Fitosociologia vol. 41 (1) suppl. 1: 101-107, 2004

Integrating phytosociological and agronomic analysis to support the sustainable management of Mediterranean grasslands

S. Bagella[1] & P. P. Roggero[2]
[1]*Dipartimento di Botanica ed Ecologia vegetale, Università di Sassari, via Muroni 25, 07100 Sassari; email: sbagella@uniss.it*
[2]*Dipartimento di Scienze Ambientali e delle Produzioni Vegetali, Università Politecnica delle Marche, via S. Allende, 60132 Ancona; email: p.p.roggero@univpm.it*

Abstract
The paper analyses the integration of different methodologies for assessing the grazing value of grasslands, aimed at supporting decisions for their sustainable management, that is, the long term preservation of their productive potential. The attribution of an agronomic value (specific index) to each species can be used for a preliminary evaluation of their productive potential. It can be also considered a first step in the exploitation of data already available from studies made on grasslands using a range of approaches, among them phytosociological tables. A data base file containing a collection of Specific indices for 1796 taxa, based on evaluations made by different authors, who applied the Grazing Value method in a range of environments in the Mediterranean area, has been made available on the web site http://www.agr.unian.it/ (download area, ricerca).

Key words: database, grasslands, grazing value, phytosociology, point quadrats, specific indices.

Riassunto
Analisi fitosociologiche e agronomiche integrate per la gestione sostenibile delle praterie nel mediterraneo. La gestione sostenibile delle praterie secondarie può scaturire dall'integrazione di informazioni derivanti da diversi approcci di studio. La stima del valore agronomico di ciascuna specie (indice specifico) costituisce una valida base per una valutazione preliminare delle sue capacità produttive. Rappresenta inoltre la prima fase conoscitiva per l'utilizzazione di dati già disponibili, derivanti da studi realizzati con diverse metodologie, come ad esempio le tabelle fitosociologiche. Al fine di rendere più agevole l'integrazione delle informazioni è stata realizzata una raccolta degli indici specifici di 1796 taxa proposti da vari autori per diverse aree del Mediterraneo, disponibile nel sito http://www.agr.unian.it/ (download area, ricerca).

Parole chiave: database, fitosociologia, indici specifici, praterie, rilievi puntiformi, valore agronomico.

Introduction

Grazed grasslands are complex systems, whose sustainable management requires an integrated approach based on multiple perspectives (Pearson & Ison, 1997). Agronomy, vegetation and animal sciences deal with the most relevant biophysical processes, which control the functioning and evolution of the vegetation of grasslands systems.

The main objective of this paper was to illustrate a method of facilitating the integration of different methodological approaches to interpret the space-time composition of grassland vegetation and its dynamic in relation to environmental, agronomic and management factors. The motivation was to provide a method that could support the sustainable management of grasslands.

The paper illustrate an example of possible integration of agronomic and phytosociological approaches to the evaluation of the grazing value of Mediterranean grasslands. The agronomic approach is often based on the assessment of grassland growth rates, using grazing simulation schemes (Corrall & Fenlon, 1978; Sarno *et al.*, 1989), and/or on the assessment of the grazing value (Daget & Poissonet, 1969; Daget & Godron, 1995; Cavallero *et al.*, 2002). Phytosociological data provide information on the botanic composition, ecology, dynamic and spatial distribution of phytocoenosis (Géhu & Rivas-Martinez, 1981; Theurrilat, 1992; Biondi, 1994). The integration of phytosociological and agronomic data can be effective for the identification, agronomic characterisation and management of grazed vegetation coenosis.

Grazing value of grasslands

The agronomic value of a grassland can be attributed to the floristic composition, the specific contribution and the agronomic value of each species. The specific contribution can be expressed as number of individuals, aboveground phytomass production, frequency in a transect or soil covering rate of each species.

