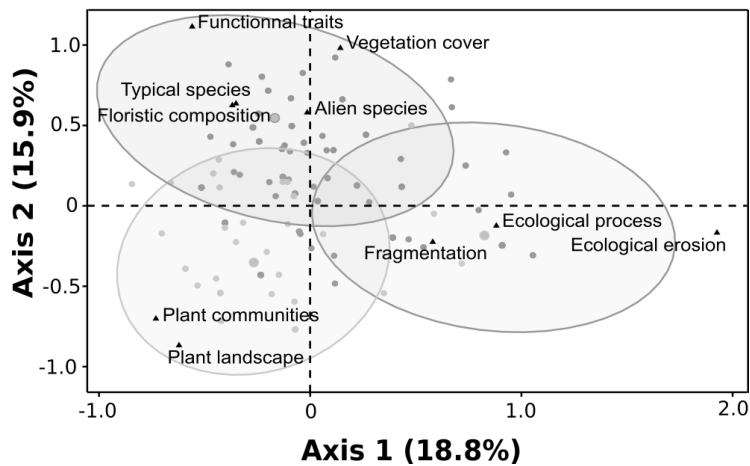
254 Area represents the occupied surface in km<sup>2</sup> of a habitat type. 81 records (36% of all selected records)  
255 discuss "Area". 33% (27 records) on the parameter at the biogeographic scale and 67% (55 records) at the Natura  
256 2000 site scale. The most commonly used method to obtain habitat area is mapping (53% - 43 publications) or  
257 by remote sensing (26% - 21 records). To monitor the changes in area over time and space, diachronic analysis  
258 are mainly used (21% - 17 publications). From our research, 48% of the records (39 records) use the EUNIS  
259 typology, followed by Natura 2000 (24.6% - 20 records) and syntaxonomic (17.3% - 14 records) typologies.  
260 Dune systems (72.8% - 59 records), salt meadows (60.5% - 49 records) and cliffs (43% - 35 records) are the  
261 coastal habitats whose distribution has most frequently been studied.

262 Structure is defined by the physiognomy of the dominant species that make up the habitat and abiotic  
263 features: Function is defined by the essential ecological processes that occur internally and may include physical  
264 processes (e.g. dune formation and erosion). This parameter is the most studied (205 records), its evaluation is  
265 carried out, essentially at the level of Natura 2000 sites (68% - 140 publications). Figure 4 shows three main  
266 approaches to assess the conservation status of the "Structure and functions" parameter: (i) the first ellipse  
267 (leftright) represents dynamic-geomorphological approach (to study ecological erosion and landscape  
268 fragmentation); (ii) the second ellipse (bottom left) concerns phytosociological scale (to identify plant  
269 communities contained in habitat and their dynamic trajectories); (iii) the third ellipse (top left) represents a  
270 species scale (to define the typical species, the presence or absence of alien species, the floristic composition or  
271 functional traits).

272

273 Two approaches with different characteristics are highlighted (Figure 4). Each approach corresponds to  
274 an ellipse: the first ellipse (leftmost) represents an approach at the regional scale based on phytosociological and  
275 landscape relevés; the second ellipse represents an approach at the local scale in a context of monitoring and  
276 management of coastal habitats.





277

278 **Figure 4.** Distribution of the criteria used to evaluate the parameter "Structure and functions". Multiple Correspondence  
 279 Analysis (MCA) of records classified according to "Plant landscape", "Plant communities composition", "Functional  
 280 traits", "Vegetation cover", "Alien species", "Floristic composition", "Typical species", "Fragmentation", "Ecological  
 281 process", "Ecological erosion". Time period: 1997-2019. Number of records: 191.

282

283 Future prospect is not defined in the Directive but it is recommended to be assessed by considering the  
 284 future trends and likely future status of the three other parameters (Range, Area, Structure and functions). 138  
 285 records (61% of all selected records) cover the parameter "Future prospects". Future prospects of each of the  
 286 three parameters (Range, Area, and Structure and functions) should mainly reflect the future trends which are  
 287 based on a comparison of pressures and conservation measures (DG Environment, 2017). However, in most of  
 288 the records in our review the method used is based on two main approaches: (1) the typology based on a list of  
 289 threats observed on studies areas and (2) diachronic analysis to define past and current trends in habitat evolution  
 290 (Valentini et al., 2015; Diez-Garretas et al., 2019).

291

#### 292 4. Discussions

293 We have reviewed the literature on aspects related to the application of the Habitats Directive in assessing  
 294 the conservation status of coastal habitats. Our aim was to identify important trends and research gaps. Our  
 295 results showed (1) an increase in the number of publications on conservation status assessment over time, mainly  
 296 from 2011 onwards; (2) a bias according to the coastal habitats studied as 80% of the publications focus on dune  
 297 systems ; (3) a strong geographical bias, most of the scientifically published research being carried out in two  
 298 biogeographical regions (Atlantic and Mediterranean) and in two countries (Italy and France); (4) that the  
 299 conservation status is based on the assessment of 4 parameters recommended by the guidelines (Range, Area,  
 300 Structure and functions, Future prospects); (5) that the definitions of these 4 parameters lack clarity and imply a  
 301 diversity of methodological approaches which are against a standardised protocol; (6) that even if there are tools  
 302 and methods (e.g. numerical classification and remote sensing) which would favour the standardisation of a  
 303 protocol, the current procedure is essentially based on expert judgements and the summaries on a  
 304 biogeographical scale are only a partial synthesis of the reality on the ground.

305

306 One of the most striking results is the lack of comparability in the definition of concepts and especially  
 307 for the definition of the reference state (Bijlsma et al. 2019). The European Commission asks each Member State  
 308 to define the reference state of habitats and the criteria used to assess the conservation status parameters. Thus,  
 309 each European country defines its own reference states, thus creating two major problems: on the one hand, the  
 310 lack of conceptual and methodological coherence between European countries, methodological transposition  
 311 problems from one country to another and a non-standardized habitat assessment on a biogeographic region at  
 312 European scale. Reference states will be unique to each country but it is necessary that the methods used to  
 313 define them are compatible.

314 In France, for example, the reference state can be defined from a "natural" or "semi-natural" state, i.e.  
 315 not disturbed by human activities, but it can also mean the best existing or achievable state in a given space  
 316 where man is considered as a whole in the ecosystem (Maciejewski et al., 2016). Given the anthropogenic  
 317 activities that have significantly altered natural environments, the definition of the reference state is delicate, a  
 318 widely applied solution is to do the opposite, i.e. define a state of degradation (Janssen et al., 2016).

319 Although Art. 17 uses the term 'Favourable Conservation Status' and it is to be used for Art 17  
 320 reporting, multi-scale and temporal monitoring of habitats is an approach that would allow us to move away

321 from the concept of a reference state and evaluate "favourable" or "unfavourable" conservation status while  
322 having an assessment of the changes taking place in the plant landscape. The development of partnerships  
323 between academics and managers will facilitate the implementation of monitoring protocols adapted to the scale  
324 of Natura 2000 sites and according to the habitats of Community interest. From these various follow-ups, it will  
325 then be possible to identify trends and changes at the biogeographic scale when the Natura 2000 network covers  
326 most of the habitat within the region being assessed. The feasibility of this approach will depend on time,  
327 available data resources (manpower, finance ...).

328  
329 The definitions of the four parameters and their methodologies remain fairly fuzzy. This lack of clarity  
330 favours the multiplication of methodological approaches that make it difficult to standardize a protocol.  
331 Moreover, the syntheses for assessing the conservation status of these four parameters at the biogeographic scale  
332 come from syntheses of data produced at local scales (sites) that differ from one habitat to another, from one  
333 country to another and from one biogeographic region to another. This synthesis is therefore a partial evaluation  
334 of the conservation status and not very representative of all the regions.

335 Many authors note the difficulty of assessing "Range" for two reasons: (i) the lack or absence of data on  
336 certain habitats (Gigante et al., 2016); (ii) the need to have survey data to assess this parameter (Prisco et al.,  
337 2012; Chytrý et al., 2016). The spatial range of habitats is generally represented by maps of plant communities at  
338 different scales. The combination of ecological modelling and remote sensing offers many advantages over field  
339 investigations and image interpretation, thus harmonizing and standardizing maps of current and potential habitat  
340 range within biogeographic regions (Álvarez-Martínez et al., 2017). Field mapping of habitats remains an  
341 expensive and time-consuming method that can only be carried out at a large scale. The other problem with the  
342 field maps currently being produced is based on the share of subjectivity in habitat delineation: each observer has  
343 his or her own vision. This observation implies the need to promote mapping methods that can be transposed and  
344 repeated from one site to another (Ichter et al., 2014). Remote sensing is increasingly used to automate habitat  
345 mapping, especially when combined with other datasets (eg geology, digital terrain models), but these  
346 techniques, which are currently being developed, are not widely used (Borre et al., 2017; Agrillo et al., 2018).  
347 This method should be more objective and repeatable than field mapping. Some authors propose to use old  
348 satellite images to establish a surface reference state (Cabello et al., 2018) and to do diachronic analysis in time  
349 and space (Valentini et al., 2015) but these approaches are carried out at coastal site scales (Tomaselli et al.,  
350 2012).

351 The definition and the assessment of Structure and functions is based on expert knowledge. At present,  
352 there is no standardised protocol for its assessment at local level and comparison at national and biogeographic  
353 levels. This standardization is difficult to achieve because each state agency uses its own criteria (Figure 5).  
354 "*Typical species*" is considered as one of the main criteria for assessing the status of Structure and functions.  
355 There is no agreement on the definition of typical species, no univocal vision of the situation currently exists but  
356 this notion is often discussed in the publications. Typical species for Art 17 reporting are those which mainly  
357 occur in a habitat type or at least in a subtype or a variant of a habitat type (European Commission, 1992; DG  
358 Environment, 2017). In this context, the concept of 'diagnostic species composition', a kind of 'reference state'  
359 (Gigante et al., 2016), becomes central. Two approaches can be distinguished to define "*Typical species*": the  
360 first is based on the definition of "faithful" or "diagnostic" species that are strictly linked to one habitat and  
361 cannot be found in another (Chytrý et al., 2002); the second is based on "*sentinel*" species which constitute a  
362 criteria of artificialization or environmental degradation (Caro, 2010). Gigante et al. (2018) propose to integrate  
363 the entire floristic pool into the assessment of the conservation status of the "Structure and function" parameter  
364 in order to have a vision that is as representative as possible of the habitat. However, DG Environment (2017)  
365 specifies that typical species indicate favourable habitat quality. Thus, by definition, typical species cannot  
366 include those that indicate degradation. On the other hand, the development of databases allows a better  
367 understanding of the structure and functioning of habitats (Chytrý et al. 2016) and facilitates the crosswalks  
368 between the different typologies (Rodwell et al. 2018).

369 Future prospects is the parameter with the most variation in approaches. In most studies, the evaluation  
370 of this parameter is based on a qualitative analysis based on a typology of threats to habitats (Pakeman et al.,  
371 2017; Bezzi et al., 2018). Several indexes have been set up to assess the vulnerability of habitats (Williams et al.,  
372 2011; Ciccarelli et al., 2017), their naturalness (Boteva et al., 2004), their resilience (Garcia-Lozano et al., 2018)  
373 or their degree of artificialisation (Pinna et al. 2015; Tsiripidis et al., 2018). Future prospects requires  
374 consideration of future trends in all three parameters: range, area, structure and functions, in relation to the  
375 current conservation status (DG Environment, 2017). This parameter should best reflect management methods in  
376 favour of the conservation of coastal habitats but also anticipate global changes (climate change, land-use  
377 scenarios and trends in certain policies) which are aspects that will influence future trends and which will  
378 involve their deterioration. The assessment of this parameter takes time and on coastal areas the time required for  
379 the survey depends on several variables such as the morphological complexity of the area, its accessibility, the  
380 complexity of the vegetation mosaic and the competence of the field operator (Del Vecchio et al., 2019). Future

381 prospects must be developed to detect the level of pressure currently exerted on the habitat but also to quickly  
382 detect potential impacts to support management measures to mitigate and treat impacts on habitats. Innovative  
383 technologies such as remote sensing could be used to assess changes in critical habitat functions related in part to  
384 species distribution. Overall, these contributions of remote sensing are of the utmost importance not only to  
385 monitor invasions, but also to mitigate, restore and improve environmental quality, adapt to their potential  
386 impacts (Simberloff et al., 2013). Moreover, the functional traits of species are increasingly being used to  
387 highlight changes and functional divergences between coastal habitats (eg embryo dunes vs fixed dunes) (Torca  
388 et al., 2019). In particular, the functional traits of typical species are studied to better understand functional  
389 characteristics (plant height, specific leaf area, leaf dry matter content, leaf size, leaf thickness, seed mass, seed  
390 shape) and the strategies adopted by plants in response to disturbances (Jiménez- Alfaro et al., 2015; Mahdavi  
391 and Bergmeier, 2016). Plot monitoring to follow changes in specific composition can be used to quantify  
392 temporal changes in species composition (Sperandii et al., 2019). Despite being challenging and time  
393 consuming, revisitation studies are highly recommended tools for analyzing temporal dynamics in plant  
394 communities (Del Vecchio et al., 2019).

