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SIVIM: an on-line database of Iberian and Macaronesian vegetation

SIVIM – das Online Datenbank-System zur Vegetation der iberischen Halbinsel und der Makaronesischen Inseln

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Abstract

SIVIM (Sistema de Información de la Vegetación Ibérica y Macaronésica) is an information system designed for capturing, hosting, editing, analyzing and outputting georeferenced plot data of Iberian and Macaronesian vegetation. It currently hosts 86,000 relevés, mainly from the northern half of the Iberian Peninsula and the Balearic Islands, and will grow to 100,000 relevés in the near future. SIVIM has been conceived to offer direct and free on-line access to relevés, tables, as well as to floristic, syntaxonomical and bibliographical records. The system also offers on-line software for edition and analysis of vegetation data. The main characteristics of SIVIM are presented, and its particular technical solutions to typical data banking problems as well as its future objectives are briefly commented.

Keywords: *relevés, vegetation databank, floristic databank, biodiversity informatics, information system*

Zusammenfassung

SIVIM ist ein Informationssystem, mit welchem georeferenzierte Daten zur iberischen und makaronesischen Vegetation erfasst, gehostet, editiert, analysiert und ausgegeben werden können. Momentan umfasst das System 86.000 Aufnahmen. In naher Zukunft soll die Anzahl der Aufnahmen auf 100.000 steigen, hauptsächlich durch Daten aus dem Norden der Iberischen Halbinsel und von den Balearen. SIVIM wurde initiiert, um einen direkten, freien Online-Zugang zu Vegetationsaufnahmen, Vegetationstabellen, sowie zu floristischen, syntaxonomischen und bibliographischen Daten anzubieten. Außerdem bietet es Online-Software, um Vegetationsdaten zu editieren und zu analysieren. Dieser Beitrag gibt eine Übersicht über die wesentlichen Eigenschaften von SIVIM und erläutert die implementierten technischen Lösungen typischer Datenbankprobleme sowie die zukünftigen Ziele.

Schlüsselwörter: Vegetationsaufnahme, Vegetations-Datenbank, Floristische Datenbank, Biodiversitätsinformatik, Informationssystem

1 Introduction

Over the last three decades, but especially in the last one, a remarkable number of vegetation databases have been developed in the frame of national and international programs devoted to the study, management and conservation of plant biodiversity. Vegetation databases store a vast number of vegetation plots, including the large number of phytosociological relevés made in the Braun-Blanquet tradition, as well as other plant community data from publications and unpublished documents (theses, reports, etc...). Such rapidly growing databases are contributing to the knowledge of the typology, distribution and ecology of plant communities (Chytrý & Rafajová 2003), as well as to the autoecology and chorology of plant species. They are also opening new methodological approaches for classical questions in the fields of community classification, community ecology, biogeography and macroecology (Bekker et al. 2007), including impacts of climate change (Lenoir et al. 2008).

According to Schaminée et al. (2009) and Hennekens (2009) (http://geobot.botanik.uni-greifswald.de/portal/index.php?option=com_content&task=view&id=99&Itemid=272) there are more than 4,300,000 vegetation plot records existing in Europe, of which around 1,800,000 are already stored in electronic format thanks to a growing list of vegetation computerizing projects. Some remarkable examples are the French database *Sophy* (http://sophy.u-3mrs.fr), a pioneer that began in 1978 and is currently storing 187,000 relevés; the database of the Dutch agency *Alterra* (*Green World Research*, http://www.synbiosys.alterra.nl), scoring with around 600,000 relevés in TURBOVEG format (Hennekens & Schaminée 2001); the Czech vegetation database from Masaryk University at Brno (http://www.sci.muni.cz/botany/vegsci/dbase.php?lang=en) that stores around 137,000 relevés (Chytrý & Rafajová 2003); or the German database *VegetWeb* (http://www.floraweb.de/vegetation/aufnahmen.html) that stores around 11,000 relevés in a format similar to the American database *VegBank* (http://vegbank.org), sponsored by the *Ecological Society of America – Panel on Vegetation Classification*, which hosts around 22,000 plots from USA and Canada, mainly from forest vegetation. With exception of the latter two systems, these databases are not public but some of them offer copies of the data for scientific use on request.

