PENSOFT.

Relational databases for plants and habitat types monitoring under Directive 92/43/EEC (Habitat Directive): an example from Campania (Italy).

Annalisa Santangelo[1], Gabriele de Filippo[2], Valeria Rossetti[2], Sandro Strumia[3]

1 *Department of Biology, University of Naples "Federico II", Naples, Italy*

2 *Istituto di Gestione della Fauna, Via M. da Caravaggio 143/Y, Naples, Italy*

3 *Department of Environmental, Biological and Pharmaceutical Sciences and Technologies, University of Campania "Luigi Vanvitelli", Caserta, Italy*

Corresponding author: Sandro Strumia (sandro.strumia@unicampania.it)

Abstract

The implementation of the Habitat Directive (Dir. 92/43/EEC) entails gathering a large amount of field data. As for monitoring activities, along with spatial data (GIS data), tabular data regarding habitat, plant and animal species population size, and pressures and threats acting on them are collected. In this paper we describe two relational databases designed to ensure a correct and efficient data storage for the habitats listed in Annex I and the Plant species listed in the Annexes II, IV and V. The two relational Databases were designed in Microsoft Access format. In both databases, "Lookup Tables" related to the taxon were used to avoid replication and to centralize the data. Data Tables were used to store the raw data deriving from monitoring activities. The adopted databases allow the storage of collected data in a standard and homogeneous format and make data entry easier to users, reducing input errors. The databases comply with the mandatory actions of art. 11 and 17 of the Habitat Directive and give a prompt reply to the basic requests of users. Finally, the databases aim to provide citizens and/or other end users with all the data gathered in a single regional repository, with zoological data in addition.

Keywords

Introduction

The Habitat Directive (Dir. 92/43/EEC, hereafter HD) regulates all the processes/regulations that the Member States (MSs) of the European Union have to follow to maintain or restore at a favourable conservation status the habitats listed in Annex I and the species listed in Annexes II, IV and V (art. 2). These processes/regulations include: a) the setting up of the Natura 2000 (N2000) Network (art. 3, 4); b) the establishment of the necessary conservation measures for each Network site (art. 6); c) the surveillance (monitoring) of the conservation status of the natural habitat and species referred to in art. 2 (art. 11). Moreover, every six years each MS has to draw up a Report on the implementation of the measures taken (art. 17, subsection 1). All the MS Reports are used by the Eu-

ropean Commission (DG Environment) to evaluate the progress in achieving the goal of maintaining or restoring at a favourable conservation status the habitat types and the species listed in the Annexes (art. 17, subsection 2).

Monitoring activities, in addition to ensuring the effectiveness of the conservation measures applied on a local scale in a Special Area of Conservation (SAC) (EC Notice 2019 quoting EC 2013), are also carried out to assess the conservation status of the habitat types and species listed in the Annexes at a Biogeographical region level (EEA, 2011). Indeed, the monitoring results are synthesized at Biogeographical region level and published thanks to the reporting activities ex art. 17.

In this respect, Italy has drawn up guidelines for the implementation of the monitoring plans, outlining for each species and habitat type the required field activ-

ities (Angelini et al. 2016; Ercole et al. 2016; Stoch and Genovesi 2016). Monitoring activities are expected to produce a massive amount of very different data. Together with spatial data (GIS data), tabular data regarding habitat type, plant and animal species population size, and pressures and threats acting on them are collected. Moreover, for habitats and plant species, it is necessary to carry out phytosociological relevés in order to identify the habitat type of Annex I and to record the indicators useful for the assessment of the conservation status both of habitat type and of habitat of the species of Annexes II, IV and V.

Differently from other MSs, Italy has partially delegated the HD implementation to the Local Authorities, namely Administrative Regions and Autonomous Provinces (D.P.R. 357/1997; D.M. MATT 03.09.2002) and Management Bodies of the SACs. The Local Authorities have to regulate specific monitoring plans through regional laws, on the basis of the national guidelines. The Management Body of a SAC is responsible for taking decisions on habitat and species management by drafting the Management Plan of the SAC and applying the site-specific conservation measures. The Local Authorities and the Management Body of a SAC can be represented by different institutions. In fact, D.P.R. 357/1997 states that if the SAC is located within the boundaries of a National Nature Parks or Reserve, the Management Body is the same as the protected area. With respect to the other SACs, each Local Authority must identify the related Management Body by means of an autonomous local legislative measure.

The effects of these legal provisions on monitoring activities are very important. Even though a monitoring plan drafting is mandatory for the Local Authority, its actual implementation involves the Management Body of the SAC. In fact, according to the Notice of European Commission (EC Notice 2019 quoting EC 2013), monitoring should assess the effectiveness of the conservation measures taken by the Management Body thanks to the Management Plan of target habitats and species present in the SAC. In this respect, the Management Body can take decisions autonomously.

