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Integrated tools and methods for the analysis of agro-ecosystem's functionality through vegetational investigations.

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Abstract
The floristic-vegetational indexes system proposed by Taffetani & Rismondo (2009) is here integrated and improved with some recent practical examples.
The method is based on the integration and the reprocessing of data coming from vegetation studies and information stored inside two databases that have been set-up for this purpose. This method was created for the analysis of the ecological functionality of agro-ecosystems and it allows measurement of the evolutive level and ecological characteristics of the individual phytocoenoses. Moreover, it allows evaluations of the conservation status of specific rural contexts, comparisons of the effects of different land management practices, and quantification of the value of the ecosystem services. This is thus a method for the correct application of the Habitat Directive 92/43/CEE and for the identification of HNV Farmland Areas.
This paper presents updates concerning the databases and some indexes. These modifications arise from the need to make the analysis model more flexible and effective, and to improve the analytical structure of the system. We provide here an overall description of the structure of the two databases and of their relationships, together with all indexes included in the analytical system.
Potential applications of the system, concerning the identification of areas with the best, or the worst, conservation status and of the most appropriate management techniques for the conservation of agro-biodiversity, are showed with practical examples.

Keywords: Phytosociology, agro-ecosystem, floristic-vegetational indexes, databases, biodiversity.

Riassunto
Il sistema di indici floristico-vegetazionali proposto da Taffetani & Rismondo (2009) viene integrato e perfezionato con alcuni più recenti esempi applicativi.
Il metodo, basato sull'integrazione e la rielaborazione di dati derivanti dallo studio della vegetazione e di informazioni contenute in due database appositamente costituiti (floristico-sintassonomico e delle classi sintassonomiche), viene utilizzato per l'analisi della funzionalità ecologica degli ecosistemi agricoli e permette di misurare il grado evolutivo e le caratteristiche ecologiche delle singole fitocenosi. Consente inoltre di valutare lo stato di conservazione di determinati contesti rurali, mettere a confronto gli effetti di modalità gestionali differenti e quantificare il valore dei servizi ecosistemici. Costituisce un metodo per la corretta applicazione della Direttiva 92/43/CEE e l'individuazione delle aree agricole ad elevato valore naturalistico (HNV Farmland Areas). Viene fornita una descrizione della struttura dei due database e delle relazioni intercorrenti tra gli stessi e vengono proposte modifiche che scaturiscono dalla necessità di rendere più agile ed efficace il modello di analisi e di migliorare la struttura analitica del sistema di bioindicatori.
I risultati applicativi presentati mostrano le potenzialità assunte dal sistema nei confronti dell'individuazione delle aree caratterizzate dalle più gravi problematiche di conservazione e delle tecniche gestionali più idonee alla tutela della biodiversità in ambito agricolo.

Parole chiave: Fitosociologia, agroecosistema, indici floristico-vegetazionali, database.

Introduction

The protection of the semi-natural elements of the rural landscape (Sykora *et al*., 2002; Davis & Pullis, 2007; Devictor & Jiguet, 2007; Manhoudt *et al*., 2007) and the maintainance of a favorable conservation status of plant and animal biodiversity is essential to preserve the ecological farming systems (Beaufoy *et al*., 1994; Altieri, 1999; Benton *et al*., 2003; Tscharntke *et al*., 2005; Kleijn *et al*., 2006).

The analysis of the vegetal landscape allows the characterisation of the quality of agro-ecosystems on the basis of the results from interactions of the environmental factors with the combined effects arising from various forms of anthropogenic disturbance. The consequent mosaic is influenced by the specific pedoclimatic and morphological conditions (Rivas-Martínez *et al*., 2004; Casavecchia *et al*., 2007), as much as by the different management practices adopted by individual farmers. The maintenance of this mosaic is functional towards the conservation of landscape, communities, and species diversity (Tonioli *et al*., 2005).

A quantitative evaluation of floristic biodiversity and of the conservation status of different habitats inside specific rural realities can be obtained through the application of indexes that provide a numerical synthesis of the ecological information that is linked to the individual phytocoenoses. In this regard, there have been several applicative examples relative to the national (Vitali *et al*., 2008; Puppi, 2008; Puppi & Mongardi, 2008) or international contexts (Penas *et al*., 2005).

The bioindicators system (Taffetani e Rismondo, 2009), here updated, is based on vegetation study: the environmental quality is measured on the basis of the characteristics of the single phytocoenosis; it doesn't depend only from indication provided by the individual species. The information content of each vegetation community comes from the attribution of a numeric value to every single syntaxonomic class and from the assignment of each species to a syntaxonomic class, on the basis of its ecological features.

The study of the vegetation (Westhoff & Van der Maarel, 1978; Gèhu & Rivas-Martínez, 1981) with the phytosociological method provides a scientific approach that has been used all over the world and that has numerous advantages:

- it is a rapid method, where the results can be applied at all levels, and are generalisable.
- it is based on a hierarchical system (Westhoff & Van der Maarel, 1978; Pignatti *et al*., 1995) that expresses the ecological features of the coenoses, their structures, and their geographical distributions;
- it allows an interpretation of the dynamism of the coenoses and predicts their transformation following management changes;
- it allows the subdivision of the territory into homogeneous units from the ecological and dynamic points of view;
- the data for the vegetation are widely available for a large part of the European territory, and in particular, for the Italian area, and important cartographic processings (Gallizia Vuerich *et al*., 1998) and diachronic comparisons are therefore possible;
- it has been adopted by the Directive 92/43/EEC, which is the most important European normative for conservation.