395 Finally, approaches to assess the conservation status of these four parameters should draw from the Red  
396 Lists of species and habitats, particularly to assess and monitor habitat loss and fragmentation (Brooks et al.,  
397 2019) but also from Essential Biodiversity Variables, which aim to monitor ecosystems based on standardized  
398 variables (Pettorelli et al., 2016).

399  
400 Our results show that there is a real disparity in studies concerning coastal habitats. Indeed, among all  
401 coastal habitats, dunes are the most studied environments and the most taken into account in conservation status  
402 assessment studies (80% of the studies we examined concern dune systems), particularly within the Atlantic and  
403 Mediterranean biogeographical regions. Dunes are the most vulnerable habitats to human and natural pressures.  
404 In general, dunes have an essential buffer role against storms and inland habitats (McLachlan & Brown, 2006), a  
405 role that can be limited when they are disturbed (frequentation, alien species...). Thus, given the important  
406 conservation issues, numerous legislative measures have been implemented to protect them on a global scale  
407 (Heslenfeld et al., 2004). Assessment of Range and Area are the two most studied parameters for all coastal  
408 habitats. However, for the parameters Structure and function and Future prospects, disparities exist between  
409 habitat types. Indeed, the analysis of the literature shows that the trend is more towards a phase of learning and  
410 understanding the structure (physiognomy, dynamics) and functioning (ecological and anthropogenic processes)  
411 of habitats than an evaluation phase. This trend is largely explained by the recent increase (since 2012) of  
412 methodological approaches that are being implemented to improve knowledge on the different types of coastal  
413 habitats, especially on the most threatened habitats. It is on the basis of this knowledge and long-term monitoring  
414 data that it will be possible to determine the optimal state of structure and functioning of each habitat. A  
415 rebalancing of studies on all habitats (salt steppes, lagoons, cliffs, etc.) would provide an overall picture of the  
416 conservation status of all coastal habitats. Our review shows the need for interdisciplinary work: most studies  
417 focus either on ecological processes or on floristic and vegetation aspects (floristic and phytosociological  
418 approach) or on range and area aspects (spatial approach). No current studies have combined all of these aspects  
419 for the same habitat. The development of a multidisciplinary approach would make it possible to integrate all the  
420 knowledge needed to assess the conservation status of habitats in an integrated and effective way. This approach  
421 can improve preventive actions against threats to habitats that contribute to maintaining their functionality  
422 (Attorre et al., 2018; Rodwell et al., 2018).

423

## 424 5. Conclusions

425 We have reviewed and discussed the methods and tools that are used in the literature to assess the  
426 conservation status of coastal habitats in Europe. Indeed, although HD implies assessing of 4 parameters (Range,  
427 Area, Structure and functions, Future prospects) it does not require any agreed methodological approaches,  
428 which raises real difficulties for the actors who are led to assess the conservation. The procedure currently being  
429 implemented is essentially based on expert judgements and is carried out by each country. Thus, the assessment  
430 of the state of conservation at the biogeographic scale is a synthesis of these partial assessments. The application  
431 of HD currently remains very disparate from one biogeographic region to another, from one country to another  
432 and from one habitat to another. Many studies have been carried out in the Atlantic and Mediterranean regions,  
433 mainly in Italy and France, and most of them concern dune systems representing the most threatened  
434 environments. These divergences are closely linked to the lack of clear and precise definitions of the main  
435 concepts (reference status, typical species and parameters in particular) which are still debated among scientists  
436 but also to the lack of available data. Most of the methods currently used in the literature are limited by the  
437 available data, which do not currently allow a multi-scalar and spatial view of the assessment of the conservation  
438 status of coastal habitats.

439 Despite the constraints we have identified, interest in assessing the conservation status of coastal  
440 habitats has become prevalent over the past decade. There has been a significant increase in work on various  
441 types of coastal habitats (cliffs, lagoons, salt steppes, salt meadows, dunes), advancing interdisciplinary  
442 strategies for more effective protocol implementation and habitat conservation status monitoring. With regard to  
443 all the records analysed, the aims are to promote (i) recent and innovative methods for automatic and objective  
444 modelling of habitat range and area; (ii) pragmatic protocols applicable by all Natura 2000 site managers for  
445 assessing and monitoring the conservation status; and (iii) a concerted and multiscale management strategy.  
446 Measures could be taken to change this situation: for example, the use of databases would help to structure and  
447 standardise data and promote exchange between actors ; experimental monitoring investigations should be  
448 encouraged to gain a more accurate picture of changes and trends in habitats, particularly in the context of global  
449 changes.

450

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453

## 454 **Declaration of competing interest**

455 The authors declare that they have no known competing financial interests or personal relationships that could have appeared  
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## 457 **Appendix**

458 **Appendix A** – Publications included in our in-depth review (225 publications, period 1992-2019).

459 **Appendix B** – Keywords selection protocol and literature search criteria

460 **Appendix C** – Typology and distribution of the number of publications concerning coastal habitats by  
461 biogeographic region and by European countries.

462 **Appendix D** – Supplementary analysis.

463

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632 **Appendix A. Conservation status of coastal areas publications of ecological, interdisciplinary**  
633 **and other foci included in our in-depth review (225 publications, period 1992-2019).**

Authors	Title	Item Type	Source Title	Publication Year	Num Pages	Num Pages	Issue	Volume	Language
Loidi, J.	Phytosociology applied to nature conservation and land management	Journal - Article	Applied Vegetation Ecology	1994	17-30	-	-	-	en
Van Wijnen, H. J., Bakker, J. P., De Vries, Y.	Twenty years of salt marsh succession on a Dutch coastal barrier island	Journal - Article	Journal of Coastal Conservation	1997	1-9	-	1	3	en
Acosta, A., Blasi, C., & Stanisci, A.	Spatial connectivity and boundary patterns in coastal dune vegetation in the Circeo National Park, Central Italy	Journal - Article	Journal of Vegetation Science	2000	149-154	-	1	11	en
Esselink, P., Zijlstra, W., Dijkema, K. S., van Diggelen, R.	The effects of decreased management on plant-species distribution patterns in a salt marsh nature reserve in the Wadden Sea	Journal - Article	Biological Conservation	2000	61-76	-	1	93	en
Lee, M.	Coastal defence and the Habitats Directive: predictions of habitat change in England and Wales	Journal - Article	The Geographical Journal	2001	39-56	-	1	167	en
Rodwell, J S, Schaminée, J H J, Mucina, L, Pignatti, S, Dring, J, Moss, D	The diversity of European vegetation	Report	Report EC-LNV	2002	116	-	-	54	en
Ekeboom, J., Erkkilä, A.	Using aerial photography for identification of marine and coastal habitats under the EU's Habitats Directive: identifying marine and coastal habitats from aerial photographs	Journal - Article	Aquatic Conservation: Marine and Freshwater Ecosystems	2003	287-304	-	4	13	en
Paskoff, R	La conservation des dunes littorales implique-t-elle leur stabilisation ? L'exemple de la côte atlantique Coastal dune fields in Atlantic Europe: towards a dynamic conservation	Journal - Article	Nature Sciences Sociétés	2003	288-294	-	3	11	fr
Bioret, F., Glémarec, M., Géhu, J.M.	Identification des habitats côtiers de la Directive Habitats présents en France	Journal - Article	Fitosociologia	2004	43-51	-	1	41	fr
Boteva, D., Griffiths, G., Dimopoulos, P.	Evaluation and mapping of the conservation significance of habitats using GIS: an example from Crete, Greece	Journal - Article	Journal for Nature Conservation	2004	237-250	-	4	12	en
Ejrnæs, R., Bruun, H. H., Aude, E., Buchwald, E.	Developing a classifier for the Habitats Directive grassland types in Denmark using species lists for prediction	Journal - Article	Applied Vegetation Science	2004	71-80	-	1	7	en
Schmidt, K.S., Skidmore, A.K., Kloosterman, E.H., van Oosten, H., Kumar, L., Janssen, J.A.M.	Mapping Coastal Vegetation Using an Expert System and Hyperspectral Imagery	Journal - Article	Photogrammetric Engineering & Remote Sensing	2004	703-715	-	6	70	en
Stanisci, A., Acosta, A., Ercole, S., Blasi, C.	Plant communities on costal dunes in Lazio (Italy)	Journal - Article	Annali di Botanica	2004	115-128	-	-	4	en



Biondi, E., Colosi, L.	Environmental quality : An assessment based on the characters of the plant landscape.	Journal - Article	Plant Biosystems - An International Journal Dealing with all Aspects of Plant Biology	2005	145-154	-	2	139	en
Bock, M., Rossner, G., Wissen, M., Remm, K., Langanke, T., Lang, S., Klug, H., Blaschke, T., Vrščaj, B.	Spatial indicators for nature conservation from European to local scale	Journal - Article	Ecological Indicators	2005	322-338	-	4	5	en
Dimopoulos, P., Bergmeier, E., Fischer, P.	Monitoring and conservation assessment of habitat types in Greece: fundamentals and exemplary cases	Journal - Article	Annali di Botanica	2005	7-20	-	-	5	en
Penas, A., Del Río, S., Herrero, L.	A new methodology for the quantitative evaluation of the conservation status of vegetation: the potentiality distance index (PDI).	Journal - Article	Fitosociologia	2005	23-31	-	2	42	en
Acosta, A., Ercole, S., Stanisci, A., & Blasi, C.	Sandy coastal ecosystems and effects of disturbance in Central Italy	Journal - Article	Journal of Coastal Research	2006	985-989	-	39	-	en
Alonso, I, Sánchez, I, Cabrera, L, Benavides, A, Alcántara-Carrió, J, Usera, J	Decadal Evolution of a Coastal Dune Field and Adjacent Beaches at North of Fuerteventura (Canary Islands, Spain)	Journal - Article	Journal of Coastal Research	2006	198-203	-	-	39	en
Arnaud-Fassetta, G., Bertrand, F., Costa, S., Davidson, R.	The western lagoon marshes of the Ria Formosa (Southern Portugal): Sediment-vegetation dynamics, long-term to short-term changes and perspective	Journal - Article	Continental Shelf Research	2006	363-384	-	3	26	en
Dimopoulos, P., Bergmeier, E., Fischer, P.	Natura 2000 Habitat Types of Greece Evaluated in the Light of Distribution, threat and Responsibility	Journal - Article	Biology & Environment: Proceedings of the Royal Irish Academy	2006	175-187	-	3	106	en
Evans, D.	The Habitats of the European Union Habitats Directive	Journal - Article	Biology & Environment: Proceedings of the Royal Irish Academy	2006	167-173	-	3	106	en
Frederiksen, L., Kollmann, J., Vestergaard, P., Bruun, H.H.	A multivariate approach to plant community distribution in the coastal dune zonation of NW Denmark	Journal - Article	Phytocoenologia	2006	321-342	-	3	36	en
Tagliapietra, D., Ghirardini Volpi, A.	Notes on coastal lagoon typology in the light of the EU Water Framework Directive: Italy as a case study	Journal - Article	Aquatic Conservation: Marine and Freshwater Ecosystems	2006	457-467	-	5	16	en
Acosta, A., Ercole, S., Stanisci, A., Pillar, V. D. P., & Blasi, C.	Coastal vegetation zonation and dune morphology in some Mediterranean ecosystems	Journal - Article	Journal of Coastal Research	2007	1518-1524	-	-	236	en
Costa, J.C., Monteiro-Henriques, T., Neto, C., Arsénio, P., Aguiar, C.	The application of the Habitats Directive in Portugal	Journal - Article	Fitosociologia	2007	23-28	-	-	44	en
Farris, E, Pisanu, S, Secchi, Z, Bagella, S,	Gli habitat terrestri costieri e litorali della Sardegna settentrionale: verifica della loro attribuzione sintassonomica ai	Journal - Article	Fitosociologia	2007	165-180	-	1	44	it