The final effect of this complicated legal and administrative framework is that the monitoring activities could be carried out in a very different way by the different Management Bodies, even within the same Local Authority. As a consequence, monitoring activities may involve several groups of operators acting in the different SACs of the same Local Authority, and differences in storing the data may arise. Afterwards, all these data must converge into a regional centralised archive containing all the information and all the characteristics of the N2000 sites. A data repository not planned to unify nonuniform data may therefore negatively affect the data analysis as required by the HD, art. 17.

The importance of botanical data computerization has been a subject of scientific interest since the last twenty years of the twentieth century. The botanical databases are mainly aimed at the use of floristic and phytosociological research (e.g. Gòmez-Pompa and Nevling 1988; Dennis 2000; Pankhurst 2004; Danin et al. 2006; Santangelo et al. 2008; Zielińska et al. 2010; Dengler et al. 2012; Domina et al. 2013; Lucarini et al. 2015; Bedini et al. 2016; Longo et al., 2021). Particular attention has been paid to the creation of taxonomic-nomenclatural databases (Bisby 2000; Peruzzi 2018), now available online, for the worldwide and local floras (e.g. POWO 2022; Euro+Med 2006 onwards; Portal to the Flora of Italy 2022). As for the monitoring activities required by the HD, many articles and technical reports (e.g. Barbier et al. 2009; Weinke and Ragger 2013; Viciani et al. 2014; AA.VV. 2015; Uzunov et al. 2016; Floranet LIFE Floristic Geodatabase, 2021) mainly discuss the outcome of the monitoring activities, analysing original data. Some papers do not address issues connected to the design or implementation of the database used to store the tabular data, not allowing a constructive methodological comparison. The little attention paid to a methodological data storage disagrees with the importance of this feature in terms of management of the same "biological objects" (e.g. habitat type or species listed in the Annexes of the HD) shared by Local Authorities and Management Bodies.

The main purpose of this paper is to draw the attention of the botanists involved as consultants by different Institutions, to the key features of the repository that is intended to store the data specifically gathered for monitoring purposes, under 92/43/EEC.

In this respect we describe the two databases that were specifically designed in an Administrative Region (Campania) to store and to manage monitoring data gathered by different operators. These databases were distributed to private corporations that won several calls for bids announced by the Management Bodies of the N2000 Network. All the activities are carried out according to the Monitoring Plan of the N2000 Network of the Campania region (hereafter MPCam, Giunta Regionale della Campania 2021) for the habitat types and the plant species.

Methods

Two relational Databases (DBs) were designed in Microsoft Access format, the same software used by the European Environment Agency to manage the N2000 data (EEA, 2017, 2021, 2022). The DBs were specifically planned to save and manage sampling data derived from the monitoring activities on habitat types (HD Annex I) and plant species (HD, Annex II, IV, V). The DBs refer to the vascular plants of the Italian flora and to the species of Bryophytes and Lichens of community interest present in Campania. Although the two DBs are very similar in their structure, there are some differences about relational tables and forms for data entry and query, due to the different data stored in the two DBs: HabitatDB and PlantDB. The official language of the DBs is Italian as they were planned to be used by Italian target personnel.

In both DBs there are common tables related to the taxon, acting as "Lookup Table" to avoid data replication

and to allow their centralization (Hernandez 2013). The Lookup Tables are used for the variables that are univocally linked to another one (e.g. for plant species a "taxon" and its presence in a list of protected species). All the other tables are typical Data Tables useful to store the raw data deriving from field work. In this respect some tables are present in both DBs, while other tables are present either in HabitatDB or PlantDB. All the tables are linked to each other through relational key attributes based on numeric or alpha-numerical codes.

Forms and subforms (in Microsoft Access terminology: masks and submasks, respectively) are provided to facilitate data entry and consultation. Data entry forms are available both in a basic form (one record of data at a time) and as a multiple item form (multiple records of data at the same time). The data consultation is mainly provided in a datasheet form (Murray 2020).

Results

Tables

The HabitatDB and the PlantDB contain Lookup Tables (LT) and Data Tables (DT). The Lookup Tables, present in both DBs, related to the taxon and other standard data referring to EU official documents are the following:

Species – The LT includes information about all the vascular plants of the Italian flora, according to Bartolucci et al. (2018) and Galasso et al. (2018). Specifically, nomenclatural data (family, taxon) and other related attributes (Italian endemic, taxon taxonomically doubtful) are available. The categories "N" for native and "A" for alien are specified for each taxon. Species of Bryophytes and Lichens of community interest present in Campania were added.