The application of the mentioned method for the analysis of the agro-ecosystems allows to convert the qualitative information related to vegetation into a quantitative data; it also allows measurement of the environmental value of a specific area at a given moment, and interpretation of the dynamic relationships that exist between the elements that make up the vegetal landscape. Taking into account the simplification of the agricultural systems and the need to translate the data from the vegetation into qualitative values that can express even small variations in the loss of natural conditions, the objective of the bioindicator system is to make use of the enormous informational content of the vegetation, by attributing to the coenoses numerical values linked to their main dynamic and ecological components, which are easily interpretable and which can be integrated with other indicators, such as those ecological and economic. This is therefore a system of indexes, not a model, constructed to evaluate separately the main factors that are considered, and to be easy to interpret, modify and update. The methodology allows information to be obtained regarding the evolutive dynamics (structuring or complexity loss), the biodiversity and the ecology, of every individual vegetal community.

The integration of numeric values calculated for the coenoses with spatial data obtained from the cartographic processing allows instead the evaluation of the overall conservation status of entire territorial contexts.

The system represents an important instrument of analysis aimed at interpretation of management dynamics and at monitoring of the conservation status of the coenoses, and as a valid decisional support for indicating exploitational models for conservation or reconstruction of particular habitat types.

Materials and methods

Floristic-syntaxonomic database

The floristic-syntaxonomic database comprises the list of all of the species included in the Italian Flora (Pignatti, 1982; Conti *et al*., 2005). Within this database, for every taxa, the following data have been inserted: numerical code, species name, life form, chorological type, and classification of the exotic flora (cultivated, adventitious, exotic, hemihemerophyte) (Viegi *et al*., 2003; Camarda *et al*., 2005; Poldini *et al*., 2001) and the endangered flora (IUCN classification, attachments II, IV, V of the Habitat Directive 92/43 EEC) (IUCN 2001; Pignatti *et al*. 2001; Pignatti *et al*., 2001; Scoppola & Spampinato, 2005).

Each species has also been associated with a code through which the species is linked to a series of information that is needed for the calculation of the various indexes described below. This information is in part derived from the attribution of the species to a specific syntaxonomic class. The unique assignment of each entity to its reference class is based on consultation of the contributions of various European authors (Guinochet *et al*., 1973; Rameau *et al*., 1989; Oberdorfer, 1990; Royer, 1991; Biondi *et al*., 1995; Rivas-Martínez *et al*., 2002; Klotz *et al*., 2002; Biondi *et al*., 2005; Taffetani & Rismondo, 2009).

The criteria for the choice of the class to which a species belongs is mainly based on the frequency of the syntaxonomic attribution ascertained from the literature and on the ecological and phytogeographical role of each taxon. For species where these literature references are not available, the class was assigned on the basis of the ecological and biogeographical significance of the taxon in the study territory (Taffetani & Rismondo, 2009).

The database updating is still in progress as the method is applied to new territories. This also involves the correction of the syntaxonomic attributes regarding some of the botanical entities, according to a careful re-evaluation of the ecological role of these entities in the new agro-ecosystem contexts studied. The floristic-syntaxonomic database is therefore a dynamic instrument, as it will be subjected to successive improvements; for this reason, the web was chosen for its divulgation, and it will be available online at the web address of www.museobotanico.univpm.it. As an example, an extract of the database is given in Figure 1, which shows the fields containing the information described above.

Syntaxonomic classes database

The database of the syntaxonomic classes takes into consideration the main European vascular vegetational classes, constructed according to the scheme proposed by Rivas-Martínez *et al.* (2002), and reduced to the classes of Italian territory. The ecological information obtained from the attribution of the species to specific syntaxonomic classes (described in the preceding paragraph) are derived from the possibility of relating the vegetational classes both according to the serial dynamic evolutive gradients and to the ecological gradients of dependence on limiting factors (above all, those edaphic) that regulate the development of the coenoses linked to them. For this reason, the vegetational classes have been divided through the attribution of a code that characterises them as classes with serial dynamic evolution (*se*), and as classes with specific edaphic characters: hydrophilous (*sw*), xerophilous (*sx*) and halophilous (*sa*).

Starting with these considerations, a coefficient (*y*) has also been attributed to each syntaxonomic class; this quantifies the evolutive value of the various vegetational types that have serial dynamic interactions, or ecological links, with the specific limiting factors. In the case of the vegetational classes that are considered as "serial" (*se*), the attribution of the coefficient, defined as the coefficient of maturity ($y_{se}=m$), is based on the physiognomico-structural, synecological and syndynamic factors. This has a range of values from 1, assigned to classes of commensal species of the cultivated fields or the pioneering terophytic phytocoenoses, to 9, attributed to the classes of forest vegetation (Taffetani & Rismondo, 2009). In the present study, the value of 0 has also been added to the exotic or cultivated entities that have no evolutive significance and are therefore not attributable to specific syntaxonomic classes, although they are anyway present (and therefore measurable) with different values of coverage within the rural territory. It is also important to stress that the classes of herbaceous coenoses take up the major part of the range considered (values from 1 to 7). This allows greater emphasis to be given to the floristic and structural differences that exist between the various terophytic or hemicryptophytic communities that in the agro-ecosystems are in the majority with respect to those arbustive and arboreal, as well as being more sensitive in terms of responses to the variations in anthropogenic disturbances.