In spite of the large amount of computerized plot records in Europe, there are still some scientific, technological and even political obstacles (e. g. syntaxonomical and taxonomical standardization; Bruelheide & Chytrý 2000) that limit the wide use of the data (Ewald 2001). Because of that, the access to large biodiversity databanks and the standardization and linkage of all sorts of ecological databases is considered a priority that may open up new research lines and methodological possibilities on the related issues (Ozinga et al. 2005, Bekker et al. 2007, Schaminée et al. 2007, 2009).

2 The SIVIM data bank and web

2.1 Antecedents, context and current status

The longstanding phytosociological tradition in Spain has produced an estimated number of 150,000 to 200,000 (165,000 according to Hennekens 2009) relevés. However, the compilation of dispersed and often poorly accessible literature sources containing relevés (to date, more than 1,500 references on Iberian and Macaronesian vegetation have been collected under SIVIM) is a difficult task. Thus, the Iberian vegetation checklist (Rivas-Martínez et al. 2001, 2002), a valuable work series gathering all published Iberian syntaxa, was not able to manage the majority of available relevés because they were not computerized.

SIVIM (in Spanish, *Sistema de Información de la Vegetación Ibérica y Macaronésica*; http://www.sivim.info/sivi) was born in the frame of a nationally funded research project of the Global Change, Earth Sciences and Biodiversity Program. A consortium of four Spanish universities with a team of 22 researchers are currently involved in the database management: University of Barcelona (X. Font, J. Carreras, E. Carrillo, J.M. Ninot, J. Moreno and R. Quadrada), University of the Basque Country (EHU, Bilbao) (J. Loidi, I. Biurrun, J.A. Campos, I. García-Mijangos and M. Herrera), University of Castilla-La Mancha (Toledo) (F. Fernández-González, P. Rodríguez Rojo, R. Pérez-Badia, S. Sardinero and V. Bouso), and University of León (C. Lence, C. Acedo, R. Alonso, F. Llamas, S. del Río and L. Herrero). The project has been recently renewed for the next 3 years.

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 15 years ago and now hosts 21,000 relevés from Catalonia and neighbouring areas (Font & Ninot 1995). Most of the characteristics applied in SIVIM are based on those already implemented and tested in BDBC.

SIVIM is conceived as a vegetation data system designed for capturing, hosting, editing, analyzing and outputting georeferenced vegetation data. It was created with the aim to be a helpful tool both in scientific research and in assessment of decision making on land planning and management.

There are two other projects in Spain concerning floristic databases at the national scale. The Spanish GBIF node (http://www.gbif.es) compiles specimen records from the information delivered by natural history collections (Herbaria). The project *Anthos* (http://www.anthos.es) has been developed in the Royal Botanical Garden of Madrid to compile floristic records from the botanical literature. As SIVIM has been developed for recording data from phytosociological relevés, with the ensemble of these three projects plant data from all types of sources will be available in the immediate future. Phytosociological data with their coverage of all species present in a relevé, regardless of their frequency and taxonomic status, are an important complement to herbarium collections and the floristic literature, both of which are preferentially focused on relatively uncommon species and taxonomically difficult groups. 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 86,000 phytosociological relevés, mainly from central and northern Spain as well as Balearic islands (Fig. 1), where data compilation has primarily focused so far. These relevés contain around 1,500,000 floristic records, which are now available for consultation not only in the SIVIM web but also in the national (http://www.gbif.es) and international (http://www.gbif.org) GBIF nodes. Around 1,500 scientific references (books and papers) have been screened for their inclusion into the database, the oldest dating from more than 80 years ago. One of the project goals by the end of 2009 is to reach 100,000 Ibero-Macaronesian vegetation relevés which would represent two thirds of the lower estimation of accessible data in the territory covered by the database. During its first year of operation, the SIVIM web has received 20,000 visits for consulting or requesting data. In the last year, visits are mainly from Spain (47 %) and European research centers, secondly by enviroment consultings and in a minority from public agencies.

