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The Iberian and Macaronesian Vegetation Information System (SIVIM, www.sivim.info), five years of online vegetation's data publishing

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Abstract
The SIVIM website was born six years ago. After a first stage of fast growing, the number of queries to its database has currently surpassed 100,000 per year. SIVIM offers its users the opportunity to access to large datasets facilitating phytosociological reviews, plant conservation management and taxonomic chorological studies, amongst others. Therefore, the number of scientific papers and books as well as other websites that cite our website is enlarged everyday. New data have been constantly brought into the project, which means that more than 130,000 phytosociological relevés are currently accessible, storing more than two million specific floristic observations. According to the Global Index of Vegetation-Plot Databases (GIVD), and taking into account the number of computerized relevés, SIVIM is the fourth largest database in the world.
New analysis tools have been developed during this year, among them the on line calculation of species and syntaxa's fidelity values, and a new remarkable tool to model the potential distribution of taxa and syntaxa (based on the maximum entropy algorithm), and their future trends in response to climate change (projections for the years 2020, 2050, and 2080). We should also emphasize ZamiaDroid, the latest integration within the project, which allows querying SIVIM by mobile devices (smartphones and tablets). With respect to programming, we implemented a new system so that users can report errors directly to SIVIM administrators.
Concerning future actions, we aim to develop an online expert system in order to survey and classify vegetation communities and to open SIVIM to participative projects, especially those related to photography of plants and vegetation types. The SIVIM project has been funded by two research projects, CGL2006-13421-C04 (2007-2009) and CGL2009-13317-C03 (2010-2012), consecutively.

Keywords: analysis tools, database, relevés, vegetation.

Introduction

The importance of having large biodiversity databases has been highlighted in several international forums, as well as in the recent national report on the climate change impacts (Moreno, 2005). Databases of plant species occurrence in conjunction with environmental data can be a powerful tool to understand ecological relations or predict the effect of external drivers on ecological processes and species reactions (Chytrý & Rafajová, 2003; Smart *et al*., 2003; Lenoir *et al*., 2008; Schaminée *et al*., 2009). Descriptive studies on vegetation using phytosociological methods include, in most cases, data as relevé tables and constitute an important source of phytosociological, ecological and floristic information.

The great number of publications currently available within the Iberian Peninsula and the Macaronesian archipelagos (nearly 1,700 references are already compiled in SIVIM) give rise to a large number of accessible relevés. We estimate there are approximately 175,000 relevés available for the concerned area (Font *et al*., 2009). These data are scattered in numerous publications (either national or international), and in a great number of unpublished works (PhDs, Master theses, reports, and so on). The difficulty in finding some of these works, along with the large diversity detected on the information sources, frequently causes some data to go easily unnoticed even to expert users, being for non-specialists almost impossible to work with all the data from an extensive territory.

Moreover, the knowledge of the composition and distribution of plant communities is becoming increasingly necessary, partially as a consequence of surveying the habitats enclosed in the Habitats Directive 92/43/CE (the legend of which is mostly based on phytosociological vegetation units). However, not only is the knowledge of the distribution and occurrence of vegetation types important for phytosociological studies, but also for the assessment of decision making on land planning and management and for ecological research in general.

We can find a substantial number of independent projects aiming to computerize vegetation data all over the world. The Global Index of Vegetation-Plot Databases (GIVD, http://www.givd.info) has recorded 184 databases hosting 2,838,550 vegetation plots worldwide. The first initiative to relate these databases is being

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carried out by the European Vegetation Archive (EVA; Chytrý *et al*., 2012). However, the political, institutional, scientific and technological obstacles that should be overcome are still important. Among the scientific challenges of computerizing information on plants, we could point out the taxonomic and nomenclatural ones (Jansen & Dengler, 2010), which can be partially solved by using nomenclatural web services like that suggested by the EuroSL project (Dengler *et al*., 2012).

A standard exchange for plot-based vegetation data (Veg-X) that allows for observations of vegetation at both individual and aggregated observation levels, and makes them available to the entire ecological community has been created (Wiser *et al*., 2011). The access to large biodiversity data banks is leading to the emergence of new research lines on this topic, and to methodological possibilities unthinkable until now (Ozinga *et al*., 2005; Bekker *et al*., 2007).