Hygrophilous, xerophilous or halophilous coefficients have been given to the vegetational classes with edaphic character ($y_{sw;sx;sa}=s$; value range, 1-9). These reveal the ability of these coenoses to develop

CODE	FBIO	TCOR	NOME	CCOD	BROM	FLOF	OBER	ROYE	RIVA	FLFF	BFLO
38901200	H caesp	PALEOTEMP.	Bromus erectus Hudson	FEBR	FEBR	FEBR	FEBR	FEBR	FEBR		
187306000	P caesp	EUROSIB.	Salix viminalis L.	SAPO		SAPU, ALGL	SAPU			SAPU	SAPU
229900400	T scap	AVV.	Amaranthus retroflexus L.	STME		STME, ARVU	STME		STME		
335311400	NP	EURIMEDIT.	Rubus ulmifolius Schott	RHPR		RHPR	RHPR		RHPR		
472000300	P scap	EUROP.-CAUC.	Acer campestre L.	QUFA		QUFA	QUFA		QUFA		
606200100	H scap	S-MEDIT.	Foeniculum vulgare Miller	ARVU			STME, ARVU,		ARVU		
732801400	H scap	EURIMEDIT.	Mentha spicata L.	MOAR		MOAR	ARVU				
757905500	T scap	AVV.	Veronica persica Poiret	STME		STME	STME		STME		
892600100	T scap	AVV.	Conyza canadensis (L.)	STME		STME	STME, EPAN		STME		STME
935800100	H scap	CIRCUMBOR.	Artemisia vulgaris L.	ARVU		ARVU	ARVU		ARVU		

Fig. 1 - Floristic-syntaxonomic database extract and related fields: CODE (numeric code for each species); NOME (genre and species); FBIO (life form); TCOR (chorological type); CCOD (identification code of the class assigned to the species; for legend see Tab. 1); BROM (class attribution according to Biondi *et al*. 1995); FLOF (class attribution according to Guinochet *et al*. 1973); OBER: (class attribution according to Oberdorfer 1990); ROYE (class attribution according to Royer 1991); RIVA (class attribution according to Rivas-Martínez *et al*. 2002); FLFF (class attribution according to Rameau *et al*., 1989; BFLO (class attribution according to Klotz *et al*., 2002).

under hygrophilous/ dry conditions, or in situations with high salinity of the terrain.

In the present study, *Salici-Populetea* has also been included among the hygrophilous vegetational classes, according with Biondi *et al*. (2006). This has been defined as a hygrophilous class with a hygrophilous coefficient of 9. The orders *Populetalia albae* and *Salicetalia purpureae* are also part of the same hygrophilous class. In the original version (Taffetani & Rismondo, 2009), the class *Salici-Populetea* was not included in the database. The syntaxon *Populetalia albae* was included in the *Querco-Fagetea* non-hygrophilous forestal vegetational class, in agreement with Rivas-Martínez *et al*. (2002). The order *Salicetalia purpureae* was instead included in the hygrophilous class *Salicetea purpureae*, with a hygrophilous coefficient of 8. With these modifications, the hygrophilous indications relative to the species of the order *Populetalia albae* were therefore included.

The up-dated database of the syntaxonomic classes is given in Table 1.

Relational database for data management and calculation of the floristic-vegetational ecological indexes

In order to manage the ecological and dynamic information that is available for each species, a relational database was realised in order to integrate vegetational and floristic data. This is functional for the calculation of the ecological indexes used to evaluate the level of territory modification inside the agro-ecosystem, with regard to the anthropogenic disturbances. The logical architecture of the database allows the building of the relationships between the qualitative and quantitative data based on the ecology (and syndynamics) of the species and on their levels of coverage that are derived from the analyses of the vegetation carried out in the study areas that have been investigated to date.

Figure 2 shows the logical scheme of the relationships that exist between the various information archived within the database. This system is based on archives (entities) that contain various information (species, vegetational classes, phytosociological relevés), within which there are various fields (attributes) associated with the records included in the Tables. The various database entities are then interconnected through relationships based on structural rules (joins/relates) that establish a connection between the common 'key' attributes of two or more Tables.

These relationships are used for the formulation of complex queries that allows the information contained in the various Tables to be extracted and joined together. Specifically, through the interrogation of the relational database, it is possible to obtain a report (Fig. 3) that contains the values of the coverage (*c*) and the maturity (*m*) or edaphic (*s*) coefficients, and the typology of the synaxonomic class to which the species present in one or more phytosociological relevés belong (*se, sw, sx, sa*); joining these data allows the calculation of the specific indexes described below. In the same way, it is also possible to extrapolate other types of information contained in the database, which can be useful, for example, in analysis of life forms, chorology, the presence of exotic or endangered species, or of the ecology of the individual taxa or vegetal coenoses.

Floristic-vegetational indexes system

The floristic-vegetational indexes presented by Taffetani & Rismondo (2009) can be divided into two different categories.

Indexes of the first category (coenotic indexes; see Fig. 4) provide information linked to the individual coenoses and they are calculated using the coverage values of each species present in a phytosociological Table and the information contained in the two databases mentioned above.

Among these, there are the index of maturity (*IM*), which is a measure of the evolutive value of a vegetal community, the edaphic indexes (*IW*, *IX* and *IA*), which give the hygrophilous, xerophilous and halopilous values, the indexes of the life forms (*IT*, *IH* and *IF*), with which it is possible to calculate the percentage incidence of therophyte, hemicryptophyte and perennial non-hemicryptophyte species, the phytogeographic indexes (*IL*, *ID* and *IE*), which relate to the exotic, widely distributed and endemic floristic components, and the index of floristic biodiversity (*IFB*).