The phytosociological spectrum of the data currently available in SIVIM is summarized in Table 1 by phytosociological classes and physiognomic-ecological groups of classes (nomenclature follows Rivas-Martínez et al. 2001, 2002). By far, the most documented classes are those referred to woodland, heathland, grassland and synanthropic vegetation, each of these four major groups accounting for more than 12,000 relevés. In most of these groups, Eurosiberian and Mediterranean classes are equivalently represented in terms of number of relevés (e. g. Quercetea ilicis vs. Querco-Fagetea), meaning that SIVIM already includes almost all the available relevés from northern Iberia, where Central European vegetation develops variously in Atlantic areas and on mid-altitude mountains. Moreover, there is a noticeable documentation on the other biogeographic main vegetation units found in the area considered (Alpine, Canarian, coastal, etc). Thus, this data bank is already a representative basis for any study dealing with Iberian and Macaronesian vegetation, and is especially appropriate when focusing on the transition from Mediterranean to Eurosiberian units.

2.2 Technical issues

SIVIM was formally opened in late 2007 with the web site located in the Department of Plant Biology of the University of Barcelona. The server is a PC with a Linux operating system (SuSe 11). The Java Enterprise Edition platform was chosen in order to ensure maximum flexibility in the deployment of the system and to guarantee an appropriate scalability to support any increases of the user base. The programs (servlets) are written completely in Java language and allow consulting and downloading vegetation data (both relevés and tables) in XML format. This format is compatible with the *VegAna* (De Cáceres et al. 2003) suit of tools for vegetation analysis and edition, freely available in the same web site. The *Quercus* module of *VegAna* allows data conversion from XML to other data formats common in numerical analyses of vegetation, as well as manipulation and edition of data prior to conversion. As for the software requirements, all the programs to be used are free: Java virtual machine, database manager DB2 9.5 (Express) and Tomcat Web Server 6.0. At present the web is in Spanish, taking into account the expected language of most of their users, but for the *VegAna* packages an English version is also supported.

The process of incorporation new vegetation plots to the database depends upon the characteristics of the original sources, but most of the work is based on programmed routines that allow a rapid formatting of pdf files or scanned tables of relevés as text files, using OCR software. Further routines include detection of formatting mistakes, controls for coherence of the data and a first screening of the taxonomic nomenclature. After a last revision of the result by comparison with the source, relevés are entered to the database and available to the regional experts for further revisions.

2.3 *Site descriptors and metadata*

The SIVIM database includes fields for all the community descriptors commonly used in phytosociological relevés (e. g. Mucina et al. 2000), but the structure of data is open to other kinds of metadata susceptible to be applied in particular analyses or sampling designs (Brunt 2000). Metadata fields can be exported and managed by users to carry out specific analyses under programs or packages other than those available at the SIVIM web.

To improve the applied uses of the database and broaden its users' range, all relevés are being georeferenced with an accuracy of at least the UTM 10x10 km grid, with the scientific support of the regional experts involved in the project. Georeferencing is a major effort in the management of SIVIM, because many old relevés are not accurately located in the original publications and significant amounts of the published georeferences contain mistakes. Geographic filters and detailed checking by regional experts are the ways used to improve quality of georeferencing (Chapman & Wieczorek 2006), which, on the other hand, is a key objective for user queries (e. g., mapping outputs) and for future applications like modelling the distribution of species or communities, or assessments in plant conservation.

2.4 *Nomenclatural issues*

The handling of multiple scientific names and taxonomic concepts is one of the greatest challenges in biodiversity databases (Berendsohn et al. 1999). In SIVIM different species names recorded in relevés from different times or locations are mapped into a common nomenclatural reference, identifying them as belonging to the same taxon. It also allows the