SIVIM project

SIVIM was born in the frame of a nationally funded research project of the Global Change, Earth Sciences and Biodiversity Program (CGL2006-13421-C04) with the involvement of several Spanish universities (University of Barcelona, University of the Basque Country, University of Castilla-La Mancha and University of León). The project was refunded in 2010 for the next 3 years (CGL2009-13317-C03). The direct precursor of SIVIM was the BDBC project (Biodiversity Database of Catalonia, http://biodiver.bio.ub.es/biocat/), funded by the Generalitat (regional government) of Catalonia, which begun 17 years ago and currently hosts 21,765 relevés from Catalonia and neighboring areas (Font & Ninot, 1995). Secondly, SIVIM also includes data from the BIOVEG project (Vegetation-Plot Database of the University of Basque Country, http://www.givd.info/) which hosts 20,172 relevés (Biurrun *et al*., 2012). Most of the characteristics applied in SIVIM are based on those already implemented and tested in the BDBC. SIVIM is conceived as a vegetation information system designed for capturing, hosting, editing, analyzing and outputting georeferenced vegetation data. It was created with the aim of being a helpful tool, both in scientific research and in assessment of decision making on land planning and management. Since SIVIM has been developed to record phytosociological relevés, these data (the coverage of all species present in a relevé, regardless of their frequency and taxonomic status) are an important complement to the distributional data from herbarium collections and the floristic literature, both of which are preferentially focused on relatively uncommon species and taxonomically difficult groups and lack the information about species co-occurrence. In this context, it is remarkable that SIVIM holds the largest number of floristic data records in the national information system on phytodiversity. SIVIM currently stores almost 130,066 phytosociological relevés derived from 1,570 bibliographic references, mainly from the Iberian Peninsula and the Canary Islands. According to the *Global Index of Vegetation-Plot Databases* (GIVD), and taking into account the number of computerized relevés, SIVIM is the fourth largest database in the world. These relevés contain 2,141,254 floristic records (16.5 species per relevé in average), summing altogether 6,637 species. The individual floristic records contained in SIVIM are now available for consultation also in the national (http://www.gbif.es) and international (http://www.gbif.org) GBIF nodes.

Fig. 1 - The SIVIM Homepage.

SIVIM uses a taxonomic thesaurus following the proposals of the Anthos project (http://www.anthos.es) of the Royal Botanical Garden of Madrid for the Iberian flora, complemented by other floristic repertories from northwest Africa and the Macaronesian archipelagos and the periodic updating derived from the project *Flora iberica*. With regards to syntaxonomical nomenclature, SIVIM follows the checklist of Rivas-Martínez *et al*. (2001, 2002, 2011), but the database structure includes separated fields for the original name (verbatim, unchangeable) and for the corrected or updated name of each relevé. The syntaxonomical thesaurus solves synonymies and allows users to address queries at different levels of the hierarchical classification of vegetation.

Website

The SIVIM website (http:// www.sivim.info, Fig. 1) was presented at the XXI Conference of the Spanish Phytosociological Association in Madrid more than five years ago. In contrast to other vegetation databases, SIVIM offers free online access to relevés, tables, and floristic observations by versatile queries. Currently, the SIVIM portal allows the following query options: relevés of a specific syntaxon, distribution area (map) of a selected syntaxon, syntaxa or relevés in one

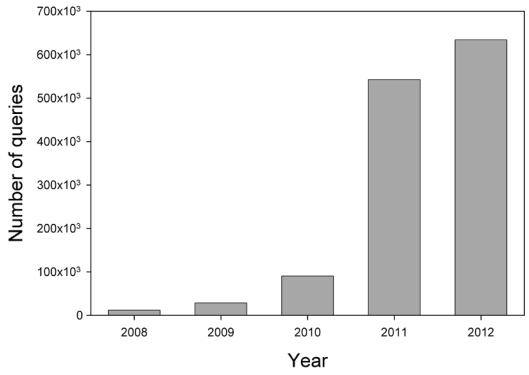

Fig. 2 - Number of queries to the SIVIM website through time (2008-2012).