The second category of indexes (cartographic indexes; see Fig. 4) instead allows a synthesis of the bioindications related to an entire territorial context, and they are calculated on the basis of the values associated to the coenoses identified and of the cartographic data. In this group, there are the index of synthetic maturity (*ISM*), which provides the mean maturity value of a specific area, and the index of unproductive areas (*IUA*), through which information about to the percentage incidence of seminatural areas (characerised by *IM*>2) is provided.

All of these indexes, along with their relevant formulae, are given within Figure 4.

In the present study, some of these indexes given above have been modified, as follows:

CNOME	CCOD	y_(m;s)	CL_TYP
Exotic or cultivated species	ESCO	0	se
Stellarietea mediae	STME	1	se
Polygono-Poetea	POPO	2	se
Artemisietea vulgaris	ARVU	3	se
Molinio-Arrhenatheretea	MOAR	4	se
Festuco-Brometea	FEBR	5	se
Koelerio-Corynephoretea	KOCO	5	se
Lygeo-Stipetea	LYST	5	se
Nardetea strictae	NAST	5	se
Poetea bulbosae	POBU	5	se
Cardamino hirsutae-Geranietea purpurei	CHGP	6	se
Galio-Urticetea	GAUR	6	se
Parietarietea	PAJU	6	se
Epilobietea angustifolii	EPAN	7	se
Mulgedio-Aconitetea	MUAC	7	se
Trifolio-Geranietea	TRGE	7	se
Calluno-Ulicetea	CAUL	8	se
Cisto-Lavanduletea	CILA	8	se
Cisto-Micromerietea	CIMI	8	se
Cytisetea scopario-striati	CYSS	8	se
Rhamno-Prunetea	RHPR	8	se
Rosmarinetea officinalis	ROOF	8	se
Erico-Pinetea	ERPI	9	se
Pino-Juniperetea	PIJU	9	se
Querco-Fagetea	QUFA	9	se
Quercetea ilicis	QUIL	9	se
Vaccino-Piceetea	VAPI	9	se
Oryzetea sativae	ORSA	1	sw
Charetea fragilis	CHFR	2	sw
Lemnetea	LEMN	2	sw
Potametea	POTA	2	sw
Bidentetea tripartitae	BITR	4	sw
Isoeto-Nanojuncetea	ISNA	4	sw
Adiantetea	ADIA	6	sw
Isoeto-Littorelletea	ISLI	6	sw
Montio-Cardaminetea	MOCA	6	sw
Oxycocco-Sphagnetea	OXSP	6	sw
Phragmito-Magnocaricetea	PHMA	6	sw
Scheuchzerio palustris-Caricetea nigrae	SPCN	6	sw
Utricularietea intermedio-minoris	UTII	6	sw
Nerio-Tamaricetea	NETA	8	sw
Alnetea glutinosae	ALGL	9	sw
Salici-Populetea	SAPU	9	sw
Tuberarietea guttatae	TUGU	2	sx
Asplenietea trichomanis	ASTR	5	sx
Festuco-Seslerietea	FESE	5	sx
Sedo-Scleranthetea	SESC	5	sx
Thalspietea rotundifolii	THRO	5	sx
Cakiletea maritimae	CAMA	2	sa
Saginetea maritimae	SAMA	2	sa
Thero-Salicornietea	THSA	2	sa
Ammophiletea	AMMO	5	sa
Crithmo-Limonetea	CRLI	5	sa
Juncetea Maritimi	JUMA	5	sa
Pegano-Salsoletea	PESA	5	sa
Sarcocornietea fruticosae	SAFR	5	sa
Spartinetea maritimi	SPMA	5	sa

Tab. 1 - Syntaxonomic classes database and related fields (CNOME= syntaxonomic class name; CCODE= syntaxonomic class code; y_(m;s)= coefficient related to maturity (m) and edaphic (s) character; CL_TYP= class type).