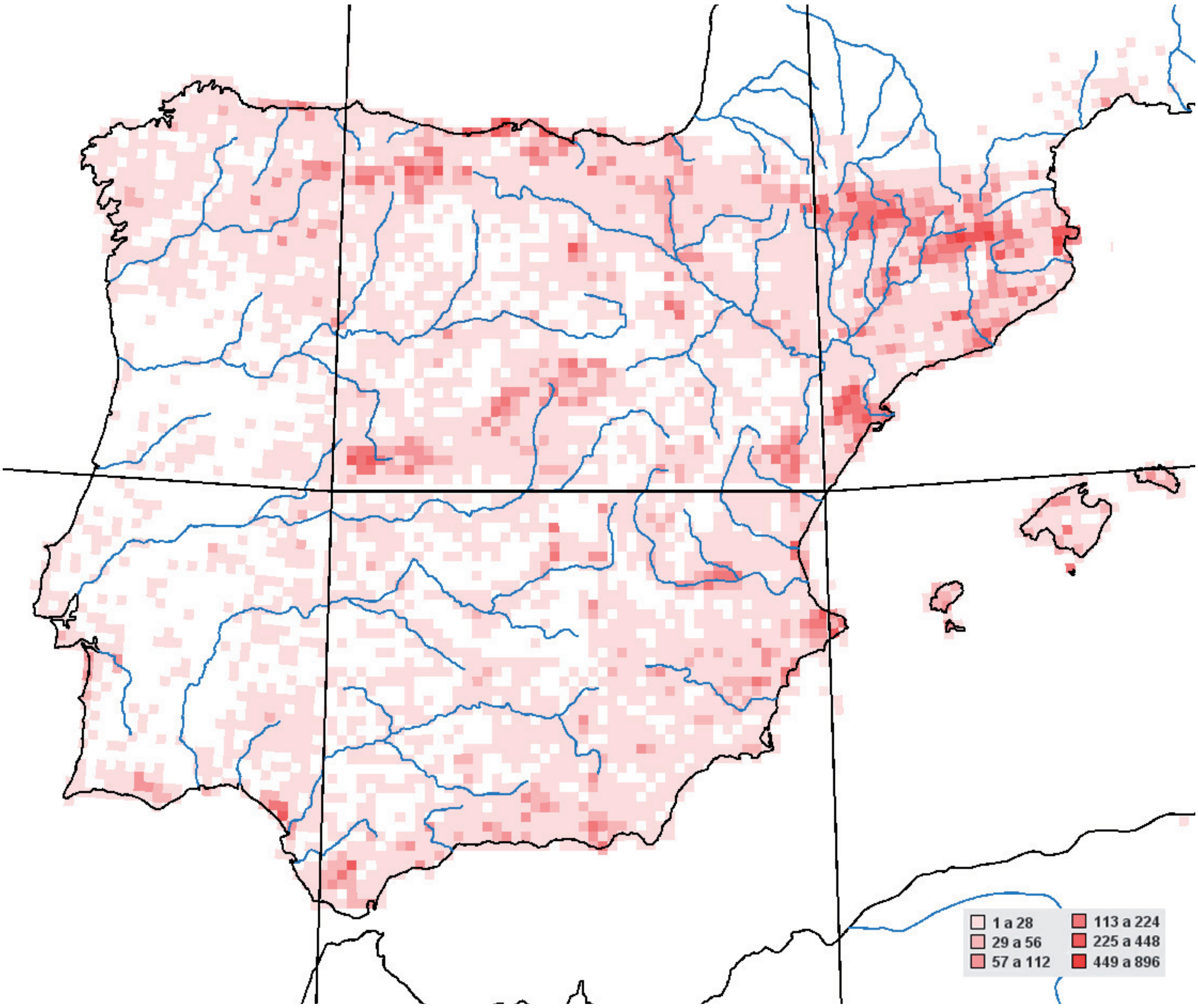

Abb. 1: Geographische Verteilung der in SIVIM digital gespeicherten Vegetationsaufnahmen.

Fig. 1: *Geographic distribution of the relevés computerized in SIVIM.*

Tab. 1: SIVIM eingestellte Aufnahmenzahl nach pflanzensoziologischen Klassen und Klassegruppen.

Tab. 1: *Number of relevés included in SIVIM per phytosociological classes and class groups.*

I. Aquatic vegetation	**1,302**
Charetea fragilis	48
Lemnetea	139
Potametea	1,017
Halodulo wrightii-Thalassietea testudinum	4
Ruppietea	46
Zosteretea marinae	48
II. Amphibious vegetation	**5,955**
Bidentetea tripartitae	324
Isoeto-Nanojuncetea	848
Isoeto-Littorelletea	216
Montio-Cardaminetea	491
Phragmito-Magnocaricetea	2,596
Oxycocco-Sphagnetea	177
Scheuchzerio palustris-Caricetea nigrae	1,293
Utricularietea intermedio-minoris	10
III. Coastal and continental halophilous and sand dune vegetation	**6,691**
Ammophiletea	2,214
Cakiletea maritimae	200
Crithmo-Limonietea	722
Juncetea maritimi	1,111
Saginetea maritimae	401
Sarcocornietea fruticosae	1,497
Spartinetea maritimae	97
Thero-Salicornietea	449
IV. Chasmophytic, epiphytic and scree vegetation	**7,185**
Adiantetea	243
Asplenietea trichomanis	3,073
Parietarietea	642
Petrocoptido pyrenaicae-Sarcocapnetea enneaphyllae	168
Anomodonto-Polypodietea	421
Greenovio-Aeonietea	188
Phagnalo-Rumicetea indurati	261
Thlaspietea rotundifolii	2,189
V. Synanthropic, fringe and megaforbic vegetation	**12,277**
Artemisietea vulgaris	1,197
Epilobietea angustifolii	112
Oryzetea sativae	52
Pegano-Salsoletea	1,269
Polygono-Poetea annuae	507
Stellarietea mediae	7,333
Galio-Urticetea	815
Cardamino hirsutae-Geranietea purpurei	163