Urbani, M., Filigheddu, R.	sensi della Direttiva 43/92/CEE “Habitat”								
Gardiner, S., Hanson, S., Nicholls, R., Zhang, Z., Jude, S., Jones, A., Richards, J., Williams, A., Spencer, T., Cope, S., Gorczyńska, M., Bradbury, A., McInnes, R., Ingleby, A., Dalton, H.	The Habitats Directive, Coastal Habitats and Climate Change – Case Studies from the South Coast of the UK	Journal - Article	Southampton, Tyndall Centre for Climate Change Research	2007	1-17	-	-	-	en
Grunewald, R., Schubert, H.	The definition of a new plant diversity index “H0 dune” for assessing human damage on coastal dunes—Derived from the Shannon index of entropy H'	Journal - Article	Ecological indicators	2007	1-21	-	1	7	en
Grunewald, R., Schubert, H.	The definition of a new plant diversity index “H'dune” for assessing human damage on coastal dunes—Derived from the Shannon index of entropy H'	Journal - Article	Ecological Indicators	2007	44197	-	1	7	en
Mehtälä, J., Vuorisalo, T.	Conservation policy and the EU Habitats Directive: favourable conservation status as a measure of conservation success	Journal - Article	European Environment	2007	363-375	-	6	17	en
Normand, S., Svenning, J. C., & Skov, F.	National and European perspectives on climate change sensitivity of the habitats directive characteristic plant species	Journal - Article	Journal for Nature Conservation	2007	41-53	-	1	15	en
Rodwell, J S, Morgan, V, Jefferson, R G, Moss, D	The Habitats Directive in the UK: some wider questions raised by the definition, notification and monitoring of grassland habitats	Journal - Article	Fitosociologia	2007	37-47	-	2	44	en
Acosta, A., Carranza, M. L., & Izzi, C. F.	Community types and alien species distribution in Italian coastal dunes	Journal - Article	Biological Invasions: From Ecology to Conservation	2008	96–104	-	-	-	en
Acosta, A., Carranza, M. L., Di Martino, L., Frattaroli, A., Izzi, C. F., & Stanisci, A.	Patterns of native and alien plant species occurrence on coastal dunes in Central Italy	Journal - Article	Plant Invasions	2008	235-248	-	-	-	en
Carranza, M.L., Acosta, A.T.R., Stanisci, A., Pirone, G., Ciaschetti, G.	Ecosystem classification for EU habitat distribution assessment in sandy coastal environments: An application in central Italy	Journal - Article	Environmental Monitoring and Assessment	2008	99-107	-	1-3	140	en
Carreño, M.F., Esteve, M.A., Martinez, J., Palazón, J.A., Pardo, M.T.	Habitat changes in coastal wetlands associated to hydrological changes in the watershed	Journal - Article	Estuarine, Coastal and Shelf Science	2008	475-483	-	3	77	en

Chust, G., Galparsoro, I., Borja, A., Franco, J., Uriarte, A.	Coastal and estuarine habitat mapping, using LIDAR height and intensity and multi-spectral imagery	Journal - Article	Estuarine, Coastal and Shelf Science	2008	633-643	-	4	78	en
Hardegen, M., Bougault, C., Quéré, E.	La cartographie des habitats dans les sites Natura 2000 de Bretagne. Application aux landes littorales de l'île de Groix et de la presqu'île de Crozon	Journal - Article	Acta Botanica Gallica	2008	153-159	-	1	155	fr
Hardegen, M., Bougault, C., Quéré, E.	La cartographie des habitats dans les sites Natura 2000 de Bretagne. Application aux landes littorales de l'île de Groix et de la presqu'île de Crozon	Journal - Article	Acta Botanica Gallica	2008	153-159	-	1	155	fr
Lengyel, S., Déri, E., Varga, Z., Horváth, R., Tóthmérész, B., Henry, P.-Y., Kobler, A., Kutnar, L., Babij, V., Seliskar, A., Christia, C., Papastergiadou, E., Gruber, B., Henle, K.,	Habitat monitoring in Europe: a description of current practices	Journal - Article	Biodiversity and Conservation	2008	3327-3339	-	14	17	en
Lengyel, S., Kobler, A., Kutnar, L., Framstad, E., Henry, P.-Y., Babij, V., Gruber, B., Schmeller, D. S., Henle, K.	A review and a framework for the integration of biodiversity monitoring at the habitat level	Journal - Article	Biodiversity and Conservation	2008	3341-3356	-	14	17	en
Stancic, Z., Brigic, A., Liber, Z., Rusak, G., Franjic, J., Skvorc, Z.	Adriatic coastal plant taxa and communities of Croatia and their threat status	Journal - Article	Acta Botanica Gallica	2008	179-199	-	2	155	en
Sterr, H.	Assessment of Vulnerability and Adaptation to Sea-Level Rise for the Coastal Zone of Germany	Journal - Article	Journal of Coastal Research	2008	380-393	-	-	-	en
Carboni, M., Carranza, M.-L., Acosta, A.	Assessing conservation status on coastal dunes: A multiscale approach	Journal - Article	Landscape and Urban Planning	2009	17-25	-	1	91	en
Gallet, S., Bioret, F., Hélou, A.	Quelles méthodes pour le suivi et l'évaluation des opérations de restauration écologique ? Exemple de la Côte Sauvage de Quiberon	Journal - Article	Ingénieries eau-agriculture-territoires	2009	73-81	-	-	-	fr
Grande, M., Chust, G., Fernandes, J A., Galparsoro, I	Assessment of the discrimination potential of bathymetric LIDAR and multispectral imagery for intertidal and subtidal habitats	Journal - Article	European Master of Science in Marine Environment and Resources	2009	-	5	-	-	en
Kontula, T., Raunio, A.	New method and criteria for national assessments of threatened habitat types	Journal - Article	Biodiversity and Conservation	2009	3861-3876	-	14	18	en
Mücher, C.A., Hennekens, S.M., Bunce, G.H., Schaminée, J.H.J., Schaeapman, M.E.	Modelling the spatial distribution of Natura 2000 habitats across Europe	Journal - Article	Landscape and Urban Planning	2009	148-159	-	2	92	en

Carranza, M.-L., Carboni, M., Feola, S., Acosta, A.	Landscape-scale patterns of alien plant species on coastal dunes: the case of iceplant in central Italy	Journal - Article	Applied Vegetation Science	2010	135-145	-	2	13	en
Cutini, M., Agostinelli, E., Acosta, T.R.A., Molina, J.A.	Coastal salt- marsh zonation in Tyrrhenian central Italy and its relationship with other Mediterranean wetlands	Journal - Article	Plant Biosystems - An International Journal Dealing with all Aspects of Plant Biology	2010	43770	-	1	144	en
Gutierrez, F., Portela-Pereira, E., Martins, M., Neto, C., Costa, J. C.	Cartografia e Interpretação de Habitats (Rede Natura 2000). Dois Exemplos no Portugal Mediterrânico	Journal - Article	<i>Actas do XII Colóquio Ibérico de Geografia. Porto: Faculdade de Letras (Universidade do Porto).</i>	2010	1-24	-	-	-	po
Isermann, M., Koehler, H., Mühl, M.	Interactive effects of rabbit grazing and environmental factors on plant species-richness on dunes of Norderney	Journal - Article	Journal of Coastal Conservation	2010	103-114	-	2	14	en
Mclaughlin, Suzanne, Cooper, J. Andrew G.	A multi-scale coastal vulnerability index: A tool for coastal managers?	Journal - Article	Environmental Hazards	2010	233-248	-	3	9	en
Plus, M., Dalloyau, S., Trut, G., Auby, A., de Montaudouin, X., Eric, E., Noël, C., Viala, C.	Long-term evolution (1988–2008) of <i>Zostera</i> spp. meadows in Arcachon Bay (Bay of Biscay)	Journal - Article	Estuarine, Coastal and Shelf Science	2010	357-366	-	2	87	en
Sipkova, Z., Balzer, S., Evans, D., Ssymank, A.	Assessing the conservation status of European Union habitats—results of the Community Report with a case study of the German National Report.	Journal - Article	Annali di Botanica	2010	1-19	-	-	-	en
Bioret, F., Lazare, J.-J. & Géhu J.-M.	Évaluation patrimoniale et vulnérabilité des associations végétales du littoral atlantique français	Journal - Article	Journal de Botanique de la Société Botanique de France	2011	39–67.	-	-	56	fr
De Luca, E., Novelli, C., Barbato, F., Menegoni, P., Iannetta, M., Nascetti, G.	Coastal dune systems and disturbance factors: monitoring and analysis in central Italy	Journal - Article	Environmental Monitoring and Assessment	2011	437-450	-	1-4	183	en
Donat, M.P., Martínez Fort, J.	Evaluación de la vegetación en un área del litoral mediterráneo en Alicante (España).	Journal - Article	Fitosociología	2011	55-66	-	2	48	es
Evans, D., & Arvela, M.	Assessment and reporting under Article 17 of the Habitats Directive. Explanatory Notes & Guidelines for the period 2007-2012	Report	European Commission, Brussels	2011	121	-	-	-	en
Feola, S., Carranza, M. L., Schaminée, J. H. J., Janssen, J. A. M., Acosta, A. T. R.	EU habitats of interest: an insight into Atlantic and Mediterranean beach and foredunes	Journal - Article	Biodiversity and Conservation	2011	1457-1468	-	7	20	en

Galdenzi, D., Pesaresi, S., Colosi, L., Biondi, E.	Methodological aspects for the evaluation of the quality of agro-ecosystems and landscapes that give rise.	Journal - Article	Fitosociologia	2011	65-76	-	2	48	en
Goberville, E., Beaugrand, G., Sautour, B., & Tréguer, P.	Evaluation of coastal perturbations: A new mathematical procedure to detect changes in the reference state of coastal systems	Journal - Article	Ecological Indicators	2011	1290-1300	-	5	11	en
Goffé, L.	Etat de conservation des habitats d'intérêt communautaire des dunes non boisées du littoral atlantique-Méthode d'évaluation à l'échelle du site Natura 2000-	Report	SPN Rapport	2011	83	-	-	18	fr
Jackson, D.W.T., Cooper, J.A.G.	Coastal dune fields in Ireland: rapid regional response to climatic change	Journal - Article	Journal of Coastal Research	2011	293-297	-	-	-	en
Jansen, F., Ewald, J., Zerbe, S.	Ecological preferences of alien plant species in North-Eastern Germany	Journal - Article	Biological Invasions	2011	2691-2701	-	12	13	en
Louette, G., Adriaens, D., Adriaens, P., Anselin, A., Devos, K., Sannen, K., Van Landuyt, W., Paelinckx, D., Hoffmann, M.	Bridging the gap between the Natura 2000 regional conservation status and local conservation objectives	Journal - Article	Journal for Nature Conservation	2011	224-235	-	4	19	en
Miccadei, E., Mascioli, F., Piacentini, T., Ricci, F.	Geomorphological Features of Coastal Dunes along the Central Adriatic Coast (Abruzzo, Italy)	Journal - Article	Journal of Coastal Research	2011	1122-1136	-	6	27	en
Nielsen, K. E., Degn, H. J., Damgaard, C., Bruus, M., & Nygaard, B.	A Native Species with Invasive Behaviour in Coastal Dunes: Evidence for Progressing Decay and Homogenization of Habitat Types	Journal - Article	AMBIO	2011	819-823	-	7	40	en
Panitsa, M., Koutsias, N., Tsiripidis, L., Zotos, A., Dimopoulos, P.	Species-based versus habitat-based evaluation for conservation status assessment of habitat types in the East Aegean islands (Greece)	Journal - Article	Journal for Nature Conservation	2011	269-275	-	5	19	en
Provoost, S., Jones, M., Laurence M., Edmondson, S.E.	Changes in landscape and vegetation of coastal dunes in northwest Europe: a review	Journal - Article	Journal of Coastal Conservation	2011	207-226	-	1	15	en
Tortajada, S., Niquil, N., Blanchet, H., Grami, B., Montanié, H., David, V., Glé, C., Saint-Béat, B., Johnson, G.A., Marquis, E., Del Amo, Y., Dubois, S., Vincent, D., Dupuy, C., Jude, F., Hartmann, H.J., Sautour, B.	Variability of fresh- and salt-water marshes characteristics on the west coast of France: A spatio-temporal assessment	Journal - Article	Water Research	2011	4152-4168	-	14	45	en