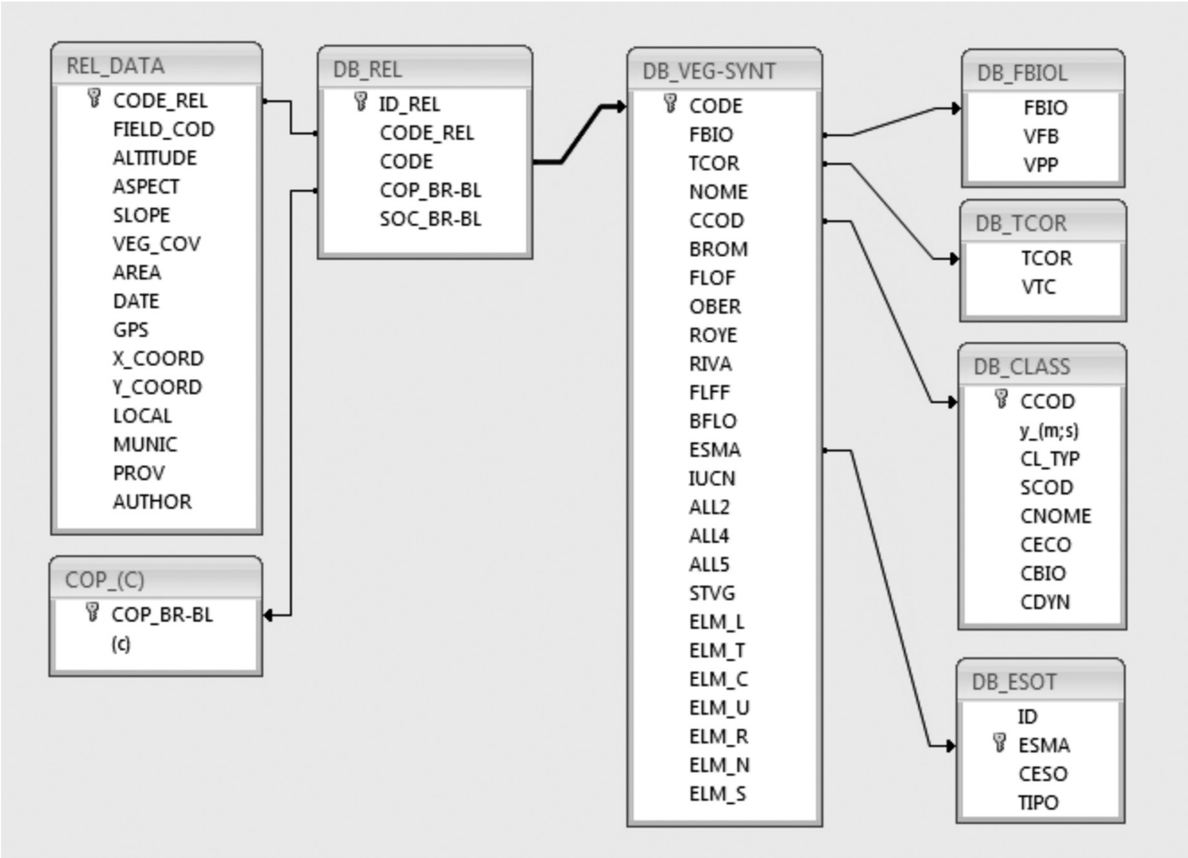

Fig. 2 - Logical scheme of the relational database containing data from phytosociological releveés (DB_REL; REL_DATA), floristic-syntaxonomic database (DB_VEG-SYNT), syntaxonomic classes database (DB_CLASS), and other secondary databases with data encoding functions.

- *Index of floristic biodiversity (IFB)*

This index is the only one calculated on the basis of the presence of the individual species and irrespective of their coverage value. It expresses the vegetal diversity relative to the single relevé or to the average of the species from the whole of a Table containing more relevés.

The formula for the calculation of this index has been modified from its original version (Taffetani & Rismondo, 2009), which was based on measuring the floristic diversity of a coenosis as the number of species per m^2. The new version of the *IFB* takes on again the suggestion provided by Puppi (2008), according to which the species richness of the phytosociological relevés corresponds to the sum of the species present in a relevé.

$$IFB = sp/rel$$

where *IFB*= index of floristic biodiversity, *sp*= number of species in a given coenosis; *rel*= single relevé.

- *Edaphic indexes (IW, IX, IA)*

The edaphic indexes allow quantification of hygrophilous, xerophilous and halophilous components in each coenosis through the information coming from the class to which the species belong.

In the present study, there have been substantial modifications made to the formulae presented in the study of Taffetani & Rismondo (2009). These indexes were originally expressed in the range from 0 to 9, which was derived from the ratio between the mathematical sum of the product between the coverage of a single species and its specific edaphic coefficient, and the mathematical sum of the coverage values of all the taxa that make up the coenosis.

The modifications were made because the calculation of an edaphic index across the scale given above carried with it an alteration of the indication to be obtained; this resulted from the overestimation of the contribution from the wood edaphophyle classes with respect to those that were less evolved but still linked to a hygrophilous, xerophilous or halophilous