Mulgedio-Aconitetea	360
Trifolio-Geranietea	469
VI. Supratimberline zonal vegetation on cryophilous geliturbated soils	**3,438**
Carici rupestris-Kobresietea myosuroidis	198
Kobresio myosuroidis-Seslerietea caeruleae	940
Caricetea curvulae	980
Loiseleurio-Vaccinietea	87
Salicetea herbaceae	270
Festucetea indigestae	963
VII. Grassland and meadow vegetation	**14,418**
Tuberarietea guttatae	2,057
Festuco-Brometea	1,577
Festuco hystricis-Ononidetea striatae	1,352
Koelerio-Corynephoretea	145
Poetea bulbosae	213
Sedo-Scleranthetea	156
Lygeo-Stipetea	3,013
Stipo giganteae-Agrostietea castellanae	44
Molinio-Arrhenatheretea	4,933
Nardetea strictae	928
VIII. Heathland, dwarf scrub and scrub vegetation	**11,742**
Calluno-Ulicetea	2,078
Cisto-Lavanduletea	1,477
Rosmarinetea officinalis	5,163
Cytisetea scopario-striati	1,241
Rhamno-Prunetea	1,783
IX. Forest, woodland, semidesert and desert potential natural vegetation	
IXa. Riparian shrublands and woodlands	**2,636**
Alnetea glutinosae	46
Betulo carpaticae-Alnetea viridis	6
Nerio-Tamaricetea	643
Salici purpureae-Populetea nigrae	1,941
IXb. Eurosiberian and Mediterranean potential natural vegetation	**13,095**
Lauro azoricae-Juniperetea brevifoliae	12
Junipero sabinae-Pinetea sylvestris	1,128
Quercetea ilicis	5,525
Querco-Fagetea	5,428
Vaccinio-Piceetea	1,002
IXc. Canarian and Madeiran potential natural vegetation	**772**
Chamaecytiso-Pinetea canariensis	262
Kleinio-Euphorbietea canariensis	238
Polycarpaeo niveae-Traganetea moquini	34
Pruno hixae-Lauretea novocanariensis	238
Relevés not adscribed to phytosociological units	**6,402**

integration of biodiversity databases of various kinds. For a potential user without expertise on nomenclatural subjects, a vegetation database should furnish a clear and sound taxonomical reference. This objective poses particular difficulties in territories like the Iberian Peninsula, where a thorough revision of the vascular flora (the *Flora iberica* project, http://www.floraiberica.org) has been in progress since 20 years and has been completed to ca. 60 % only. To cope with these problems, SIVIM uses a taxonomic thesaurus following the proposals of the *Anthos* project (www.anthos.es) of the Royal Botanical Garden of Madrid, enhanced with other floristic repertories from northwest Africa and the Macaronesian archipelagos and the periodic updating derived from *Flora iberica*. Even after the application of this thesaurus to the digitized tables of relevés, a revision is needed for detecting orthographically incorrect names or failure of taxonomic assignments. Our experience shows that further detailed revisions allow detecting other identification mistakes attributable to the authors of the relevés or to old erroneous taxonomic interpretations, which escape the automatic application of the thesaurus, and thus continuously improve the nomenclatural quality of the database. The scientific support of regional experts on flora and vegetation is crucial at this step. In any case, the original name is maintained unchangeable in a field of the database, while a second field holds the updated or corrected name according to the thesaurus or to the expert's opinion. A third field may be filled in to indicate the accuracy level of the identification. Information about taxonomical updating is being kept in the database but at present is not accessible to external users.