or more (up to 6) selected UTM 10x10 km grid cells, syntaxa or relevés present in one or more selected localities, syntaxa or relevés including one or more selected species, taxa (and their frequencies) present in a selected syntaxon, and literature references containing relevés of a selected syntaxon. Data of both relevés and tables are downloaded in B-VegAna XML format. In general, scientists and conservation managers agree that all information on biodiversity should be public and easily available as a way to improve knowledge and prevent and halt impacts on and losses of biodiversity. The only limitation concerns the public accessibility to data containing accurate locations of threatened or protected species. These data in particular should not be finer than 10x10 or 1x1 km grid cell to avoid undesirable risks. Accurate locations of these species should only be facilitated upon request and previous justification of their use for research or conservation purposes.

Web statistics of SIVIM usage

The number of queries to the SIVIM web portal has been rising since the very beginning of the project (Fig. 2), when the website was opened. During the year 2011 the increase in the number of queries was extremely high, achieving more than 500,000 queries, a rate maintained during 2012. This increase is mostly due to GoogleBot, the Google's tracker robot, which has queried all the options of the website several times, and has indexed all the SIVIM database contents. Almost a 70% of the current queries follow this path. Thanks to all this, the contents of SIVIM are also directly accessible using the Google searcher.

If we look to the origin of the queries, most of them come from Spain and are focused in academic institutions and research centers.

Relevés survey through time

Although the SIGMA trip in Catalonia promoted by J. Braun-Blanquet and P. Font-Quer during the year 1934 is usually considered the beginning of the phytosociology in the Iberian Peninsula, the relevés obtained from this famous expedition, which were published one year later (Braun-Blanquet *et al*., 1935) were not the first relevés sampled at the Iberian Peninsula. This merit goes to the Scandinavian botanist J. Frodin (1926) who published 55 relevés of the central Pyrenees, using a similar recording method to the current phytosociological approach. Nearly ninety years have passed since these first surveys, and we estimate that about 175,000 relevés have been surveyed in the territory in this period (Font *et al*., 2009, 2010). However, the surveying intensity has not been the same across time (Fig. 3), and the following four periods can be distinguished:

1926-1947 - Besides the mentioned precedents and the works carried out by Susplugas in Vallespir (Catalonia), there are few works to be highlighted for this initial period, which comprises more than 20 years. Furthermore, these works are scarce (a total of 19), and contribute few data (500 relevés).

1948-1980 - In 1948 Braun-Blanquet published his monograph dealing with Alpine vegetation of the Pyrenees (Braun-Blanquet, 1948) and from then on new phytosociological data were annually published at increasingly higher rates. In this period numerous local researchers, some of them already deceased like O. de Bolòs and S. Rivas Goday, constantly contributed with new relevés. Besides the aforementioned researchers, we should stand out S. Rivas-Martínez, J. Vigo and G. Lapraz, who published a substantial number of relevés. During this 33-year period, 343 works storing 25,000 relevés were published. Thus, during this period there was a constant gain of researchers and, consequently, of published relevés.

1981-2004 - During this 24-year period, the phytosociology experienced an authentic boom, thanks to hundreds of committed researchers who published 1,038

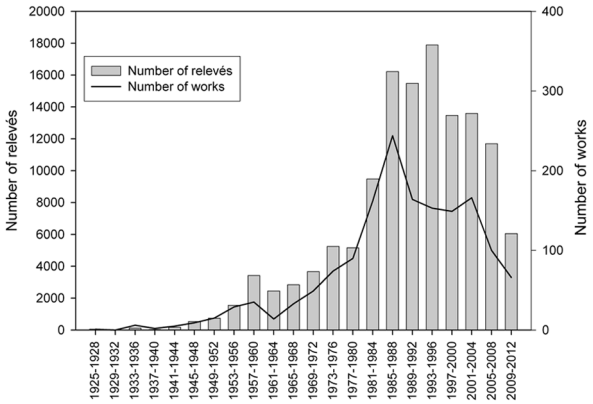

Fig. 3. Number of relevés surveyed through 4-year periods, and number of works from which these relevés come from.