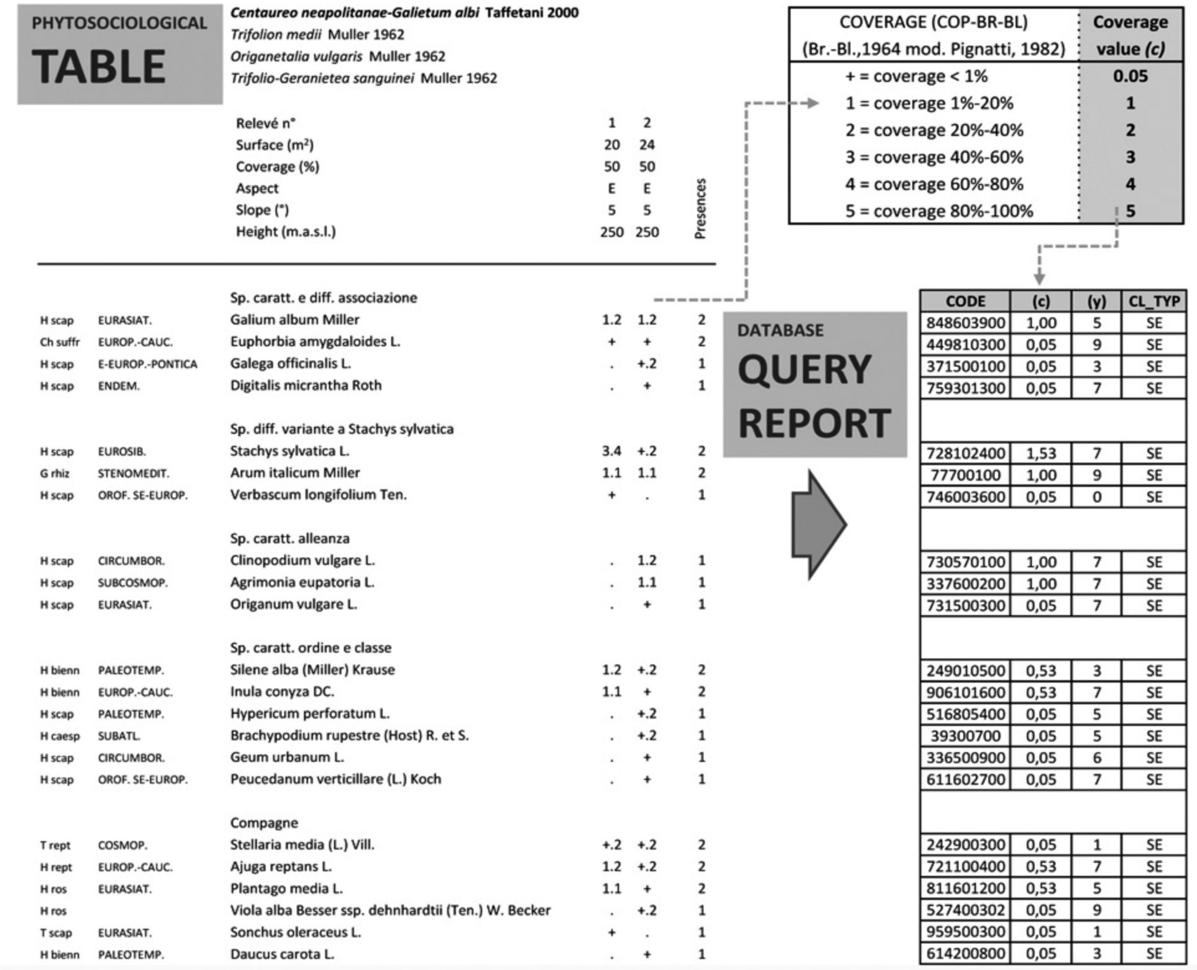

Fig. 3 - Sample report from the database query containing the data used to compute floristic-vegetational indexes, and applied to a phytosociological table.

condition.

In the calculation of the edaphic indexes, this now simply takes into account the overall coverage of species with a certain type of edaphic character.

As a consequence of the update carried out, the hygrophilous, xerophilous and halophilous indexes are calculated as a percentage ratio between the sum of coverage values of the species belonging to each of the individual edaphophyle categories and the total coverage value calculated for the coenosis:

$$IW = \frac{\sum_{i=1}^{n}[c_{(sw)}]_i}{C_{(tot)}} x100$$

$$IX = \frac{\sum_{i=1}^{n}[c_{(sx)}]_i}{C_{(tot)}} x100$$

$$IA = \frac{\sum_{i=1}^{n}[c_{(sa)}]_i}{C_{(tot)}} x100$$

where *IW*= index of hygrophilia, *IX*= index of xerophilia, *IA*= index of alophilia;

$[c_{(sw)}]_i$; $[c_{(sx)}]_i$; $[c_{(sa)}]_i$ = coverage values of each species of the hygrophilous (*sw*), xerophilous (*sx*) or halophilous (*sa*) classes, given as an absolute value for individual relevés or as a mean value for a group of relevés in a Table;

$C_{(tot)}$= total coverage value obtained by the sum of the coverage values of all of the species.