Synonyms – The LT includes all the synonyms, misapplied, and included names according to Bartolucci et al. (2018) and Galasso et al. (2018). Other synonyms for the taxon reported in Italian floras (Fiori 1923-1929; Pignatti 1982) were added too, according to Conti et al. (2005).

Regional data – The LT contains the attributes that are specific to the Campania Flora. The occurrence status in the region is indicated according to Bartolucci et al. (2018) and Galasso et al. (2018), using the same categories (Occurring, "P"; Doubtfully occurring, "D"; No longer recorded, "NC"; Extinct or possibly extinct, "EX"; Recorded by mistake, "NP"). As for the Alien flora, the following categories were used: "P A" ["CAS" (Casual), "CAS?" (Occurring with an undefined invasion status, likely as casual alien), "NAT" (Naturalized), "INV" (Invasive)]; no longer recorded, "NC A"; extinct or possibly extinct, "EX A"; data deficient, "DD A"; doubtfully occurring, "D A". Other available attributes concern the possible presence of the taxon in the Annexes II, IV; V of the HD, and/or in the list of the species protected by regional law (LR Campania 40/1994), and/or in the National Red Data Books (Rossi et al. 2013, 2020) as reported in Orsenigo et al. (2018, 2020).

Campania N2000 sites – The LT encompasses the selection for Campania region of the N2000 sites recorded in the official EU database (Natura 2000 Access database, EEA 2022), with all the available fields.

Pressure and threats code – The LT refers to the list of threats/pressure according to the Guidelines of European Environment Agency (DG Environment 2017)

Land Cover – The LT refers to the list of CORINE Land Cover types as listed in Strumia (2018).

The Data Tables used for storing field data are described below. They are grouped by the main data type. The DB in which each table is present is reported in brackets (H = HabitatDB, P = PlantDB, HP = present in both).

Data Tables related to ecological and geographical data:

Plot data sheet (HP) – The DT provides all the attributes of the monitoring plot. In detail it includes code plot (as required in MPCAM: 16), sampling date, data collector, geographical coordinates (WGS84 33T EPSG 32633), altitude, slope aspect and inclination, geological substrate.

Transect data sheet (H) – The DT includes data related to the plots distributed along a transect (e.g. sandy coastal vegetation).

Data Tables related to the monitoring data:

Floristic specimen (HP) – The DT allows the record of the raw data collected in the field. Namely, the provisional name (e.g. the name used in field sampling, waiting for the correct identification of the taxon), the plant species cover value using the Braun-Blanquet modified scale (Westhoff and van der Mareel 1978) and the type of the plant record (photo, herbarium specimen, observation).

Demographic specimen (P) – The DT was specifically designed to record the data required for monitoring plants of community interest (Ercole et al. 2016). Available fields are: number of individuals, percentage of individuals in reproductive status, presence of seeds (or spores), and/or seedlings, and/or dead individuals, evidence of vegetative reproduction.

Pressure (HP) – The DT allows ranking the pressure acting on the site/plot (High, Medium), according to DG Environment (2017).

Threats (HP) – The DT allows ranking the threats acting on the site/plot (High, Medium), according to DG Environment (2017).

Data Tables related to museological data:

Herbarium specimen (HP) – The DT encompasses all the attributes useful to herbarium specimen descriptions (type and presence of plant organs, conservation status).

Forms

The data entry forms replicate as faithfully as possible the paper forms used for the fieldwork data collection in the monitoring activities as provided in MPCAM (pp

133-138). All the fields concerning ecological and geographical data are in the upper part of the main form (Fig. 1). Other subforms are available at the bottom of the main form to store the data concerning Pressure and Threats acting on the site/plot, the demography (only in PlantDB) and the phytosociological relevés.

Most fields have an input form planned to simplify data entry, limiting typing errors. Namely, the facilitations consist of a) mandatory fields and presetting of the input value size (e.g. "plot code", "coordinates"); b) selection of default values from a list recorded in a related Lookup Table (e.g. "Land Cover", "N2000 sites", "Pressure", "Threats", Update binomial, Other synonyms); c) addition of values from a drop down list (e.g. "data collector", "Provisional name").

In the subform planned for the data entry of each taxon recorded in the phytosociological relevés (Fig. 2), users may either type the name used in the field paper form (provisional name), in case of uncertain identification, or directly choose among updated names (by the dedicated field or by "other synonyms") if the identification is certain. The cover value of each taxon must be recorded. Moreover, the type of the plant record (herbarium specimen, photo, observation) must be indicated too. Several fields useful to check the importance of the record are shown after the choice of the correct binomial of the taxon. Namely, categories of the taxon (Native/Alien), endemic, taxonomically doubtful, distributional data for Campania region (CAM) and potential inclusion in protected species list or Red List. Moreover, an ad hoc box is

devoted to the recording of the museological data of the gathered specimens.