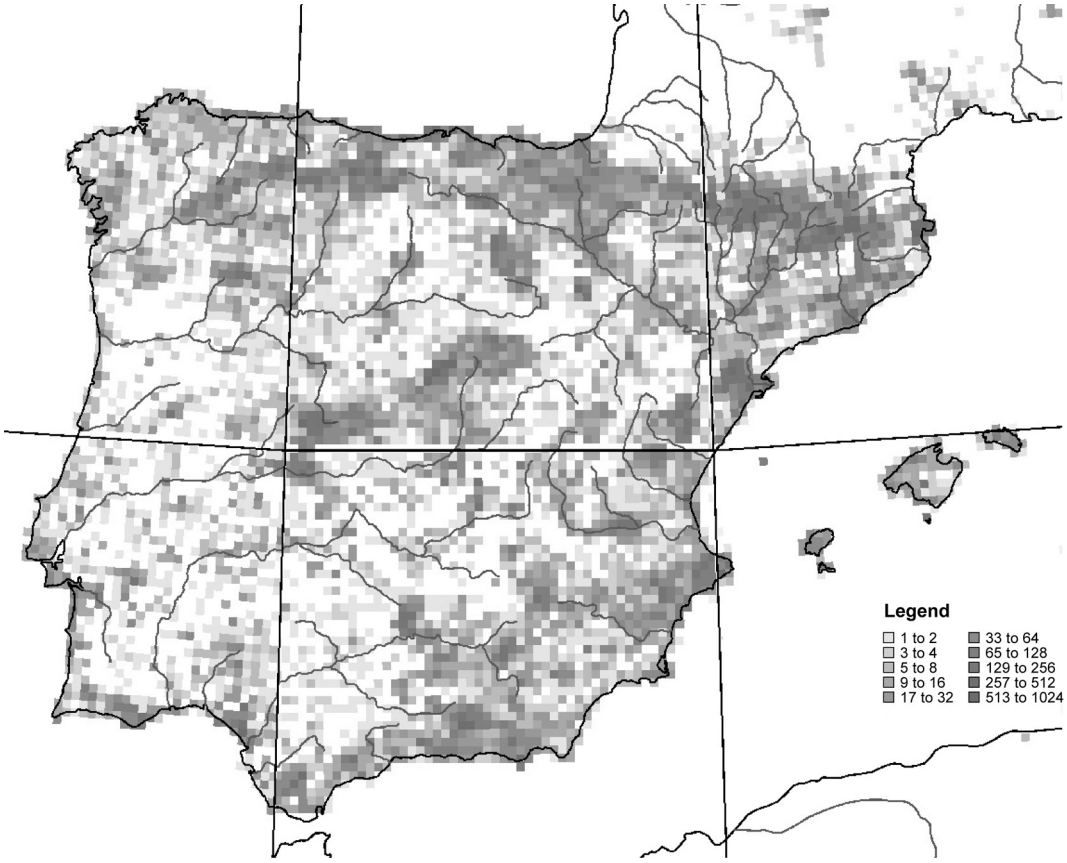

Fig. 4. Geographic distribution of the relevés computerized in SIVIM.

works (more than 43 publications per year in average) hosting more than 86,000 relevés. Throughout this period this botanical discipline was taught in almost every University in Spain, and numerous PhDs were disserted. Among them, the study performed by Sardinero (2004), storing 1,554 relevés, holds the record of published relevés within one work.

2005-2012 - Lately, the number of publications has gradually been decelerating (20 works per year in average) due to the ageing of the researchers interested on vegetation survey (in some cases due to their retirement), to the extinction of their chairs due to the current economical crisis and also to some kind of competitiveness penalty to researchers devoted to descriptive studies on vegetation. Moreover, we should not forget the effect that changes in educational plans have had on this discipline, causing in many cases the disappearance of lectures related to phytosociology and vegetation science (Jansen & Dengler, 2010). Thus, the number of PhDs dealing with this discipline has decreased abruptly in the last years. This is the reason why we expect that the current deceleration in the volume of works will continue until reaching the levels registered during the 60s.