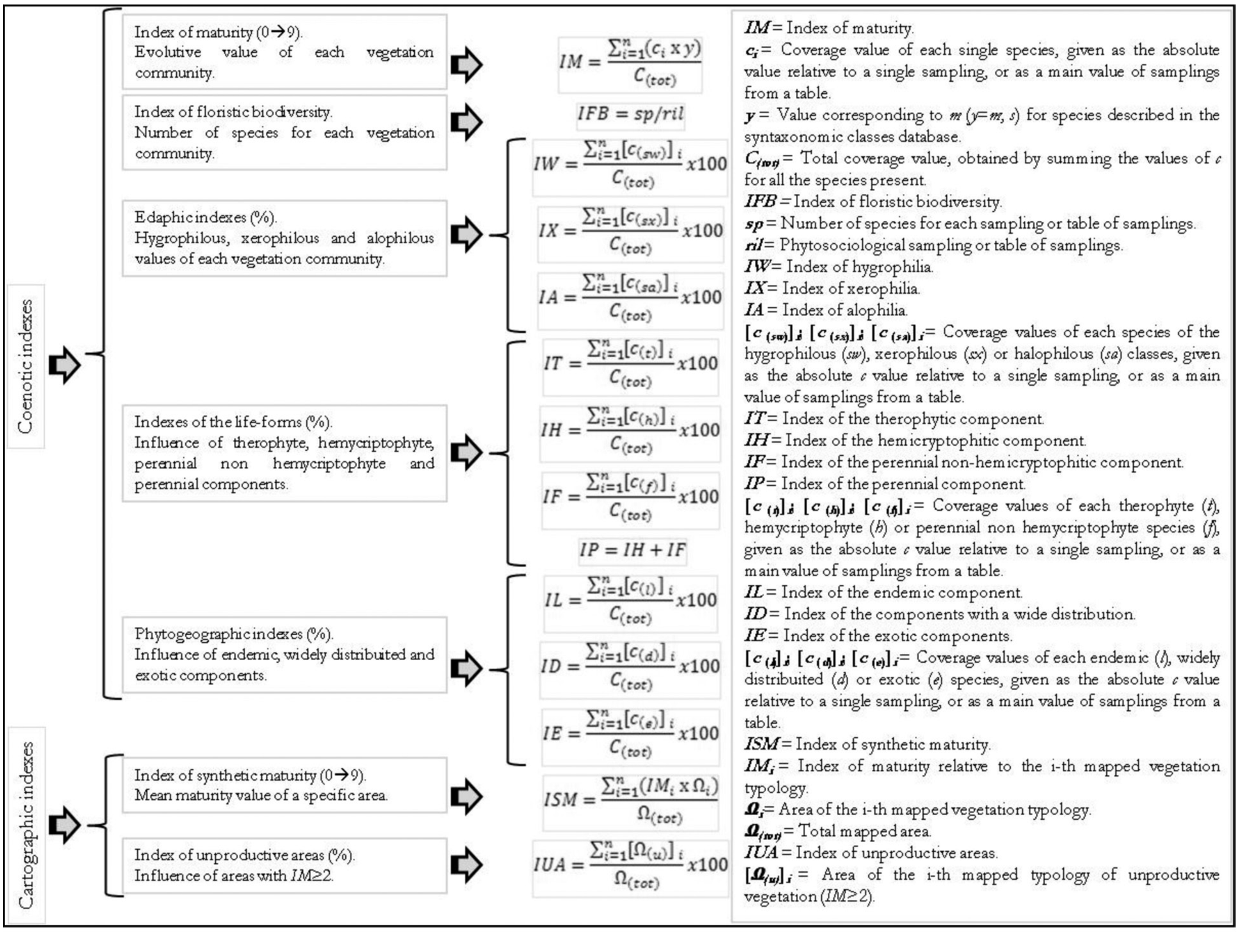

Fig. 4 - Summary of the floristic-vegetational indexes system.

Results

The bioindicators system represents the basis of a recent study concerning the evaluation of agro-ecosystem's quality of the Aspio River Basin (AN). The investigated area covers about 16500 Ha located inside the Province of Ancona, in the central Adriatic sector of the Italian peninsula. The Aspio River Basin is part of the sub-coastal area included in the temperate submediterranean region, or transition region (Blasi, 2010). It spreads on a hilly farmland area, between 0 and 572 m. a.s.l. (Monte Conero), with some urban structures (industries, towns, roads), especially in the main valley.

Conservation status and functionality of the hydrographic network were studied, in order to assess modifications occurred to the vegetation communities present in many river stretches. This is due to the intensive agricultural practices and to a high soil consumption. The analysis is based on the distinction between principal drain lines (with permanent water flow), and minor drainage ditches, located on the hillsides and characterized by the presence of water during and immediately after rain events.

Two transects illustrating the sequence of plant communities detectable on streams edges were described, with a detailed analysis of vegetation and of the hydrographic network functionality.

Variation ranges in the indexes of maturity (*IM*) and hygrophilia (*IW*) were also illustrated inside the transects. These variations are caused by changes of edaphic conditions, morphology, and of management practices.

The vegetation succession observed along the edges of the main streams is described in A scheme of Fig. 5. The water availability gradient is expressed by the evolution of the index of hygrophilia (*IW*). This showed to be higher for the plant communities belonging to hygrophilous classes, such as *Phragmito-Magnocaricetea* (*Helosciadetum nodiflori*, *Carex pendula* communities) and *Salici-Populetea* (*Rubo ulmifolii-Salicetum albae*), that grow up closer to the water. The values of the same index are lower for fringe communities (*Petasitetum hybridi*) and