Consultation and analysis of stored data

To perform a consultation and an analysis of stored data, several queries and reports are available in a main menu (Fig. 3). Some of them generate a datasheet in Microsoft Excel format to export data for further analysis and editing (e.g. matrices of phytosociological data, floristic checklist, list of pressures and threats). Report tools provide PDF files of labels suitable for herbarium specimens collected during field activities. Moreover, another option is to print replicates of the field paper forms.

Discussion

In order to get data regarding N2000 Network comparable over time, the databases make it possible 1) to set up a regional database fulfilling the requirements of art. 11 and 17; 2) to make data entry easier to users and free from errors; 3) to store data in a standard and homogeneous form; 4) to give prompt replies to the basic requests of users (scientists and site managers) and 5) to provide citizens and/or other end users with all data gathered in a single regional database, with zoological data in addition.

The DBs comply with the mandatory actions of the Local Authority (in our case the Campania region) and

Figure 1. Data entry form in Database Habitat (translated from Italian). In the upper part of the form the fields referring to the header of a phytosociological relevé are reported. At the bottom of the main form, the subform concerning Pressure acting on the plot is reported. The labels of the subforms concerning Threats and Phytosociological relevé are shown too.

Figure 2. Detail of Phytosociological relevé data entry form in Database Habitat/Plants (translated from Italian). Some fields support data entered by users (in blue), while other fields (green, in the box), include information reported in the Lookup Tables "Species" and "Regional data" and are activated by the selection of the updated name or other synonyms (red fields) of the recorded taxon. In the orange box the fields referring to the herbarium specimens are arranged.

help the Management Body of a SAC define the required management actions.

The DB layout is planned to best store the field data gathered during the monitoring activities according to MPCAM.

As the monitoring activities can be carried out by differently experienced individuals (sometimes with very poor knowledge of taxonomy and phytosociology), the DBs ensures data homogeneity, standardization and scientific value in this case. Indeed, the DBs use a standard taxonomic repository (Bartolucci et al. 2018; Galasso et al. 2018) and recently updated lists of attributes related to the species (Peruzzi et al. 2014; Rossi et al. 2013, 2020). This feature allows the comparison and the confluence at regional level of the data gathered in the different SACs.

The DBs were developed using Microsoft Access. However, the suggested structure can be easily used in other types of software. In our opinion, one of the key strengths of our DB is the use of lists (taxonomy and other characteristics of each taxon) deriving from national research projects (e.g. Portal to the Flora of Italy, 2022; Rossi et al., 2013, 2018). This choice ensures both the continuous data updating by many scientists involved in national projects and the data standardization at national level. The relational structure allows an easy updating of the tables related to the taxon, that is uniquely identified by an alphanumerical code, by the DB administrator.

The support of the facilitations provided by the forms ensures data entry accuracy and data storage consistency. The form used to store phytosociological relevés instantly marks the presence of target species (e.g. endemic and/or protected species), highlighting the scientific or management relevance of the recorded taxon.

The data analysis is simplified by the queries and the reports provided by the two DBs. All data can be easily analysed at both site and Local Authority scale, providing the information required by the HD. At SAC level, the analysis of Pressure and Threats recorded for each habitat type or species provides useful information (required by the HD, art.6) concerning the conservation measures specific to site, and its habitat types and species. The conservation measures must counteract the Pressures or Threats recorded in the SAC. To this end, the DB tools help the Management Body with the identification and quantification of Pressures and Threats. The same tools allow their prioritization in a standard and comparable way in order to define the best conservation measure to be applied.

In the HabitatDB exporting data to a raw matrix facilitates the phytosociological analysis necessary to identifying the habitat type. The attributes of each taxon recorded in the relevés (native, alien, endemic, red listed) and used as indicators of habitat functionality (MPCam: 17-18), can be easily extracted to allow the assessment of the conservation status of the sampled habitat. The same facilitations are provided by the PlantDB, allowing the use of indicators assessing the habitat of the species quality, and making population size data comparable over time, according to the provisions of MPCam (p. 69).