Relevés survey through the space

The 130,066 relevés contained in SIVIM are not evenly distributed through the territory, being mountain areas clearly better surveyed (Fig. 4). Among the computerized relevés accessible at the SIVIM website, 108,694 were carried out in the Spanish peninsular territory (21,765 in Catalonia; 20,172 in Basque Country and bordering territories), 2,774 correspond to relevés performed in the Macaronesian archipelagos, 1,917 to the Balearic Islands, 7,550 come from continental Portugal, 4,776 from Southern France, and 35 from Northern Africa. The remaining 4,325 relevés are not properly georeferenced. However, there are still nearly 1,500 UTM quadrats (10 x 10 km grid size) where no phytosociological relevés have been surveyed up to date, while on the other hand the UTM quadrat 31TBH52, in the Pyrenean Ordesa valley, where 893 relevés have been performed, holds the record of phytosociological surveys.

News of 2012

Plenty of innovations have been programmed during

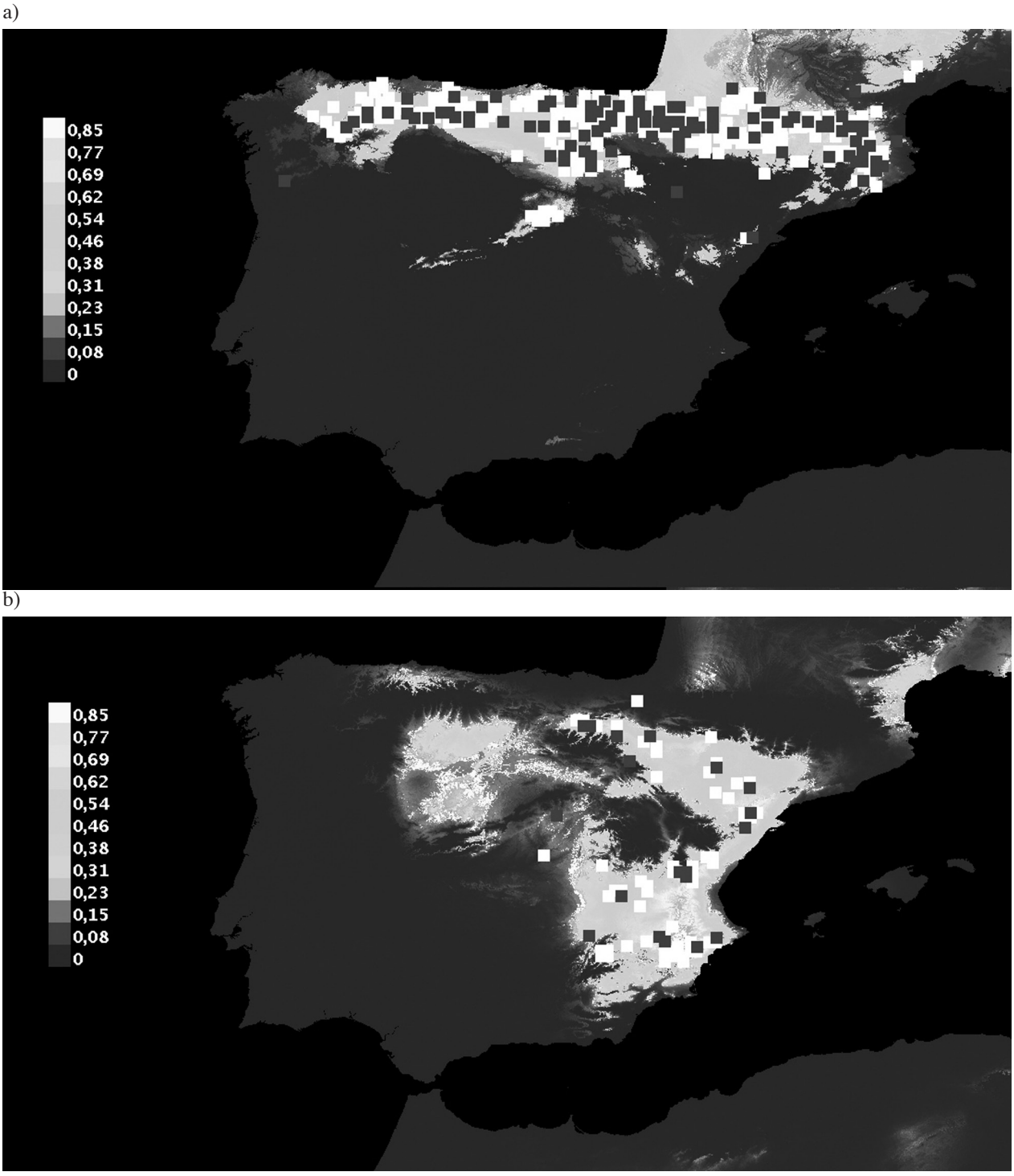

Fig. 5 - Generated maps based on the maximum entropy algorithm: a) potential distribution of *Fagus sylvatica*; b) potential distribution of *Rhamno lycioidis-Quercetum cocciferae* Br.-Bl. et O. Bolòs 1958.

the year 2012 in order to improve the SIVIM website. Among the analysis capabilities developed this year, we should highlight the implementation of a potential distribution modeling tool for taxa and syntaxa stored on the database, which is based on the maximum entropy (MaxEnt) algorithm (Phillips *et al*., 2006). Figure 5 shows two examples of the generated maps. This tool also provides the resulting ROC curves, which evaluate the model performance. Additionally, nowadays it is possible to calculate the fidelity values for both species and syntaxa online. This allows users to find out the fidelity of a particular taxon to the associations in the database, as well as the opposite option (i.e. to select a particular association and see which are

its faithful species). Moreover, it is worth to mention the recent integration of SIVIM in mobile devices, smartphones, and tablets, with an Android operating system. The new app ZamiaDroid (http://biodiver.bio.ub.es/zamiaDroid) lets the user enter georeferenced data at the field (floristic observations, and relevés), and address data query to the SIVIM is also possible. Finally, a new system has been implemented by which users can easily report errors detected in the data: nomenclatural adjustments, syntaxonomical ascriptions, georeferencing, discrepancies with respect to original sources, and so on.