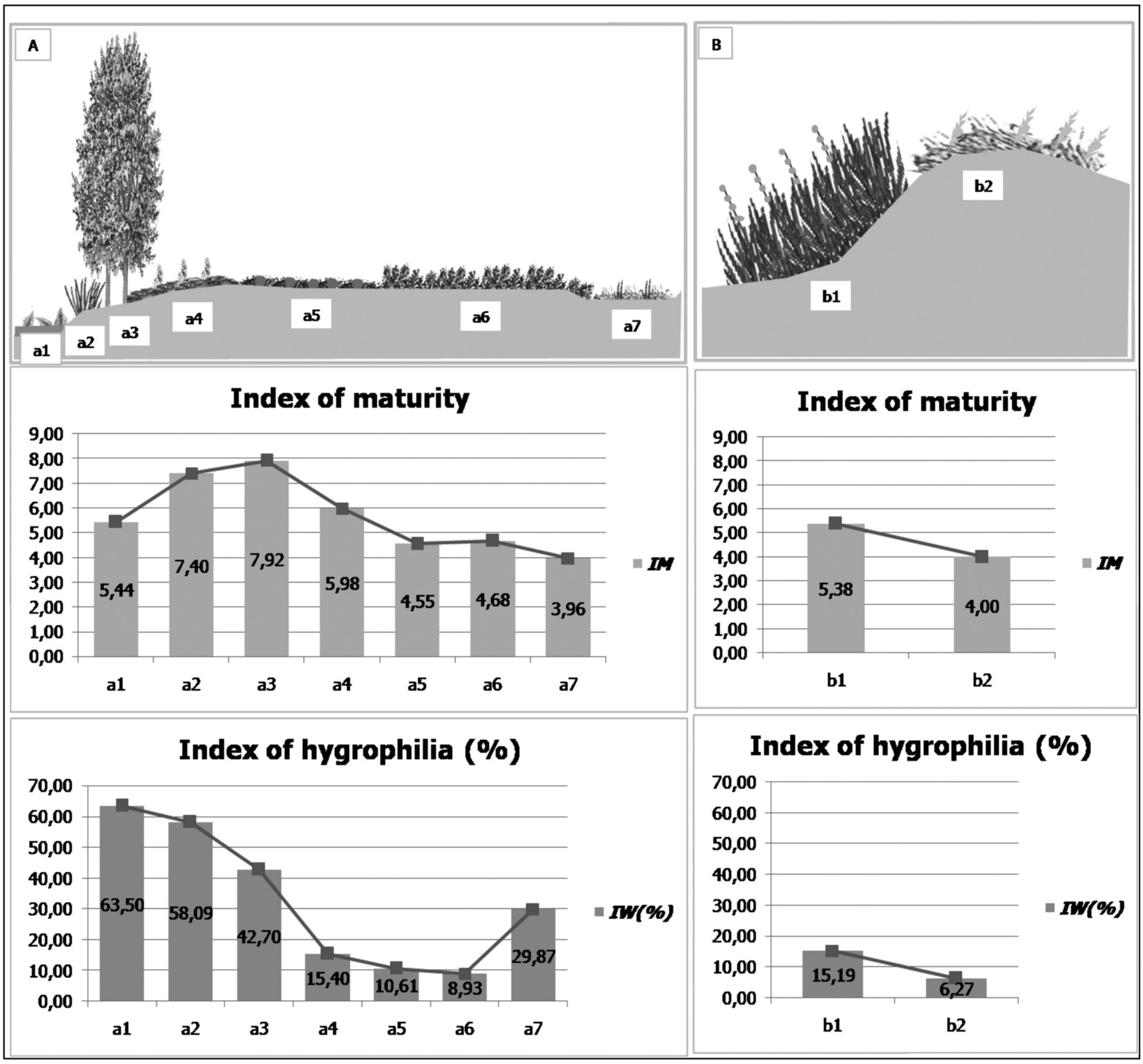

Fig. 5 - Index of maturity (IM) and index of hygrophilia (IW) of the vegetation related to the principal (A scheme) and the minor (B scheme) ditches. Legend: a1=*Helosciadetum nodiflori*; a2 *Carex pendula* communities; a3=*Rubo ulmifolii-Salicetum albae*; a4=*Petasitetum hybridi*; a5=*Ranunculetum repentis*; a6=*Festuco fenas-Caricetum hirtae*; a7=*Lolio perennis-Plantaginetum majoris Juncus bufonius* variant; b1=*Convolvulo sepii-Epilobietum hirsuti*; b2=*Agropyron repens* and *Galium album* communities.

mesophytic grasslands (*Ranunculetum repentis*, *Festuco fenas-Caricetum hirtae* and *Lolio multiflori-Plantaginetum majoris Juncus bufonius* variant). The maturity level is higher for willow communities, while it decreases in the herbaceous coenosis, with a lower value for trampled and slightly depressed areas (*Lolio multiflori-Plantaginetum majoris Juncus bufonius* variant), placed near cultivated fields and disturbed by tractors passage.

The vegetation succession of hillside ditches with periodical water flow is described in B scheme of Fig. 5. Hygrophilia and maturity indexes are higher in fringe community located inside the ditches (*Convolvulo sepii-Epilobietum hirsuti*), while they show lower values in the mesophytic grasslands of the outer edges of water courses, these belonging to *Agropyron repens* and *Galium album* communities.

The vegetation of the minor ditches inside the study area is seriously threatened by severe alterations of the hydrographic network and simplification of the vegetational landscape. This is mainly due to some farm practices applied in order to increase cultivated areas and for weed control.

Conclusions

The updates and integration carried out on the bioindicator system introduced by Taffetani & Rismondo (2009) make the method used more complete and effective for the evaluation of the complex interactions that exist between management and conservation of the agro-ecosystems.

Through the floristic-vegetational data, it is indeed possible to interpret differences in the floristic composition and the role covered by the individual species that make up the various coenoses sampled.

Inside analogous pedoclimatic contexts, these differences are often due to the effects of the constant application of specific land management practices, which end up favouring the constitution and the affirmation of coenoses characterised by a greater adaptability to survive under particular conditions.

The results clearly show how this method can be used to measure some ecological features, such as the level of maturity, the structure and the adaptability of vegetation communities to specific edaphic conditions. The conservation of biodiversity on a large scale needs a careful analysis of the conservation problems relative to the agricultural contexts. Indeed, these last characterise the major part of the national territory and represent the structure on which actions need to be organised and applied with the aim of guaranteeing that the functionality of the ecosystems is maintained. With this purpose, it is important to test and to apply management models that respect the floristic-vegetational patrimony of the rural territories. This in order to preserve residual habitats with high environmental value, and to restore vegetational communities that are more exposed to intensive cultivation and urbanisation (Celesti-Grapow *et al.*, 1996; Hill *et al.*, 2002).

In this sense, the method updated here is structured as a tool that can potentially be used for monitoring of the conservation status of the agro-ecosystem, for identification of areas with environmental richness (HNV Farmland Areas; Andersen *et al.*, 2003; Pointereau *et al.*, 2007), and as a support for strategic management choices.

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