Reports facilitate the management of herbarium specimens, whose collection is mandatory in case of plant records that update distributional data for Campania region (MPCam: 16). Namely, the mandatory delivery of herbarium material to an institutional museum (MPCam: 16), is made easier by the provided report in PDF format for labelling specimens.
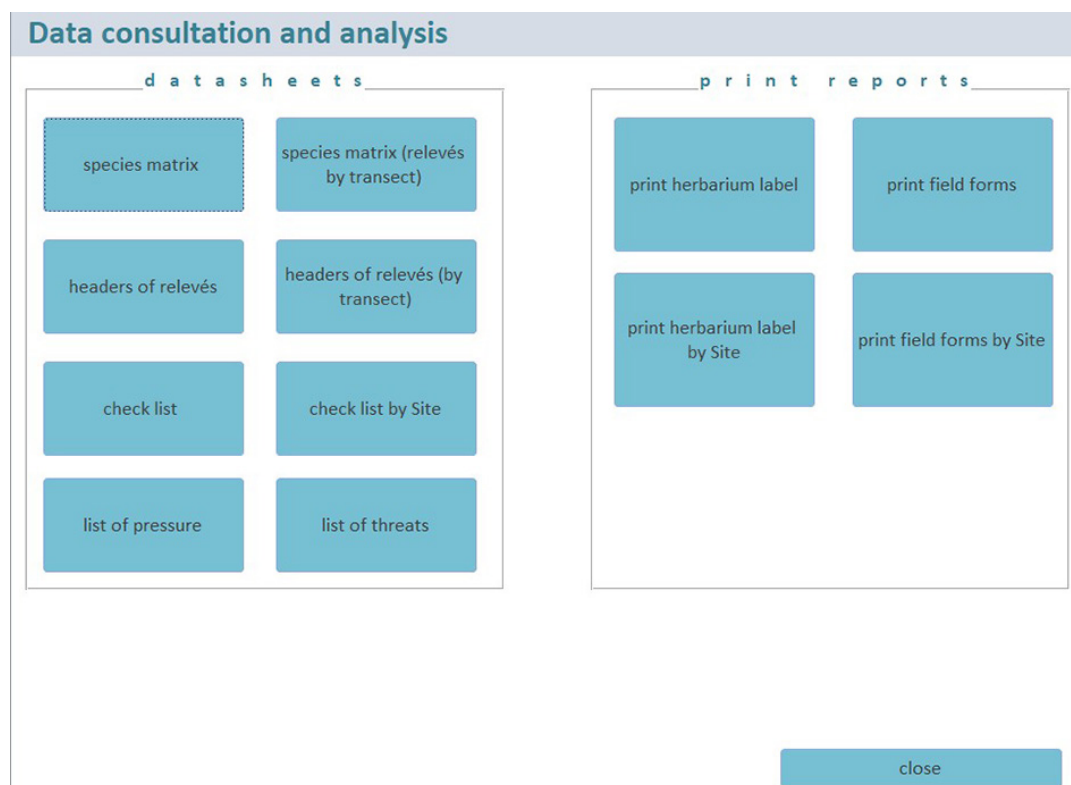
Figure 3. Main menu form for consultation and analysis of stored data in HabitatDB (translated from Italian). The buttons to generate a datasheet in Excel format are arranged on the left. On the right the buttons to print reports in PDF format are reported.

As for Standard Data Form updating, the DBs allow the extraction of the information required in the Commission Implementing Decision (EC 2011). Namely, the "Species size" in Sect. 3.2 of the Standard Data Form or the list of "Other species" (Sect. 3.3) that can be easily extracted by the "Species" and "Regional data" tables by a provided query (e.g. Checklist).

What is more, the availability of georeferred distributional data for all the recorded species, easy to import into the GIS environment, represents a very feasible tool of biodiversity management.

Finally, the databases make all the botanical and zoological data collected in the monitoring activities available in a single regional repository to citizens and/or other users, as required by the art. 17(1).

Conclusion

The outcome of the monitoring activities ex art. 11 can be used to assess the conservation status of habitat types and species listed in the HD Annexes and to comply with the art.17 (Biogeographical Region level). The same data can be used by the Management Body of each site of N2000 Network (site level) to assess the conservation measures effectiveness, in order to comply with the priority taken by the conservation objectives described in the Management Plan.

In Italy the national regulations (DPR357/97; D.M. MATT 03.09.2002) referred some matters (such as Environment) to Local Authorities (namely Administrative Regions, Autonomous Provinces), importantly complicating the HD application. As a matter of fact, in Italy the monitoring activities are not in charge of one central Authority, as in other MSs, and they are planned by the different Local Authorities independently, e.g. in terms of sampling design, skills of involved personnel and repositories used to store data. Moreover, the monitoring plan is put into practice by the Management Bodies that have the authority to choose differently skilled professionals.