Williams, A T, Duck, R W, Phillips, M R	Coastal dune vulnerability among selected Scottish systems	Journal - Article	Journal of Coastal Research	2011	1263-1267	-	57	-	en
Baumberger, T., Affre, L., Torre, F., Vidal, E., Dumas, P.-J., Tatoni, T.	Plant community changes as ecological indicator of seabird colonies' impacts on Mediterranean Islands	Journal - Article	Ecological Indicators	2012	76-84	-	1	15	en
Biondi, E., Burrascano, S., Casavecchia, S., Copiz, R., Del Vico, E., Galdenzi, D., Gigante, D., Lasen, C., Spampinato, G., Venanzoni, R., Zivkovic, L., Blasi, C.	Diagnosis and syntaxonomic interpretation of Annex I Habitats (Dir. 92/43/EEC) in Italy at the alliance level	Journal - Article	Plant sociology	2012	5-37	-	1	49	en
Buffa, Gabriella, Fantinato, Edy, Pizzo, Leonardo	Effects of Disturbance on Sandy Coastal Ecosystems of N-Adriatic Coasts (Italy)	bookSection	Biodiversity Enrichment in a Diverse World	2012	339-372	-	-	-	en
de la Vega, L. C., Favennec, J., Gallego-Fernández J., Pascual Vidal, C.(eds)	Conservation des dunes côtières Restauration et gestion durables en Méditerranée occidentale	Report	Union Internationale pour la Conservation de la Nature et de ses ressources	2012	-	124	-	-	fr
Debaine, F., Robin, M.	A new GIS modelling of coastal dune protection services against physical coastal hazards	Journal - Article	Ocean & Coastal Management	2012	43-54	-	-	63	en
Fenu, G., Cogoni, D., Ferrara, C., Pinna, M. S., Bacchetta, G.	Relationships between coastal sand dune properties and plant community distribution: The case of Is Arenas (Sardinia)	Journal - Article	Plant Biosystems - An International Journal Dealing with all Aspects of Plant Biology	2012	586-602	-	3	146	en
Gamito, S., Patrício, J., Neto, J. M., Marques, J. C., Teixeira, H.	The importance of habitat-type for defining the reference conditions and the ecological quality status based on benthic invertebrates: The Ria Formosa coastal lagoon (Southern Portugal) case study	Journal - Article	Ecological Indicators	2012	61-72	-	-	19	en
Prisco, I., Carboni, M., Teresa, A.T.R	VegDunes – a coastal dune vegetation database for the analysis of Italian EU habitats	Journal - Article	Biodiversity & Ecology	2012	191-200	-	-	4	en
Prisco, I., Acosta, A. T. R., Ercole, S.	An Overview of the Italian Coastal Dune Eu Habitats	Journal - Article	Annali di Botanica	2012	39-48	-	-	2	en
Sancho, F.E., Freire, P., &	Coastal dunes vulnerability indexes: a new proposal and	Journal - Article	Coastal engineering	2012	12	-	-	-	en

Oliveira, F.S.B.F.	application to Ria Formosa coast (Portugal).								
Schmeller, D., Maier, A., Evans, D., Henle, K.	National responsibilities for conserving habitats – a freely scalable method	Journal - Article	Nature Conservation	2012	21-44	-	-	3	en
Tomaselli, V., Tenerelli, P., Sciandrello, S.	Mapping and quantifying habitat fragmentation in small coastal areas: a case study of three protected wetlands in Apulia (Italy)	Journal - Article	Environmental Monitoring and Assessment	2012	693-713	-	2	184	en
Angiolini, C., Landi, M., Pieroni, G., Frignani, F., Finoia, M.-G., Gaggi, C.	Soil chemical features as key predictors of plant community occurrence in a Mediterranean coastal ecosystem	Journal - Article	Estuarine, Coastal and Shelf Science	2013	91-100	-	-	119	en
Attorre, F., Maggini, A., Di Traglia, M., De Sanctis, M., Vitale, M.	A methodological approach for assessing the effects of disturbance factors on the conservation status of Mediterranean coastal dune systems	Journal - Article	Applied Vegetation Science	2013	333-342	-	2	16	en
Bessa, F., Cunha, D., Gonçalves, S.C., Marques, J.C.	Sandy beach macrofaunal assemblages as indicators of anthropogenic impacts on coastal dunes	Journal - Article	Ecological Indicators	2013	196-204	-	-	30	en
Bunce, R.G.H., Bogers, M.M.B., Evans, D., Jongman, R.H.G.	Field identification of habitats directive Annex I habitats as a major European biodiversity indicator	Journal - Article	Ecological Indicators	2013	105-110	-	-	33	en
Campos, J.A., Biurrun, I., García-Mijangos, I., Loidi, J., Herrera, M.	Assessing the level of plant invasion: A multi-scale approach based on vegetation plots	Journal - Article	Plant Biosystems - An International Journal Dealing with all Aspects of Plant Biology	2013	1148-1162	-	4	147	en
Del Vecchio, S., Acosta, A., Stanisci, A.	The impact of <i>Acacia saligna</i> invasion on Italian coastal dune EC habitats	Journal - Article	Comptes Rendus Biologies	2013	364-369	-	7	336	en
Eliáš, P., Sopotlieva, D., Dítě, D., Hájková, P., Apostolova, I., Senko, D., Melečková, Z., Hájek, M.	Vegetation diversity of salt-rich grasslands in Southeast Europe	Journal - Article	Applied Vegetation Science	2013	521-537	-	3	16	en
Godet, L., Thomas, A.	Three centuries of land cover changes in the largest French Atlantic wetland provide new insights for wetland conservation	Journal - Article	Applied Geography	2013	133-139	-	-	42	en
Henle, K., Bauch, B., Auliya, M., Külvik, M., Pe'er, G., Schmeller, D. S., Framstad, E.	Priorities for biodiversity monitoring in Europe: A review of supranational policies and a novel scheme for integrative prioritization	Journal - Article	Ecological Indicators	2013	5-18	-	-	33	en
Lepareur, F., Bertrand, S., Papuga, G., & Richeux, M.	État de conservation de l'habitat 1150 «Lagunes côtières»: Méthode d'évaluation à l'échelle du site Natura 2000-Guide d'application Version 1.	Report	Service du patrimoine naturel, Muséum national d'histoire naturelle	2013	-	111	-	-	fr

Malavasi, M., Santoro, R., Cutini, M., Acosta, A.T.R., Carranza, M.L.	What has happened to coastal dunes in the last half century? A multitemporal coastal landscape analysis in Central Italy	Journal - Article	Landscape and Urban Planning	2013	54-63	-	-	119	en
Malvárez, G., Jackson, D., Navas, F., Alonso, I., Hernandez-Calvento, L.	A Conceptual Model for Dune Morphodynamics of the Corralejo Dune System, Fuerteventura, Spain.	Journal - Article	Journal of Coastal Research	2013	1539-1544	-	sp2	65	en
Martins, Mónica C., Neto, Carlos S., Costa, José C.	The meaning of mainland Portugal beaches and dunes' psammophilic plant communities: a contribution to tourism management and nature conservation	Journal - Article	Journal of Coastal Conservation	2013	279-299	-	3	17	en
Robins, N. S., Pye, K., Wallace, H.	Dynamic coastal dune spit: the impact of morphological change on dune slacks at Whiteford Burrows, South Wales, UK	Journal - Article	Journal of Coastal Conservation	2013	473-482	-	3	17	en
Rodwell, J., Janssen, J. A. M., Gubbay, S., Schaminée, J. H. J.	Red List Assessment of European Habitat Types - A feasibility study -	Report	Alterra Wageningen UR	2013	79	-	-	-	en
Ward, R. D., Burnside, N. G., Joyce, C. B., Sepp, K.	The use of medium point density LiDAR elevation data to determine plant community types in Baltic coastal wetlands	Journal - Article	Ecological Indicators	2013	96-104	-	-	33	en
Bertacchi, A., Lombardi, T.	Diachronic analysis (1954–2010) of transformations of the dune habitat in a stretch of the Northern Tyrrhenian Coast (Italy)	Journal - Article	Plant Biosystems - An International Journal Dealing with all Aspects of Plant Biology	2014	227-236	-	2	148	en
Brus, D.J., Slim, P.A., Heidema, A.H., van Dobben, H.F.	Trend monitoring of the areal extent of habitats in a subsiding coastal area by spatial probability sampling	Journal - Article	Ecological Indicators	2014	313-319	-	-	45	en
Chefaoui, R.M.	Landscape metrics as indicators of coastal morphology: A multi-scale approach	Journal - Article	Ecological Indicators	2014	139-147	-	-	45	en
Ciccarelli, D.	Mediterranean Coastal Sand Dune Vegetation: Influence of Natural and Anthropogenic Factors	Journal - Article	Environmental Management	2014	194-204	-	2	54	en
García-Madrid, A.S., Molina, J.A., Cantó, P.	Classification of habitats highlights priorities for conservation policies: The case of Spanish Mediterranean tall humid herb grasslands	Journal - Article	Journal for Nature Conservation	2014	142-156	-	2	22	en



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Hladik C. & Alber M.	Classification of salt marsh vegetation using edaphic and remote sensing-derived variables	Journal - Article	Estuarine, Coastal and Shelf Science	2014	47-57	-	-	141	en
Janssen, J.A.M., Weeda, E. J., Schippers, P., Bijlsma, R. J., Schaminée, J. H. J., Arts, G. H. P., Deerenberg C., Jak, R.G.	Habitattypen in Natura 2000-gebieden	Report	Wot-technical report 8	2014	-	199	-	-	en
Pintó, J., Martí, C., Fraguell, R.M.	Assessing Current Conditions of Coastal Dune Systems of Mediterranean Developed Shores	Journal - Article	Journal of Coastal Research	2014	832-842	-	4	30	en
Pye, K., Blott, S.J., Howe, M.A.	Coastal dune stabilization in Wales and requirements for rejuvenation	Journal - Article	Journal of Coastal Conservation	2014	27-54	-	1	18	en
Rapinel, S., Clément, B., Magnanon, S., Sellin, V., Hubert-Moy, L.	Identification and mapping of natural vegetation on a coastal site using a Worldview-2 satellite image	Journal - Article	Journal of Environmental Management	2014	236-246	-	-	144	en
Ruocco, M., Bertoni, D., Sarti, G., Ciccarelli, D.	Mediterranean coastal dune systems: Which abiotic factors have the most influence on plant communities?	Journal - Article	Estuarine, Coastal and Shelf Science	2014	213-222	-	-	149	en
Ssymank A., Ellwanger G., Ihl A. & Carsten Burggraf C.	Krite Öffentlichkeitsbeteiligung und -information beim Management des Schutzgebietsnetzes Natura 2000	Journal - Article	Natur und Landschaft	2014	264-270	-	6	89	de
Stanisci, A., Acosta, A. T. R., Carranza, M. L., De Chiro, M., Del Vecchio, S., Di Martino, L., Frattaroli A.R., Fusco S., Izzi C.F., Pirone G., Prisco, I.	EU habitats monitoring along the coastal dunes of the LTER sites of Abruzzo and Molise (Italy)	Journal - Article	Plant Sociology	2014	51-56	-	1	51	en
Ondiviela B., Recio M., Juanes J.A.	A management approach for the ecological integrity of NE Atlantic estuaries	Journal - Article	Ecological Indicators	2015	-	-	-	-	-
Bio, A., Bastos, L., Granja, H., Pinho, J.L.S., Gonçalves, J.A., Henriques, R., Madeira, S., Magalhães, A., Rodrigues, D.	Methods for coastal monitoring and erosion risk assessment: two Portuguese case studies	Journal - Article	Revista de Gestão Costeira Integrada	2015	47-63	-	-	15	en
Del Vecchio, S., Prisco, I., Acosta, A.T.R., Stanisci, A.	Changes in plant species composition of coastal dune habitats over a 20-year period	Journal - Article	AoB Plants	2015	1-10	-	-	7	en
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Gutierrez, F., Gabriel, L., Emidio, A., Mendes, P., Neto, C., Reis, E.	Modelling the Potential natural vegetation in the Loures Municipality (Lisbon Metropolitan Area)	Journal - Article	Finisterra-Revista Portuguesa de Geografia	2015	31-62	-	99	50	en
Jiménez-Alfaro, B., Marcenò, C., Guarino, R., Chytrý, M.	Regional metacommunities in two coastal systems: spatial structure and drivers of plant assemblages	Journal - Article	Journal of Biogeography	2015	452-462	-	3	42	en
Klemas, V.V.	Coastal and Environmental Remote Sensing from Unmanned Aerial Vehicles: An Overview	Journal - Article	Journal of Coastal Research	2015	1260-1267	-	5	31	en
Meyer, S., Bergmeier, E., Becker, T., Wesche, K., Krause, B., Leuschner, C.	Detecting long-term losses at the plant community level - arable fields in Germany revisited	Journal - Article	Applied Vegetation Science	2015	432-442	-	3	18	en
Ondiviela, B., Recio, M., Juanes, J.A.	A management approach for the ecological integrity of NE Atlantic estuaries	Journal - Article	Ecological Indicators	2015	105-115	-	-	52	en
Pinna, M. S., Canadas, E. M., Fenu, G., & Bacchetta, G.	The European Juniperus habitat in the Sardinian coastal dunes: Implication for conservation	Journal - Article	Estuarine, Coastal and Shelf Science	2015	214-220	-	-	164	en
Pinna, M. S., Cogoni, D., Fenu, G., & Bacchetta, G.	The conservation status and anthropogenic impacts assessments of Mediterranean coastal dunes	Journal - Article	Estuarine, Coastal and Shelf Science	2015	25-31	-	-	167	en
Sciandrello, S., Tomaselli, G., Minissale, P.	The role of natural vegetation in the analysis of the spatio-temporal changes of coastal dune system: a case study in Sicily	Journal - Article	Journal of Coastal Conservation	2015	199-212	-	2	19	en
Valentini, E., Taramelli, A., Filipponi, F., Giulio, S.	An effective procedure for EUNIS and Natura 2000 habitat type mapping in estuarine ecosystems integrating ecological knowledge and remote sensing analysis	Journal - Article	Ocean & Coastal Management	2015	52-64	-	-	108	en
Zlinszky, A., Deák, B., Kania, A., Schroiff, A., & Pfeifer, N.	Mapping Natura 2000 habitat conservation status in a pannonic salt steppe with airborne laser scanning.	Journal - Article	Remote Sensing	2015	2991-3019	-	7	3	en