During our discussions with managers of other floristic databases, they have suggested that phytosociological relevés may contain more taxonomic identification errors than other sources of floristic data. However, the frequency of errors depends upon authors and territories, and is more serious in regions that have been subject to nomenclatural and taxonomic instability in the last decades. From these relatively few cases, it would be wrong to attribute low accuracy to phytosociological data in general, which are mostly sound assessments of species assemblages. In addition, it must be remembered that other data sources, such as herbarium specimens, also contain identification or georeferencing errors, which also require continuous revision in the future by specialists. However, to obtain detailed information on the distribution of a large list of species in a certain territory, the records from herbarium collections do not yield a sufficient density of data, so that additional data sources like field observations are indispensable. This is the case for several groups of organisms in the GBIF project (most typically birds), where field observations contribute the vast majority of data. In the Iberian Peninsula, as it has been pointed out, floristic records from phytosociological relevés are a principal source of plant distribution data.

As regards to syntaxonomical nomenclature, SIVIM follows the checklist of Rivas-Martínez et al. (2001, 2002), but separated fields for the original name (verbatim, unchangeable) and for the corrected or updated name of each relevé are included in the database structure. The syntaxonomical thesaurus solves synonymies and allows users to address queries to different levels of the hierarchical classification of vegetation.

The nomenclatural solutions adopted so far in SIVIM fits to the requirements for connection to other biodiversity databases, like GBIF standards. Nevertheless the proper implementation of a complete concept taxonomy, through developing the 'potential taxon' (Berendsohn 1995), 'assertion' (Pyle 2004) or 'taxon concept' (Franz et al. 2008, Jennings et al. 2009; http://vegbank.org) formulations, will require adaptations in the current thesaurus difficult to cope with in the context of nomenclatural instability. Syntaxonomical nomenclature is even harder to manage properly because names but also circumscriptions of syntaxa at the level of individual relevés are involved. Improvements on these subjects will be tackled in the next stage of the project.

2.5 Consulting and downloading data

Unlike other vegetation databases, SIVIM is conceived to offer direct and free on-line access to relevés, tables, and floristic, syntaxonomical or bibliographical records through versatile queries. The SIVIM portal currently offers the following query options:

- relevés of a particular syntaxon
- distribution area (map) of a selected syntaxon (Figure 2)
- syntaxa or relevés in one 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
- literature references containing relevés of a selected syntaxon

Data downloading of both relevés and tables is performed in XML format. Downloading details and options for data conversion were indicated in section 2.2. To date, no noticeable problems have arisen from putting relevés on line, but consultations with the editors of the main journals containing relevés included in SIVIM were carried out, and permission is requested to authors of unpublished relevés (dissertations, doctoral theses) before their inclusion in the database. In general, scientists and conservation managers share a high level of agreement about 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 making public the accurate location of threatened or protected species, plants in particular, which should not be finer than the 10x10 or 1x1 km grid cell to avoid possible risks. Accurate locations of these species should only be facilitated upon request and previous justification of their use for research or conservation purposes.

3 Conclusions and future issues

As presented here, SIVIM has been conceived and designed to offer free on-line access to vegetation data, including some basic tools for editing and analysing them. Such traits make it unique among the currently available vegetation databanks, and should facilitate its applications in biodiversity inventory, management and conservation, besides other more obvious uses related to research and education.

Several enhancements of the database are under way or have been scheduled for the next phase of the project and will be soon available. New relevés will be added, coming mainly from those areas rather poorly covered until now: Southern Spain, Portugal and the Macaronesian archipelagos. The improvement of record quality is a key target for biodiversity databases (Lobo 2008) and will require additional efforts for revision of floristic updating and georeferencing, including the integration of new regional experts in new areas and the implementation of automatic filters for error detection. As we have found vegetation classification and syntaxonomical work on large data sets to be a way of stimulating the revision and correction of database records, SIVIM will aim to promote this kind of research and offer flexible tools for interacting with users capable to generate nomenclatural and georeferencing corrections during their research. In fact, the teams involved in SIVIM are developing research lines for optimal use of the database in vegetation classification, invasive plant biology (Chytrý et al. 2008) and the analysis of the diagnostic value of plant species (De Cáceres et al. 2008). Mapping outputs can also be improved in order to make the system more attractive and to broaden the range of potential users. In particular, new modules for the generation of distribution models of species and communities, including GIS thematic maps for those environmental variables required in modelling, could be a valuable contribution of SIVIM in the frame of vegetation databases. Finally, the linkage to other national or local databases is a task for the immediate future (Schaminée et al. 2009).