Currently, in Campania the activities required by the monitoring plan are being developed by private corporations that won several calls for bids announced by the Management Bodies. These corporations recruited differently experienced professionals by terminable contracts and agreements. In such a context, where the necessary involvement of scientists in the sampling activities is not ensured, the use of a repository planned to store data in a standard and homogeneous form represents a focal tool to give them scientific accuracy.

The stored data standardization makes it easier to provide the Ministry of Ecological Transition (MiTE) with the data required by art. 17 and to update Standard Data Forms (EC, 2011). The distributional data of taxa of interest could be available in the National Network of Biodiversity, improving this important project, which carries

out a strong joint action in support of the National Biodiversity Strategy (re3data.org 2022).

In our opinion, monitoring under the HD is an "ecotonal" topic between science (floristic, taxonomy, phytosociology, plant ecology) and bureaucracy (e.g. mandatory practical actions required by laws referring to different Authorities at different levels). The DBs presented in this paper were intended to balance the two sides of the same law: science and bureaucracy. In this respect, they were imagined and planned for the purpose of creating a tool able to meet the requirements of scientific accuracy and to fulfil the practical requests of Institutions at the same time.

Finally, we hope this paper may contribute to the botanists' debate about the actual role of the scientific community and their contribution in the matter of the complex processes and mandatory actions required by the Habitat Directive.

Acknowledgments

Bibliography

AA.VV. (2015) Relazione finale del Programma di monitoraggio scientifico di Specie Vegetali e Habitat della Direttiva 92/43/CEE. Formulazione del programma di monitoraggio scientifico della rete Azione D1. Available on line http://www.biodiversita.lombardia.it/index.php?option=com_content&view=article&id=107:monitoraggio-scientifico&catid=79:generale&Itemid=464

Angelini P, Casella L, Grignetti A, Genovesi P (Eds) (2016) Manuali per il monitoraggio di specie e habitat di interesse comunitario (Direttiva 92/43/CEE) in Italia: habitat. ISPRA, Serie Manuali e linee guida, 142/2016. http://isprambiente.gov.it

Barbier Y, Lejeune P, Dufrêne M and Rondeux J (2009) An ArcGIS-based tool for the relational data management assistance of Natura 2000 habitat units in the Walloon Region, Belgium. Biotechnol. Agron. Soc. Environ. 13(2): 243–248. https://popups.uliege.be/1780-4507/index.php?id=3980

Bartolucci F, Peruzzi L, Galasso G, Albano A, Alessandrini A, Ardenghi NMG, et al. (2018) An updated checklist of the vascular flora native to Italy. Plant Biosystems 152(2): 179–303. https://doi.org/10.1080/11263504.2017.1419996

Bedini G, Pierini B, Roma-Marzio F, Caparelli KF, Bonari G, Dolci D, Gestri G, D'Antraccoli M, Peruzzi L (2016). Wikiplantbase #Toscana, breaking the dormancy of floristic data. Plant Biosystems 150: 601–610. https://doi.org/10.1080/11263504.2015.1057266

Bisby F (2000) The Quiet Revolution: Biodiversity Informatics and the Internet. Science 289(5488): 2309–2312. https://doi.org/10.1126/science.289.5488.2309

Conti F, Abbate G, Alessandrini A, Blasi C (Eds) (2005) An annotated check-list of the Italian vascular flora. Palombi, Roma, 420 pp.

Danin A, Fragman- Sapir O, 2006. Flora of Israel Online. http://flora.org.il/en/plants/

Dengler J, Oldeland J, Jansen F, Chytrý M, Ewald J, Finckh M, Glöckler F, Lopez-Gonzalez G, Peet RK, Schaminée JHJ.(Eds) (2012) Vegetation databases for the 21st century. Biodiversity & Ecology 4: 388–388. https://doi.org/10.7809/b-e.00055

Dennis A 2000. CalFlora: California flora database. The CalFlora Database, a nonprofit organization, Berkeley, California. Available at https://www.calflora.org/collab.html (accessed 23/11/2022)

DG Environment (2017) Reporting under Article 17 of the habitats Directive: Explanatory notes and guidelines for the period 2013-2018. Brussels (http://cdr.eionet.europa.eu/help/habitats_art17)

D.M. MATT (3.9.2002) Linee guida per la gestione dei siti Natura 2000. G.U. n. 224 24/09/2002

D.P.R. (357/1997) Regolamento recante attuazione della direttiva 92/43/CEE relativa alla conservazione degli habitat naturali e seminaturali, nonché della flora e della fauna selvatiche. G.U. n. 248, 23-10-1997 and subsequent amendments and additions