Adamo, M., Tarantino, C., Tomaselli, V., Veronico, G., Nagendra, H., & Blonda, P.	Habitat mapping of coastal wetlands using expert knowledge and Earth observation data	Journal - Article	Journal of Applied Ecology	2016	1521-1532	-	5	53	en
Asensi, A., Díez-Garretas, B., Pereña, J.	Alien plants of coastal dune habitats in southern Spain	Journal - Article	Plant Biosystems - An International Journal Dealing with all Aspects of Plant Biology	2016	477-483	-	3	150	en
Bazzichetto, M., Malavasi, M., Acosta, A.T.R., Carranza, M.L.	How does dune morphology shape coastal EC habitats occurrence? A remote sensing approach using airborne LiDAR on the Mediterranean coast	Journal - Article	Ecological Indicators	2016	618-626	-	-	71	en
Bilkovic, D.M., Mitchell, M., Mason, P. & Duhring, K.,	The Role of Living Shorelines as Estuarine Habitat Conservation Strategies	Journal - Article	Coastal Management	2016	161-174	-	-	44	en
Del Vecchio, S., Slaviero, A., Fantinato, E., Buffa, G.	The use of plant community attributes to detect habitat quality in coastal environments	Journal - Article	AoB Plants	2016	1-14	-	-	8	en
Demartini, C.	Les végétations des cotes Manche-Atlantique francaises :essai de typologie et de cartographie dynamico-catenales	Thesis	Thesis / Doctorat thesis. Brest.	2016	-	671	-	-	fr
Duarte, I., Rego, F.C., Casquilho, J.P., Arsénio, P.	A Relevance Index for the habitat areas of Natura 2000 Network based on their Rarity and Representativeness	Journal - Article	Ecological Indicators	2016	202-213	-	-	61	en
European Commission, Directorate-General for the Environment	Mapping and assessment of ecosystems and their services mapping and assessing the condition of Europe's ecosystems: progress and challenges : 3rd report - final, March 2016.	book	European Union, 2016	2016	-	179	-	-	en
Gigante, D., Foggi, B., Venanzoni, R., Viciani, D., & Buffa, G.	Habitats on the grid: The spatial dimension does matter for red-listing	Journal - Article	Journal for Nature Conservation	2016	1-9	-	-	32	en
Gutierrez, F., Teodoro, A. C., Reis, E., Neto, C., Costa, J. C.	Remote Sensing Technologies for the Assessment of Marine and Coastal Ecosystems	Journal - Article	Mapping along Continental Shelves	2016	69-104	-	-	13	en
Hulisz, P., Piernik, A., Mantilla-Contreras, J., Elvisto, T.	Main Driving Factors for Seacoast Vegetation in the Southern and Eastern Baltic	Journal - Article	Wetlands	2016	909-919	-	5	36	en
Jasprica, N., Milović, M., Kovačić, S., Stamenković, V.	Phytocoenotic diversity of the NE-Adriatic island of Olib	Journal - Article	Plant Sociology	2016	53-78	-	1	53	en

Maciejewski, L., Lepareur, F., Viry, D., Bensettiti, F., Puissauve, R., Touroult, J.	État de conservation des habitats: propositions de définitions et de concepts pour l'évaluation à l'échelle d'un site Natura 2000.	Journal - Article	Revue d'écologie	2016	3-20	-	1	71	fr
Mahdavi, P., Bergmeier, E.	Plant functional traits and diversity in sand dune ecosystems across different biogeographic regions	Journal - Article	Acta Oecologica	2016	37-45	-	-	74	en
Malavasi, M., Santoro, R., Cutini, M., Acosta, A.T.R., Carranza, M.L.	The impact of human pressure on landscape patterns and plant species richness in Mediterranean coastal dunes	Journal - Article	Plant Biosystems - An International Journal Dealing with all Aspects of Plant Biology	2016	73-82	-	1	150	en
Marcenò, C., & Jiménez-Alfaro, B.	The Mediterranean Ammophiletea Database: a comprehensive dataset of coastal dune vegetation	Journal - Article	Phytocoenologia	2016	2-11	-	-	-	en
Prisco, I., Stanisci, A., Acosta, A.T.R	Mediterranean dunes on the go: Evidence from a short term study on coastal herbaceous vegetation	Journal - Article	Estuarine, Coastal and Shelf Science	2016	40-46	-	-	182	en
Prisco, Irene, Carboni, Marta, Jucker, Tommaso, Acosta, Alicia T.R.	Temporal changes in the vegetation of Italian coastal dunes: identifying winners and losers through the lens of functional traits	Journal - Article	Journal of Applied Ecology	2016	1533-1542	-	5	53	en
Šilc, U., Mullaj, A., Alegro, A., Ibraliu, A., Dajić Stevanović, Z., Luković, M., Stešević, D.	Sand dune vegetation along the eastern Adriatic coast.	Journal - Article	Phytocoenologia	2016	339-355	-	4	46	en
Viciani, D., Dell'Olmo, L., Ferretti, G., Lazzaro, L., Lastrucci, L., Foggi, B.	Detailed Natura 2000 and CORINE Biotopes habitat maps of the island of Elba (Tuscan Archipelago, Italy)	Journal - Article	Journal of Maps	2016	492-502	-	3	12	en
Zhao, Q., Bai, J., Huang, L., Gu, B., Lu, Q., & Gao, Z.	A review of methodologies and success indicators for coastal wetland restoration	Journal - Article	Ecological Indicators	2016	442-452	-	-	60	en
Almeida, D., Neto, C., & Costa, J. C.	Active or passive recovery? Discussing implications of vegetation diversity in unmanaged salt marshes	Journal - Article	Estuarine, Coastal and Shelf Science	2017	201-208	-	-	191	en
Borre, J. V., Spanhove, T., Haest, B.	Towards a Mature Age of Remote Sensing for Natura 2000 Habitat Conservation: Poor Method Transferability as a Prime Obstacle	bookSection	The Roles of Remote Sensing in Nature Conservation	2017	11-37	-	-	-	en

Brady, A.F. & Boda, C.S.	How do we know if managed realignment for coastal habitat compensation is successful? Insights from the implementation of the EU Birds and Habitats Directive in England	Journal - Article	Ocean & Coastal Management	2017	164-174	-	-	143	en
Brownett, J., Mills, R.	The development and application of remote sensing to monitor sand dune habitats	Journal - Article	Journal of Coastal Conservation	2017	643-656	-	5	21	en
Cappucci, S., Valentini, E., Monte, M. Del, Paci, M., Filipponi, F., Taramelli, A.	Detection of Natural and Anthropogenic Features on Small Islands	Journal - Article	Journal of Coastal Research	2017	73-87	-	-	77	en
Cicarelli, D., Pinna, M.S., Alquini, F., Cogoni, D., Ruocco, M., Bacchetta, G., Sarti, G., Fenu, G.	Development of a coastal dune vulnerability index for Mediterranean ecosystems: A useful tool for coastal managers?	Journal - Article	Estuarine, Coastal and Shelf Science	2017	84-95	-	-	187	en
Delbosch, P., Bioret, F., Panaiotis, C.	Heritage assessment of vegetation series of Corsica	Journal - Article	Plant sociology	2017	3-12	-	2	54	en
DG Environment	Reporting under Article 17 of the Habitats Directive: Explanatory notes and guidelines for the period 2013–2018	Report	Report, Brussels	2017	1-188	-	-	-	en
Doxa, A., Albert, C.H., Leriche, A., Saatkamp, A.	Prioritizing conservation areas for coastal plant diversity under increasing urbanization	Journal - Article	Journal of Environmental Management	2017	425-434	-	-	201	en
Garbutt, A., de Groot, A., Smit, C., Pétillon, J.	European salt marshes: ecology and conservation in a changing world	Journal - Article	Journal of Coastal Conservation	2017	405-408	-	3	21	en
García-Ayllón S.	Diagnosis of complex coastal ecological systems: Environmental GIS analysis of a highly stressed Mediterranean lagoon through spatiotemporal indicators	Journal - Article	Ecological Indicators	2017	451-462	-	-	83	en
García-Ayllón, S.	Diagnosis of complex coastal ecological systems: Environmental GIS analysis of a highly stressed Mediterranean lagoon through spatiotemporal indicators	Journal - Article	Ecological Indicators	2017	451-462	-	-	83	en
Duhalde, M., Levrel, H., Guyader, O.	Is the choice of conservation measures influenced by the targeted natural habitats? The case of French coastal Natura 2000 sites.	book	Ocean & Coastal Management	2017	15-27	142	-	-	en
Hernández-Cordero, A.I., Hernández-Calvento, L., Espino, E.P.C.	Vegetation changes as an indicator of impact from tourist development in an arid transgressive coastal dune field	Journal - Article	Land Use Policy	2017	479-491	-	-	64	en
Jones, A. R., Schlacher, T. A., Schoeman, D. S., Weston, M. A., Withycombe, G. M.	Ecological research questions to inform policy and the management of sandy beaches	Journal - Article	Ocean & Coastal Management	2017	158-163	-	-	148	en