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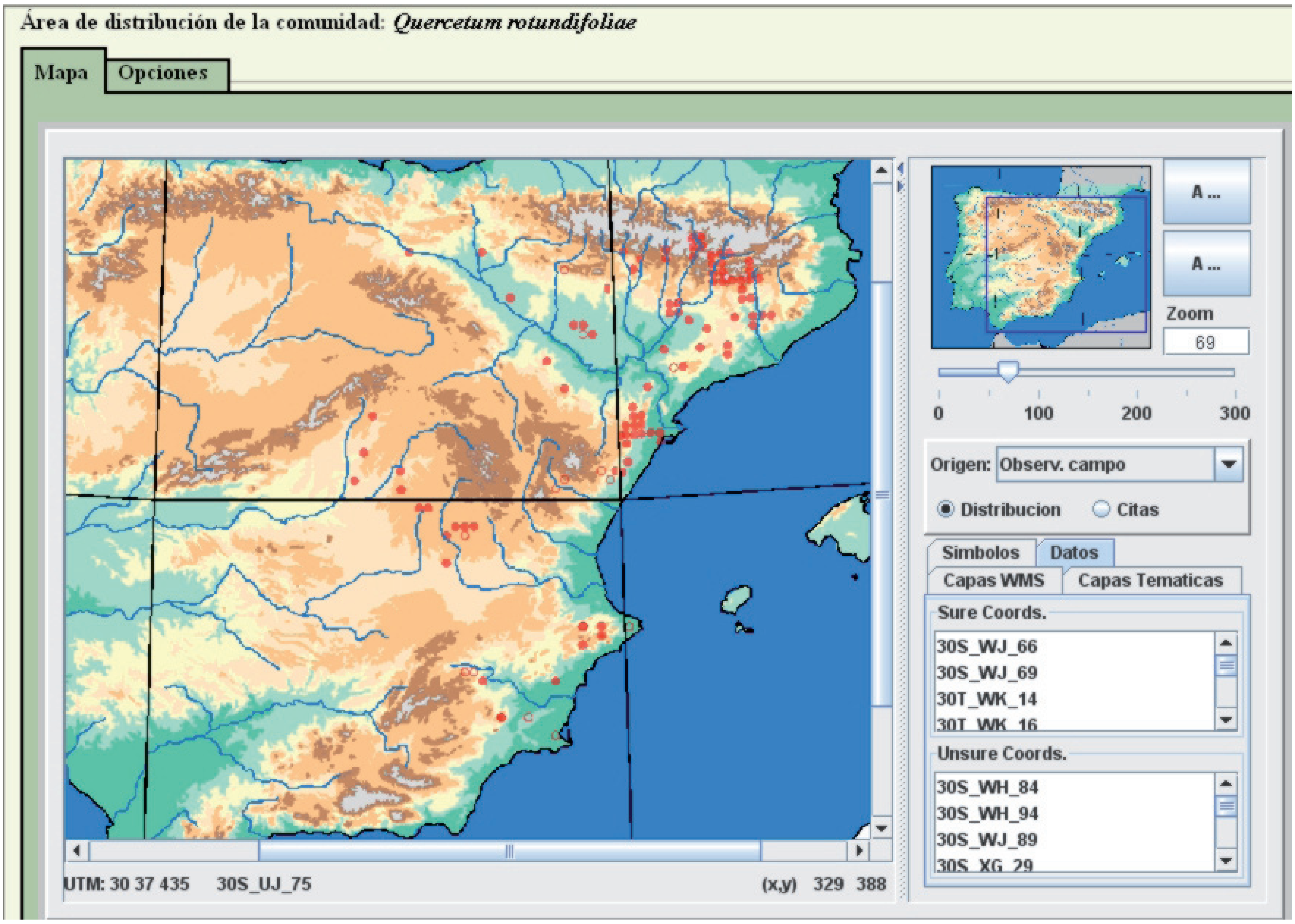

Abb. 2: Distribution map of the association Quercetum rotundifoliae.

Fig. 2: *Verbreitungskarte der Assoziation Quercetum rotundifoliae.*

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