Domina G, Aleffi M, Alessandrini A, Bacchetta G, Bagella S, Bartolucci F, et al. (2013) 1, 10, 100, how many floristic databases are there in Italy? In: Raimondo FM and Domina G (Eds), XIV OPTIMA Meeting, 9-15 September 2013, Palermo, (Italy). Orto Botanico ed Herbarium Mediterraneum, Palermo 165 pp. ISBN 978-88-903108-8-1

EC (2011) Commission Implementing Decision of 11 July 2011 concerning a site information format for Natura 2000 sites (notified under document C(2011) 4892) (2011/484/EU). Available at https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32011D0484

EC (2013) Commission Note on Establishing Conservation Measures for Natura 2000 sites Doc. Hab.13-04/05, September. Available at https://ec.europa.eu/environment/nature/natura2000/management/docs/commission_note/comNote%20conservation%20measures_EN.pdf

EC Notice (2019) Managing Natura 2000 sites. The provisions of the Habitats Directive 92/43/EEC. Official Journal of the European Union, C33/01.

EEA (2011) Biogeographical regions, Europe 2011. Available at https://sdi.eea.europa.eu/catalogue/srv9008075/api/records/5e884531-3b0e-4643-af14-ae6281d6fb24

EEA (2017) Natura 2000 data flow document. Available at https://www.eea.europa.eu/themes/biodiversity/document-library/natura-2000/the-natura-2000-data-flow/view

EEA (2021) Article 17 - 2020 dataset. Available at https://www.eea.europa.eu/data-and-maps/data/article-17-database-habitats-directive-92-43-eec-2 - Prod-ID: DAT-15-en Created 19 Oct 2020 Published 19 Oct 2020 Last modified 01 Sep 2021.

EEA (2022) Natura 2000 Access Database. Available at https://www.eea.europa.eu/data-and-maps/data/natura-14

Ercole S, Giacanelli V, Bacchetta G, Fenu G e Genovesi P (Eds) (2016) Manuali per il monitoraggio di specie e habitat di interesse comunitario (Direttiva 92/43/CEE) in Italia: specie vegetali. ISPRA, Serie Manuali e linee guida, 140/2016. http://isprambiente.gov.it

Euro+Med (2006 onwards). Euro+Med Plantbase - the information resource for Euro-Mediterranean plant diversity. http://ww2.bgbm.org/EuroPlusMed/

Fiori A (1923-1929) Nuova Flora Analitica d'Italia. 1-2. Tipografia Ricci, Firenze.

Floranet LIFE Floristic Geodatabase (2021) Available at https://www.floranetlife.it/en/database/ accessed December 2022

Galasso G, Conti F, Peruzzi L, Ardenghi NMG, Banfi E, Celesti-Grapow L, et al. (2018) An updated checklist of the vascular flora alien to Italy. Plant Biosystems 152(3): 556–592. https://doi.org/10.1080/11263504.2018.1441197

Giunta Regionale della Campania (2021) Aggiornamento delle 'Linee Guida per il Piano di Monitoraggio di Habitat e specie di interesse comunitario terrestri e delle acque interne della Campania e manuale tecnico di campionamento'. Decreto Dirigenziale 50 del 18/11/2021. (https://www.naturacampania.it/public/CASA_DEdipart50dg06uod07_20210000050ver02.pdf).

Gómez-Pompa A and Nevling LI (1988) Some Reflections on Floristic Databases. Taxon 37(3) 764–775. https://doi.org/10.2307/1221113

Hernandez JM (2013) Database Design for Mere Mortals: A Hands-On Guide to Relational Database Design. Addison-Wesley Professional. 597 pp. ISBN: 9780133122282

Longo D, Baglivo A, Cibei C, Dose G, Giordana F, Magni C, Salvai G, Servodio S, Tomasi D, Zepigi M, Nicolella G (2021) Acta Plantarum, more than a forum: a new national floristic distribution database completes the numerous online IPFI facilities Biogeographia 36: s004. https://doi.org/10.21426/B636049352

Lucarini D, Gigante D, Landucci F, Panfili E, Venanzoni R (2015) The anArchive taxonomic Checklist for Italian botanical data banking and vegetation analysis: Theoretical basis and advantages. Plant Biosystems 149(6): 958–965. https://doi.org/10.1080/11263504.2014.984010

Murray DJ (2020) Microsoft Access 2019Tutorial and Lab Manual. University at Buffalo, United States of America. ISBN 978-1-942163-02-2

Orsenigo S, Montagnani C, Fenu G, Gargano D, Peruzzi L, Abeli T, et al. (2018) Red Listing plants under full national responsibility: Extinction risk and threats in the vascular flora endemic to Italy. Biological Conservation 224: 213–222. https://doi.org/10.1016/j.biocon.2018.05.030