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Mahdavi, P., Isermann, M., Bergmeier, E.	Sand habitats across biogeographical regions at species, community and functional level	Journal - Article	Phytocoenologia	2017	139-165	-	2	47	en
Marignani, M., Bruschi, D., Astiaso Garcia, D., Frondoni, R., Carli, E., Pinna, M.S., Cumo, F., Gugliermetti, F., Saatkamp, A., Doxa, A., Queller, Emi M., Chaieb, M., Bou Dagher-Kharrat, M., El Zein, R., El Jeitani, S., Khater, C., Mansour, S., Al-Shami, A., Harik, G., Alameddine, I. el-Fadel, M., Blasi, C.	Identification and prioritization of areas with high environmental risk in Mediterranean coastal areas: A flexible approach	Journal - Article	Science of The Total Environment	2017	566-578	-	-	590	en
Mcowen, C., Weatherdon, L.n, Bochove, J.W., Sullivan, E., Blyth, S., Zockler, C., Stanwell-Smith, D., Kingston, N., Martin, C., Spalding, M., Fletcher, S.	A global map of saltmarshes	Journal - Article	Biodiversity Data Journal	2017	-	-	-	5	en
Pakeman R.J., Hewison R.L. & Lewis R.J.	Drivers of species richness and compositional change in Scottish coastal vegetation	Journal - Article	Applied Vegetation Science	2017	183-193	-	-	-	en
Pakeman, Robin J., Hewison, Richard L., Lewis, Rob J.	Drivers of species richness and compositional change in Scottish coastal vegetation	Journal - Article	Applied Vegetation Science	2017	183-193	-	2	20	en
Pellegrino, D., Schirpke, U., Marino, D.	How to support the effective management of Natura 2000 sites?	Journal - Article	Journal of Environmental Planning and Management	2017	383-398	-	3	60	en
Prisco, I., Berardi, C., Acosta, A.T.R.	Coastal dune vegetation in central Campania: an insight on the Natural Reserve "Foce Sele-Tanagro"	Journal - Article	Plant Sociology	2017	43-50	-	2	54	en
Silan, G., Del Vecchio, S., Fantinato, E., Buffa, G.	Habitat quality assessment through a multifaceted approach: the case of the habitat 2130* in Italy	Journal - Article	Plant Sociology	2017	13-22	-	2	54	en
Sperandii, M. G., Prisco, I., Stanisci, A., Acosta, A.T.R.	RanVegDunes - A random plot database of Italian coastal dunes	Journal - Article	Phytocoenologia	2017	231-232	-	2	47	en

Stesevic, D.	Distribution of alien species along sand dune plant communities zonation	Journal - Article	Periodicum Biologorum	2017	239-249	-	4	119	en
Tomaselli, V., Adamo, M., Veronico, G., Sciandrello, S., Tarantino, C., Dimopoulos, P., Medagli, P., Nagendra, H., Blonda, P.	Definition and application of expert knowledge on vegetation pattern, phenology, and seasonality for habitat mapping, as exemplified in a Mediterranean coastal site	Journal - Article	Plant Biosystems - An International Journal Dealing with all Aspects of Plant Biology	2017	887-899	-	5	151	en
Vanden Borre J., Spanhoveat. & Haestb B.	Towards a mature age of remote sensing for Natura 2000 habitat conservation: poor method transferability as a prime obstacle	Journal - Article	Springer International Publishing	2017	11-37	-	-	-	en
Veronico, G., Sciandrello, S., Medagli, P., Tomaselli, V.	Vegetation survey and plant landscape mapping of the SCI IT9140002 "Litorale Brindisino" (Puglia, Southern Italy)	Journal - Article	Plant Sociology	2017	89-106	-	1	54	en
Zhou, X.-Y., Lei, K. & Meng, W.,	An approach of habitat degradation assessment for characterization on coastal habitat conservation tendency	Journal - Article	Science of The Total Environment	2017	618–623			593–594	en
Zivkovic, L., Biondi, E., Pesaresi, S., Lasen, C., Spampinato, G., Angelini, P.	The third report on the conservation status of habitats (Directive 92/43/EEC) in Italy: processes, methodologies, results and comments	Journal - Article	Plant Sociology	2017	51-64	-	2	54	en
Agrillo E., Alessi N., Jiménez-Alfaro B., Casella L., Angelini P., Argagnon O., Crespo G., Fernandez Gonzalez F., Monteiro Henriques T., Silva Neto C., Attorre F.,	The use of large databases to characterize habitat types: the case of Quercus suber woodlands in Europe	Journal - Article	Rendiconti Lincei. Scienze Fisiche e Naturali	2018	283-293	-	2	29	en
Álvarez-Martínez, J.-M., Jiménez-Alfaro, B., Barquín, J., Ondiviela, B., Recio, M., Silió-Calzada, A., Juanes, J.-A.	Modelling the area of occupancy of habitat types with remote sensing	Journal - Article	Methods in Ecology and Evolution	2018	580-593	-	3	9	en
Angelini, P., Chiarucci, A., Nascimbene, J., Cerabolini, B.-E.-L., Fratte, M.-Dalle, Casella, L.	Plant assemblages and conservation status of habitats of Community interest (Directive 92/43/EEC): definitions and concepts	Journal - Article	Ecological Questions	2018	87-97	-	3	29	en

Angiolini, C., Bonari, G., Landi, M.	Focal plant species and soil factors in Mediterranean coastal dunes: An undisclosed liaison?	Journal - Article	Estuarine, Coastal and Shelf Science	2018	248-258	-	-	211	en
Bezzi, A., Pillon, S., Martinucci, D., Fontolan, G.	Inventory and conservation assessment for the management of coastal dunes, Veneto coasts, Italy	Journal - Article	Journal of Coastal Conservation	2018	503-518	-	-	22	en
Bonari, G., Acosta, A., Teresa R., Angiolini, C.	EU priority habitats: rethinking Mediterranean coastal pine forests	Journal - Article	Rendiconti Lincei. Scienze Fisiche e Naturali	2018	295-307	-	2	29	en
Cabello, J., Mairota, P., Alcaraz-Segura, D., Arenas-Castro, S., Escribano, P., Leitao, P.J., Martinez-Lopez, J., Regos, A., Requena-Mullor, J.M.	Satellite Remote Sensing of Ecosystem Functions: Opportunities and Challenges for Reporting Obligations of the EU Habitats Directive	conferencePaper	IGARSS 2018 - 2018 IEEE International Geoscience and Remote Sensing Symposium	2018	6604-6607	-	-	-	en
Campagnaro, T., Trentanovi, G., Sitzia, T.	Identifying Habitat Type Conservation Priorities under the Habitats Directive: Application to Two Italian Biogeographical Regions	Journal - Article	Sustainability	2018	1-20	-	4	10	en
Carli, E., Frondoni, R., Pinna, M.S., Bacchetta, G., Fenu, G., Fois, M., Marignani, M., Puddu, S., Blasi, C.	Spatially assessing plant diversity for conservation: A Mediterranean case study	Journal - Article	Journal for Nature Conservation	2018	35-43	-	-	41	en
Caro, C., Pinto, R., Marques, J. C.	Use and usefulness of open source spatial databases for the assessment and management of European coastal and marine ecosystem services	Journal - Article	Ecological Indicators	2018	41-52	-	-	95	en
Del Vecchio, S., Fantinato, E., Janssen, J.A.M., Bioret, F., Acosta, A., Prisco, I., Tzonev, R., Marcenò, C., Rodwell, J., Buffa, G.	Biogeographic variability of coastal perennial grasslands at the European scale	Journal - Article	Applied Vegetation Science	2018	312-321	-	2	21	en
Delaney, A., Stout, J.C.	Principles of cross congruence do not apply in naturally disturbed dune slack habitats: Implications for conservation monitoring	Journal - Article	Ecological Indicators	2018	358-364	-	-	93	en



Ellwanger, Götz, Runge, Stephan, Wagner, Melanie, Ackermann, Werner, Neukirchen, Melanie, Frederking, Wenke, Müller, Christina, Ssymank, Axel, Sukopp, Ulrich	Current status of habitat monitoring in the European Union according to Article 17 of the Habitats Directive, with an emphasis on habitat structure and functions and on Germany	Journal - Article	Nature Conservation	2018	57-78	-	-	29	en
Friedrichs, M., Hermoso, V., Bremerich, V., & Langhans, S. D.	Evaluation of habitat protection under the European Natura 2000 conservation network – The example for Germany	Journal - Article	PLOS ONE	2018	e0208264	-	12	13	en
Garcia-Lozano, C., Pintó, J.	Current status and future restoration of coastal dune systems on the Catalan shoreline (Spain, NW Mediterranean Sea)	Journal - Article	Journal of Coastal Conservation	2018	519-532	-	3	22	en
Gigante, D., Acosta, A. T. R., Agrillo, E., Armiraglio, S., Assini, S., Attorre, F., Bagella, S., Buffa, G., Casella, L., Giancola, C., Giusso del Galdo, G. P., Marcenò, C., Pezzi, G., Prisco, I., Venanzoni, R., Viciani, D.	Habitat conservation in Italy: the state of the art in the light of the first European Red List of Terrestrial and Freshwater Habitats	Journal - Article	Rendiconti Lincei. Scienze Fisiche e Naturali	2018	251-265	-	2	29	en
Le Mauff, B., Juigner, M., Ba, A., Robin, M., Launeau, P., Fattal, P.	Coastal monitoring solutions of the geomorphological response of beach-dune systems using multi-temporal LiDAR datasets (Vendée coast, France)	Journal - Article	Geomorphology	2018	121-140	-	-	304	en
Lengyel, S., Kosztyi, B., Schmeller, D. S., Henry, P. Y., Kotarac, M., Lin, Y. P., Henle, K.	Evaluating and benchmarking biodiversity monitoring: Metadata-based indicators for sampling design, sampling effort and data analysis	Journal - Article	Ecological Indicators	2018	624-633	-	-	85	en
Malavasi, M., Bartak, V., Carranza, M.L., Simova, P., Acosta, A.T.R.	Landscape pattern and plant biodiversity in Mediterranean coastal dune ecosystems: Do habitat loss and fragmentation really matter?	Journal - Article	Journal of Biogeography	2018	1367-1377	-	6	45	en

Marcenò, C, Guarino, R, Loidi, J, Herrera, M, Isermann, M, Knollová, I, Tichý, L, Tzonev, RT, Acosta, ATR, FitzPatrick, Ú, Iakushenko, D, Janssen, JAM, Jiménez- Alfaro, B, Kaçki, Z, Keizer- Sedláková, I, Kolomyichuk, V, Rodwell, JS, Schaminée, JHJ, Šilc, U, Chytrý M.	Classification of European and Mediterranean coastal dune vegetation	Journal - Article	Applied Vegetation Science	2018	533-559	-	3	21	en
Muñoz-Reinoso, J.C.	Doñana mobile dunes: what is the vegetation pattern telling us?	Journal - Article	Journal of Coastal Conservation	2018	605-614	-	4	22	en
Pennetta, M., Corbelli, V., Gattullo, V., Nappi, R., Brancato, V.M., Gioia, D.	Beach vulnerability assessment of a protected area of the Northern Campania coast (Southern Italy)	Journal - Article	Journal of Coastal Conservation	2018	1017-1029	-	5	22	en
Rodwell, J.S.	The UK National Vegetation Classification	Journal - Article	Phytocoenologia	2018	133-140	-	2	48	en
Sarika, M.A., Christopoulou, A.N., Zervou, S.D., Zikos, A.C.	Vegetation units of wetland and terrestrial habitats: the case study of Spercheios River and Maliakos Gulf (Sterea Ellas, Greece), a Natura 2000 Site	Journal - Article	Hacquetia	2018	189-220	-	2	17	en
Sperandii, M.G., Prisco, I., Acosta, A.T.R.	Hard times for Italian coastal dunes: insights from a diachronic analysis based on random plots	Journal - Article	Biodiversity and Conservation	2018	633-646	-	3	27	en
Tordoni, E., Napolitano, R., Maccherini, S., Da Re, D., Bacaro, G.	Ecological drivers of plant diversity patterns in remnants coastal sand dune ecosystems along the northern Adriatic coastline	Journal - Article	Ecological Research	2018	1157-1168	-	6	33	en
Tsiripidis, I., Xystrakis, F., Kallimanis, A., Panitsa, M., Dimopoulos, P.	A bottom-up approach for the conservation status assessment of structure and functions of habitat types	Journal - Article	Rendiconti Lincei. Scienze Fisiche e Naturali	2018	267-282	-	2	29	en
Viciani, D., Dell'Olmo, L., Foggi, B., Ferretti, G., Lastrucci, L., Gennai, M.	Natura 2000 habitat of Mt. Argentario promontory (southern Tuscany, Italy)	Journal - Article	Journal of Maps	2018	447-454	-	2	14	en
Wood, Claire M., Bunce, Robert G. H., Norton, Lisa R., Smart, Simon M., Barr, Colin J.	Land cover and vegetation data from an ecological survey of "key habitat" landscapes in England, 1992–1993	Journal - Article	Earth System Science Data	2018	899-918	-	2	10	en