Conclusions and future issues

SIVIM is conceived to offer free online access to vegetation relevés from the Iberian Peninsula, the Balearic and Macaronesian archipelagos, and the bordering territories. It includes some basic tools for data analysis among which are worth to mention the taxa and syntaxa's potential distribution mapping and the quantitative estimation of fidelity (Phi and Ochiai) of taxa to plant communities. These characteristics, together with the large amount of compiled relevés, make this Project unique among the currently available vegetation databases. The SIVIM Project represents a small contribution to the task of opening up and spreading basic biodiversity data for their extensive use in research and applied issues.

Moreover, several improvements are ongoing. Regarding the data, we are working on data quality control and we are collecting more data from Portugal and the South of France, areas from where the number of available sources at our web portal is still small. The quality control will require an additional reviewing effort and an update of the taxonomic and syntaxonomic files (thesaurus) for which new regional experts' contributions will be needed. The application of automatic filters to detect probabilistic models-based errors would be helpful. Regarding the improvement of the analysis tools, all of them based on software enhancement, we should point out the possibility of using climate change models (ECHAM5, Roeckner *et al.*, 2003) in order to project the taxa and syntaxa's potential distribution for the future (years 2020, 2050, and 2080); and a web service for automatic determination of vegetation relevés as well. Araucaria (De Cáceres *et al.*, 2009), an early experimental version of this web service, is already implemented in the BDBC. We are currently working on a second version based on probabilities, which will be gradually implemented in SIVIM over the next three years. We also consider very important to encourage the participation of users, so we have developed an application to report errors and we are working on a new application to share images of plants and their communities at SIVIM.

Finally, the linkage to other national or local databases, in a similar way to EVA (European Vegetation Archive) or others initiatives, is a key task for the immediate future.

Acknowledgements

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