Orsenigo S, Fenu G, Gargano D, Montagnani C, Abeli T, Alessandrini A, et al. (2021) Red list of threatened vascular plants in Italy. Plant Biosystems 155: 310–335. https://doi.org/10.1080/11263504.2020.1739165

Pankhurst RJ (2004) Computer Technology for the Future of SW Asiatic Botany. Turkish Journal of Botany 28(1), Article 12. Available at: https://journals.tubitak.gov.tr/botany/vol28/iss1/12

Peruzzi L (2018) Floristic inventories and collaborative approaches: a new era for checklists and floras? Plant Biosystems 152(2): 177–178. https://doi.org/10.1080/11263504.2017.1419997

Peruzzi L, Conti F, Bartolucci F (2014) An inventory of vascular plants endemic to Italy. Phytotaxa 168(1): 1–75. https://doi.org/10.11646/phytotaxa.168.1.1

Pignatti S (1982) Flora d'Italia. 1-3. Edagricole, Bologna

Portal to the Flora of Italy (2022) Available at http:dryades.units.it/floritaly [Accessed: 23/11/2022]

POWO (2022) Plants of the World Online. Facilitated by the Royal Botanic Gardens, Kew. Published on the Internet; http://www.plantsoftheworldonline.org/ Retrieved 23 November 2022."

re3data.org (2022) Italian National Biodiversity Network; editing status 2022-05-04; re3data.org - Registry of Research Data Repositories. http://doi.org/10.17616/R3WH1D last accessed: 2022-12-05

Rossi G, Montagnani C, Gargano D, Peruzzi L, Abeli T, Ravera S, et al. (Eds) (2013) Lista Rossa della Flora Italiana. 1. Policy Species e altre specie minacciate. Comitato Italiano IUCN e Ministero dell'Ambiente e della Tutela del Territorio e del Mare. https://www.mite.gov.it/pagina/liste-rosse-nazionali

Rossi G, Orsenigo S, Gargano D, Montagnani C, Peruzzi L, Fenu G, et al. (2020) Lista Rossa della Flora Italiana. 2 Endemiti e altre specie minacciate. Ministero dell'Ambiente e della Tutela del Territorio e del Mare. http://www.iucn.it/pdf/LISTAROSSAvol-2-FLORAITALIANA.pdf

Santangelo A, Bronzo E, Croce A, Salvati C, Strumia S (2008) Basi di dati per le ricerche floristiche: un esempio per il Matese campano. Inform. Bot. Ital. 40 (1): 59–71.

Stoch F e Genovesi P (Eds) (2016) Manuali per il monitoraggio di specie e habitat di interesse comunitario (Direttiva 92/43/CEE) in Italia: specie animali. ISPRA, Serie Manuali e linee guida, 141/2016. http://isprambiente.gov.it

Strumia S (2018) Allegato tecnico per la realizzazione delle carte fisionomiche della vegetazione e delle coperture di uso del suolo e delle carte degli habitat. In Decreto Giunta Regionale della Campania n. 335 del 5/06/2018, allegato D. https://www.regione.campania.it/assets/documents/dgr-n-335-del-06062018.pdf

Uzunov D, Salerno G, Gangale C, Storino P, Marcianò C, Menguzzato G e Brandmayr P (2016) DBRN2kal: un geodatabase per la gestione della Rete Natura 2000 in Calabria. In: Salerno G, Cristiano D, Mendicino G, GIS Day Calabria 2016, 16 novembre 2016. Map Design Project, Catanzaro.

Viciani D, Lastrucci L, Dell'Olmo L, Ferretti G, Foggi B (2014) Natura 2000 habitats in Tuscany (central Italy): synthesis of main conservation features based on a comprehensive database. Biodivers Conserv 23:1551–1576. https://doi.org/10.1007/s10531-014-0686-6

Weinke E and Ragger C (2013) EMaRT - possibilities for the use of innovative web technologies in monitoring of Natura 2000 territories. 5th Symposium for Research in Protected Areas. 10 to 12 June 2013, Mittersill: 813–818.

Westhoff V and van der Mareel E (1978) The Braun Blanquet approach. In: Whittaker RH (Ed), Classification of Plant Communities, second ed.: 287–399. Dr Junk, The Hague, The Netherlands. https://doi.org/10.1007/978-94-009-9183-5_9

Zielińska K, Jakubowska-Gabara J, Kołodziejek J (2010) Adaptation of the "herbarium" computer database to archiving and analysis of floristic data. Folia Biologica et Oecologica 6: 145–150. https://doi.org/10.2478/v10107-009-0013-2