Chefaoui, R.M., Chozas, S.	Abandonment of traditional saltworks facilitates degradation of halophytic plant communities and <i>Carpobrotus edulis</i> invasion	Journal - Article	Applied Vegetation Science	2019	444-453	-	3	22	en
Damgaard, C., Nygaard, B., Ejrnæs, R., Bruus, M., Strandberg, B., Strandberg, M., Timmermann, A., Ehlers, B.K	Has the frequency of invasive higher plants stabilized? Results from a long- term monitoring program of Danish habitats.	Journal - Article	Applied Vegetation Science	2019	292-299	-	2	22	en
Del Vecchio, S., Fantinato, E., Silan, G., & Buffa, G.	Trade-offs between sampling effort and data quality in habitat monitoring	Journal - Article	Biodiversity and conservation	2019	55-73	-	1	28	en
Díez-Garretas, B., Comino, O., Pereña, J., Asensi, A.	Spatio-temporal changes (1956-2013) of coastal ecosystems in Southern Iberian Peninsula (Spain)	Journal - Article	Mediterranean Botany	2019	111-119	-	1	40	en
Drius, M., Jones, L., Marzialetti, F., de Francesco, M. C., Stanisci, A., Carranza, M. L.	Not just a sandy beach. The multi-service value of Mediterranean coastal dunes	Journal - Article	Science of The Total Environment	2019	1139-1155	-	-	668	en
García-Romero, L., Delgado-Fernández, I., Hesp, P. A., Hernández-Calvento, L., Hernández-Cordero, A. I., Viera-Pérez, M.	Biogeomorphological processes in an arid transgressive dunefield as indicators of human impact by urbanization	Journal - Article	Science of The Total Environment	2019	73-86	-	-	650	en
Lopes, C. L., Mendes, R., Caçador, I., & Dias, J. M.	Evaluation of long-term estuarine vegetation changes through Landsat imagery	Journal - Article	Science of The Total Environment	2019	512-522	-	-	653	en
Pätsch, R., Bruchmann, I., Schellenberg, J. Meisert, A., Bergmeier, E.	<i>Elytrigia repens</i> co-occurs with glycophytes rather than characteristic halophytes in low-growing salt meadows on the southern Baltic Sea coast	Journal - Article	Biologia	2019	385-394	-	4	74	en
Pinna, M. S., Bacchetta, G., Cogoni, D., Fenu, G.	Is vegetation an indicator for evaluating the impact of tourism on the conservation status of Mediterranean coastal dunes?	Journal - Article	Science of The Total Environment	2019	255-263	-	-	674	en
Rincón, V., Velázquez, J., Gutiérrez, J., Sánchez, B., Hernando, A., García-Abril, A., Santamaría, T., Sánchez-Mata, D.	Evaluating European Conservation Areas and Proposal of New Zones of Conservation under the Habitats Directive. Application to Spanish Territories	Journal - Article	Sustainability	2019	398	-	2	11	en
Šilc, U., Stešević, D., Rozman, A., Čaković, D., Kuzmič, F.	Alien Species and the Impact on Sand Dunes Along the NE Adriatic Coast	bookSection	Impacts of Invasive Species on Coastal Environments	2019	113-143	-	-	29	en
Sperandii, M. G., Bazzichetto, M., Acosta, A. T. R., Barták, V., Malavasi, M.	Multiple drivers of plant diversity in coastal dunes: A Mediterranean experience	Journal - Article	Science of The Total Environment	2019	1435-1444	-	-	652	en

Sperandii, M. G., Bazzichetto, M., Gatti, F., & Acosta, A. T. R.	Back into the past: Resurveying random plots to track community changes in Italian coastal dunes	Journal - Article	Ecological Indicators	2019	572-578	-	-	96	en
Torca, M., Campos, J. A., & Herrera, M.	Changes in plant diversity patterns along dune zonation in south Atlantic European coasts	Journal - Article	Estuarine, Coastal and Shelf Science	2019	39-47	-	-	218	en
Torca, M., Campos, J. A., & Herrera, M.	Species composition and plant traits of south Atlantic European coastal dunes and other comparative data	Journal - Article	Data in Brief	2019	207-213	-	-	22	en

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## 637 **Appendix B - Keywords selection protocol and literature search criteria**

638 The selection of keywords was carried out according to the PICO (Population-Intervention-Comparison-Outcome)  
639 strategy, which allows for highlighting thematic groups of words and identifying records for an overview (Higgins  
640 and Green, 2011).

641  
642 An initial list of potential keywords for the components of the PICO (Population-Intervention-Comparison-  
643 Outcome) approach was developed from a list of reference articles on the topics. In our study, "Habitats Directive"  
644 was defined as "population", "conservation status" as "intervention", "methodology" as "comparison" and  
645 "management" as "outcome". From the first list of keywords, searches were made on the SciVerse Scopus  
646 database. New potential keywords identified during the literature search were added. This list of keywords was  
647 improved as the searches progressed using an iterative approach. After checking a first list of the records found,  
648 we highlighted keywords relevant to the literature search. We then checked the results of this new search and  
649 verified the inclusion or exclusion of pre-identified and new keywords. In a third step, we restarted the search from  
650 the new selection of keywords. Since the list of keywords may differ from one publication to another, we selected  
651 the most common keywords. The literature search is based on keywords and Boolean operators (AND, OR and  
652 NOT). Each keyword was inserted in a hierarchical manner, according to its relevance, and for each term added,  
653 we evaluated the relevance of the first 20 references obtained.

654  
655 Our final database contained 225 records: 208 articles, 8 reports, 6 books, 2 theses and 1 conference paper  
656 (Appendix A). For each study, we recorded a number of information such as year of publication, type of records,  
657 type of research, country and biogeographic regions (Continental, Atlantic, Boreal, Mediterranean, Black sea) in  
658 which the studies were conducted. Several studies came from several biogeographic regions and/or countries, they  
659 were also taken into account and classified. We also sorted the records according to the scale they used to assess  
660 the conservation status : (1) at the scale of the Natura 2000 site; (2) or at the biogeographic scale. We then classified  
661 the coastal habitat types recognized by the Annex I of the Habitats Directive: Cliff, dune, stuary, Lagoon, Salt  
662 marshes, Salty steppes. Some studies took into account several habitat types, they were classified in accordance.  
663 In order to meet our two research objectives, we analyzed the content of the records selected to identify the most  
664 frequent words used in the record summaries (Tab. 1).

665 In order to examine the extent to which European countries have built their methodology to assess and monitor  
666 conservation status of coastal habitat, we have classified the typologies used to describe habitats: (1) CORINE  
667 biotope which is a catalog of identifiable biotopes, biotopes formed by flora and fauna in connection with a certain  
668 abiotic environment, with relationships between these various elements; (2) EUNIS which is a classification of  
669 natural, semi-natural and anthropogenic habitats of terrestrial and marine areas of Europe; (3) Natura 2000, i.e. the  
670 list of habitats of Community interest listed in Annex 1 of the Habitats Directive; (4) Phytosociology, i.e. the  
671 typology of syntaxons or taxonomic units of indeterminate rank (association, alliance, order, class and their sub-  
672 units); (5) Corine Land Cover corresponding to a biophysical inventory of land use and its evolution. Several  
673 studies were based on different typologies and were classified accordingly.

674 The types of methods were also recorded for each publication, either quantitative or qualitative and analytical  
675 methods. Some studies used both approaches and were classified accordingly. We also classified the types of  
676 surveys to determine the field methods used: (1) mapping (field mapping and remote sensing); (2) floristic surveys;  
677 (3) Phytosociological surveys; (4) Landscape surveys; (5) Transect; (6) Quadrat. Some studies were based on  
678 several types of surveys and were classified accordingly. Finally, we recorded the context in which the study was  
679 conducted: (1) assessment; (2) monitoring.

680  
681 Our second aim was to examine what parameters and categories have been taking into account by european  
682 countries to assess and monitor conservation status of coastal habitat. To address this issue we classified the records  
683 according to whether they dealt with the parameters recommended by the Habitats Directive (range, area, structure  
684 and functions, future prospects). For the parameter Structure and functions, we classified the criteria as follows:  
685 (1) Ecological erosion/ecological process; (2) Landscape fragmentation/plant landscape; (3) Plant communities  
686 composition; (4) Typical species; (5) Floristic composition; (6) Alien species; (7) Vegetation cover; (9) Functional  
687 traits. Some studies took into account several criteria and were also categorized consequently.

688 Finally, for the Future prospects parameter, we have classified the approaches as follows: (1) Typology, which  
689 consists of a list of threats observed in the field or that would be likely to alter the habitat in the long term; (2)  
690 Indexes used to quantify anthropogenic impacts; (3) Diachronic analyses to identify dynamic habitat trends; (5)  
691 Human pressures, which consists of identifying threats that are solely anthropogenic in origin; (7) Vulnerability is  
692 the assessment of the long-term vulnerability of the habitat; (8) Naturalness is the assessment of the naturalness of  
693 the habitat; (9) Artificialisation is the quantitative and qualitative assessment of the anthropogenic impacts of the  
694 habitat. Some studies have considered several criteria and have been categorized consequently.

695

696 We also sorted our records according to the PICO (Population-Intervention-Comparator-Outcome) components.  
697 Our target population included records that focused on all applications of the Habitats Directive in assessing the  
698 conservation status and monitoring of habitats. In 1992, the European Union adopted the European Habitats  
699 Directive (92/43/EEC) recognizing the importance of habitat types and species to be conserved. A set of habitats  
700 that require specific conservation measures by Member States is listed in Annex I of the Directive. The list of  
701 habitats was compiled by experts who selected habitat types whose main concern is conservation under the  
702 European CORINE Biotopes Programme, recently reclassified in the EUNIS classification (Davies et al. 2004).  
703 The intervention component focused on the assessment of conservation status, defined as the assessment of the  
704 floristic, faunistic and functional state of the habitats defined in Annex 1 of the Habitats Directive (Evans and  
705 Arvela 2011). The Habitats Directive has defined 4 parameters to assess the conservation status of a typical habitat:  
706 range, area, structures and functions, future prospects. The "comparison" part focused on the methodologies used  
707 to evaluate the 4 parameters mentioned above. The "results" component focused on habitat management,  
708 assessment and monitoring.

709  
710 We took into account records written in English, French, Spanish or Portuguese (when English keywords were at  
711 least mentioned in the title of the notice).

712  
713

#### 714 **References**

- 715  
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719 Guidelines for the period 2007-2012. European Commission, Brussels.  
720 Higgins, J.P., Green, S. (Eds.), 2011. *Cochrane handbook for systematic reviews of interventions* (Vol. 4). John Wiley & Sons.  
721

**Table 1. Aim of the study, hypotheses, with respective categories and subcategories, and classes used in the literature review.**

Hypotheses	Categories	Description	Sub-categories	Aim	
<b>Aim 1. to examine the extent to which european countries have build their methodology to assess and monitor conservation status of coastal habitat</b>					
<b>H1 - Typologies to define "habitat" are diversified</b>	<b>Typology</b>	Accuracy of the "habitat" (sensu biotope, sensu floristico-ecological)	-	To track down what typologies are used to describe habitat types	CORINE Biotope, EUNIS, EUR 28, Phytosociology, CORINE LAND COVER
<b>H2- The whole of coastal habitats are studied</b>	<b>Type of coastal habitat</b>	Type of coastal habitats studied	-	To track down what habitat types are studied	Cliff, Dune, Estuary, Salt marshes, Salty steppes, Lagoon
<b>H3 - Conservation status are assessed at different scales</b>	<b>Biogeographical region</b>	Biogeographical scale of the study	-	To track down what biogeographical regions are concerned by studies on conservation status of costal habitats	Alpine, Continental, Atlantic, Boreal, Mediterranean, Black sea
	<b>Spatial scale</b>	Accuracy scale in assessing the conservation status criteria	-	To track down what scales are used to assess and monitor conservation status	Natura 2000 site, Biogeography
<b>H4 - Types of methods and criterias used to assess conservation status are not standardized</b>	<b>Type of research</b>	Type of contributions	-	To track down what are the type of research that authors used to assess conservation status	Quantitative study, Qualitative and analytical approach
	<b>Types of surveys</b>	Methods used to evaluate criterias	-	To track down what are the methods and tools that authors used to assess conservation status	Mapping, Floristic relevés, Phytosociological relevés, Landscape relevés, Transect, Quadrat
	<b>Conservation status</b>	Type of contributions	-	To track down the purpose for which the authors assessed the conservation status	Assessment, Monitoring
<b>Aim 2. to examine what parameters and categories have been taking into account by european countries to assess and monitor conservation status of coastal habitat</b>					
<b>H5 - The research geographically (per european coutries) and methodologically changed along time</b>	<b>Range</b>	Range of habitat within its biogeographical area	-	To track down how assess the current and potential distribution of habitats within their biogeographic region	
	<b>Area</b>	Habitat area (in ha)	-	To track down how map areas of habitats	
<b>H5 - The research geographically (per european coutries) and methodologically changed along time</b>	<b>Structure and fonctions</b>	Structure corresponds to the physical organization, the arrangement of the elements within the habitat, its biotic characteristics, its environment (soil, geomorphology, macro and micro-climate, etc.).	Ecological system	To track down hiw assess the changes of ecological process , landscape, vegetation and Flora	Ecological erosion, ecological processus
			Landscape		Landscape fragmentation Plant landscape
			Vegetation and syntaxon		Plant communitis composition
			Flora		Typical species Floristic composition

The function corresponds to the intrinsic functioning of the habitat, i.e. all the biological actions and processes that occur naturally in the habitat and result from the interaction between all these compartments: exchanges.

Alien species  
Vegetation cover

Functionnal traits

<b>Prospective trends</b>	Prospective trends include criteria and indicators to assess the long-term viability of a habitat	Methods	To track down how authors have been targeting methods, threats types and environment quality	Typology
		Threats types		Index
		Environmental quality		Diachronic analysis
				Human pressures
				Natural pressures
				Vulnerability
				Naturalness
				Artificialization

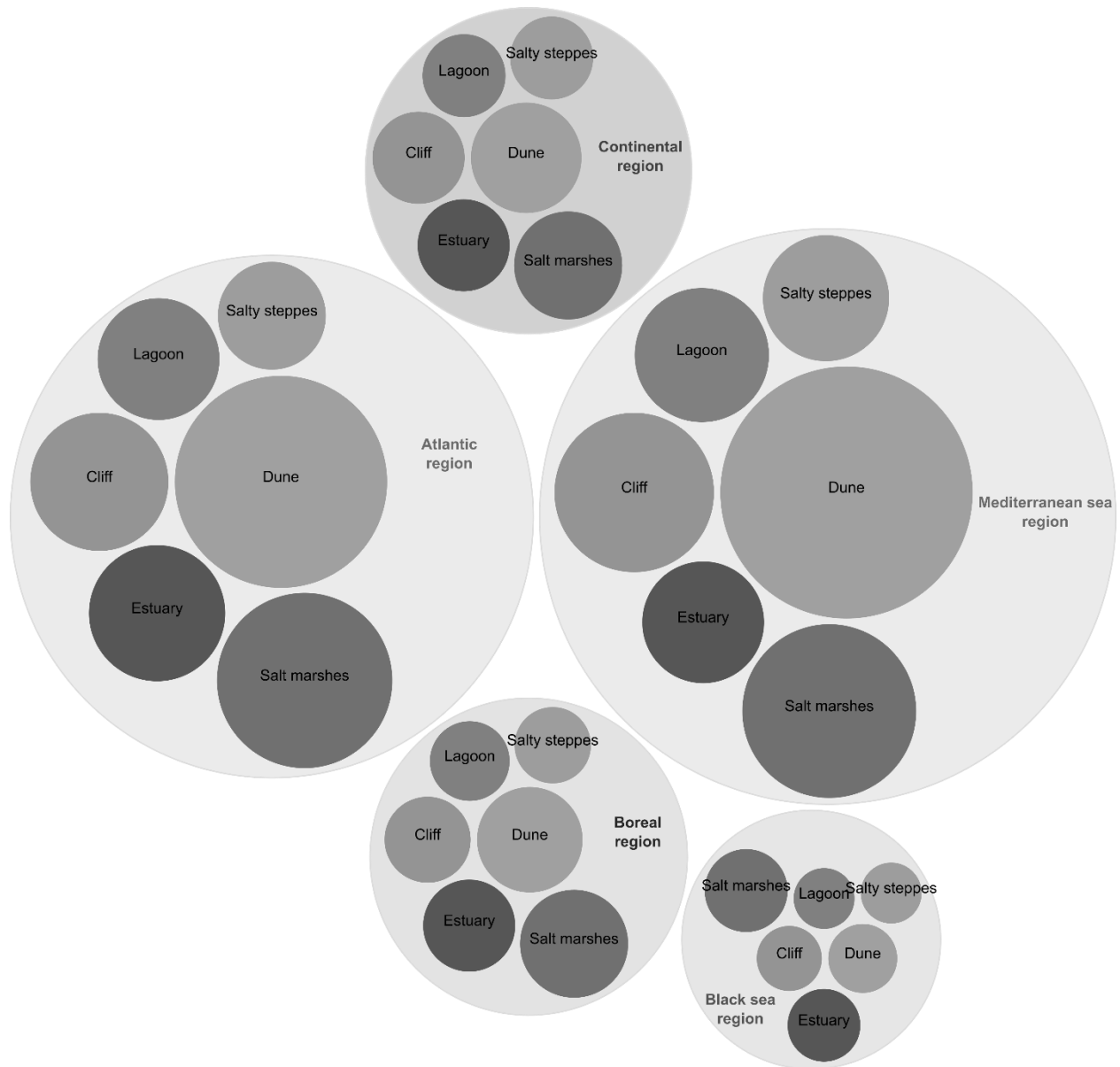


**Appendix C. Typology and distribution of the number of publications concerning coastal habitats by biogeographic region and by European countries.**

**Table. C.1. List of coastal habitats that are considered in the records reviewed in this paper. According to the habitats of the European Environment Agency (2019), all coastal habitats have been studied. They have been grouped by major types of coastal habitats.**

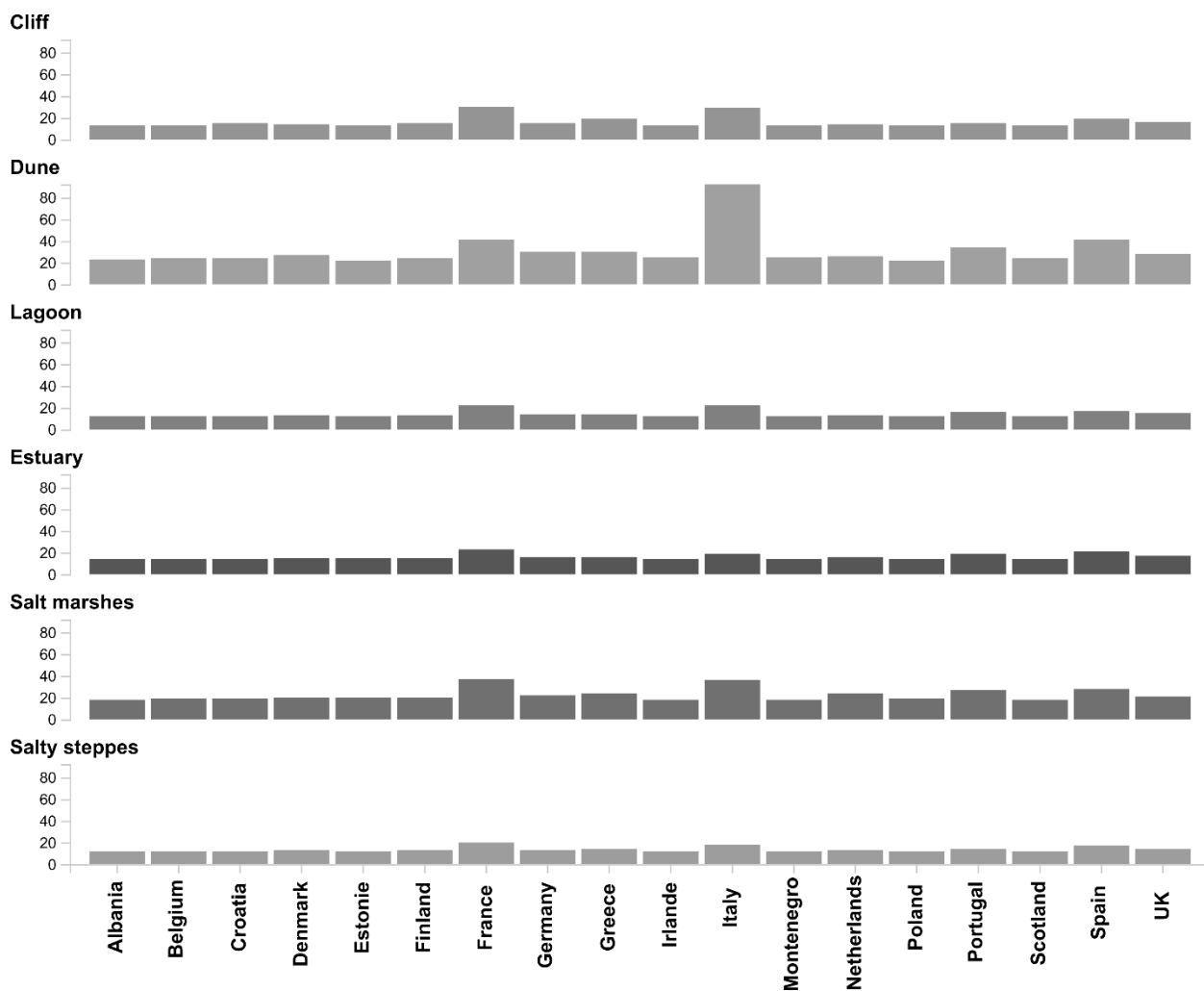
<b>Habitat types</b>	<b>Definitions</b>	<b>Number of publications</b>
Cliff	Vegetated sea cliffs of the Atlantic, Baltic, Mediterranean and Macaronesian coasts	70
Dune	Sea dunes of the Atlantic, North Sea, Baltic and Mediterranean coasts	181
Lagoon	Shallow coastal salt water of Atlantic, Black sea, Boreal, Continental, Mediterranean and Macaronesian coasts	50
Estuary	Atlantic and continental salt marshes and salt meadows	52
Salt marshes	Mediterranean and Atlantic salt marshes and salt meadows	98
Salty steppes	Salt and gypsum inland steppes	41

**Fig. C.1. Distribution of the number of records among coastal habitat types within EU biogeographic regions: a) Atlantic, b) Boreal, c) Continental, d) Mediterranean, e) Black Sea. Papers covering several biogeographic regions (44 records) have been included here. There were no publications entirely confined to the Alpine, Macaronesian and Steppic biogeographical regions only. Nested circles allow to represent hierarchies and compare values. This visualization is particularly effective to show the proportion between elements through their areas and their position inside a hierarchical structure.**



**Fig. C.2. Distribution of the number of records among coastal habitat types by European country. Among European countries comprising coastal habitats, no publications were found in Romania,**

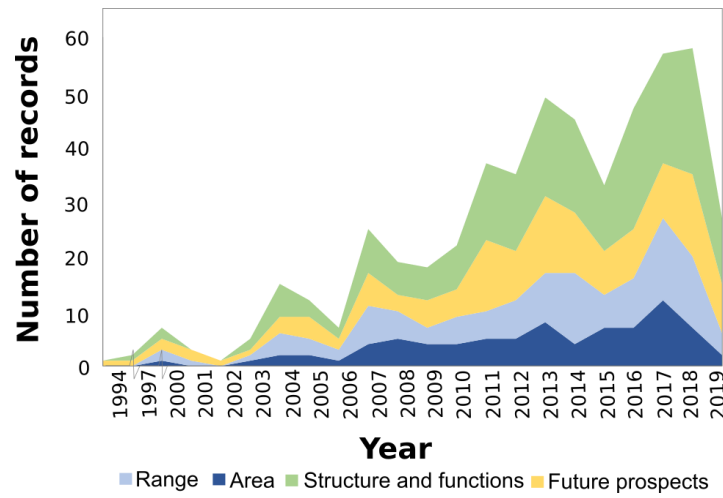
**Bulgaria, Slovenia, Cyprus, Malta, Latvia and Lithuania. This bar chart presents grouped data with rectangular bars with heights proportional to the values that they represent.**



### References

European Environment Agency (EEA), 2019. Welcome to EUNIS, the European Nature Information System. Available on : <https://eunis.eea.europa.eu/>.

## Appendix D. Supplementary analysis



**Fig. D.1.** Temporal trends in the number of published records resulting from our search on parameters (Range, Area, Structure and functions, Future prospects) used to assess conservation status for coastal habitat. Emergence of steep increase of publications on four parameters since 2007.

## **Highlights**

- The implementation of HD remains complicated today to assess and monitor the conservation status.
- Methodological disparities exist between coastal habitats, between countries and between biogeographic regions.
- Currently, methodological approaches remain mainly based on expert judgments.
- Recent and innovative methods for automatic and objective modelling can help to assess habitat range and area.
- Concerted and multiscale approaches can help to improve knowledge on structure, functions and future prospects.