The point quadrat method proposed by Daget & Poissonet (1969) is often adopted to estimate the grazing value of Mediterranean grasslands, with different techniques used in relation to the canopy height. The data are collected along transects to assess a series of indices, among which the presence specific contribution (CSP or CS) is one of the most useful.

The grazing value of single species depends on intrinsic and extrinsic factors and, among the various classification systems, one of the most widely used is the specific index, based on a discrete scale (0 to 5) indicating increasing palatability (Tab.1).

Tab.1 – Description of the specific indices.

Is	Description
5	excellent forage plant
4	very good forage plant
3	good forage plant
2	poor forage plant
1	occasionally grazed
0	ungrazed and/or toxic*

*the 0 index is also attributed to any species which does not significantly contribute to improve the agronomic value of the grassland.

The specific index (*Is*) synthesises different agronomic aspects of the grazing value, which are peculiar to each taxon, such as: productivity, nutritive value, intake, taste, digestibility and grazing tolerance (Delpech, 1960; Daget & Poissonet, 1969). However, the application of *Is* is generally restricted to the environmental context in which they have been assessed. Some examples of *Is* attributed by different authors to the same species in different geographical and environmental context are reported in Tab. 2. Some species, e.g. *Dactylis glomerata* and *Lolium perenne*, are considered excellent forage species in any environmental context, while others, e.g. *Sanguisorba minor*, are not grazed in the most favourable contexts, while they are considered excellent in less favourable contexts, such as the Tunisian rangelands (De Vries, 1950; Delpech, 1960; Poissonet, 1967 in Vivier, 1971; Delpech, 1968 in Floret, 1988; Daget & Poissonet, 1969; Le Houerou & Ionesco, 1973; Hubert, 1978; Dubost & Jouglet, 1981; Poissonet *et al*., 1981; Aidoud & Dedjaoui, 1982; Koohafkan, 1982 in Floret, 1988; Cozic, 1987; Le Houerou & Ionesco, 1987 in Floret, 1988; Floret, 1988; Cavallero *et al*., 1989; Cavallero *et al*., 1992; Grignani *et al*., 1993; Scoppola & Pelosi, 1995; Roggero, in Roggero *et al*., 2002; Talamucci in Roggero *et al*., 2002.

Is and CSP can be combined to calculate a grazing value (VP) for a given grassland (Daget & Poissonet, 1969):

$$\mathrm{VP} = 0,2 \cdot \sum_{i=1}^{n} CSP_i * Is_i$$

where:
CSP_i is the presence specific contribution
Is_i is the specific Index

Grazing values have to be assigned to a pastoral *facies*, a vegetation unit that can be considered homogeneous from a floristic and agronomic perspective.

On the basis of the VP, it is possible to extrapolate useful parameters to support decisions on the sustainable use of grasslands (Daget & Godron, 1995). For instance, a linear relationship has been found between the grazing value and the potential annual mean stocking rate of herbivores, under balanced conditions and a pressure of incessant grazing (Daget & Poissonet, 1969; Daget & Godron, 1995):

$$\mathrm{Cp} = 12\ \mathrm{VP\ UBA}^{-1}$$

where: Cp = potential annual mean stocking rate
1 UBA = equivalent of 500 Kg cattle liveweight
VP = grazing value

This allows the estimate of a sustainable annual stocking rate of cattle and, therefore, the formulation and comparison of management hypotheses.

Use of phytosociological data to estimate the grazing value of grasslands

The CSP of single species to calculate the VP can be roughly estimated from abundance/dominance values that are attributed by using the phytosociological method (Braun-Blanquet, 1928). In this case, a cover coefficient can be calculated for each taxon that is roughly comparable to the CSP of the point survey method, providing that the mean values of every abundance/dominance class is expressed in percentage terms with respect to the total (Tab. 3).

The assessment of CSP with the phytosociological method is less precise but much quicker than that measure with the point quadrat method, therefore it is suitable for preliminary evaluations and applications on a large scale.

In secondary grasslands, the agronomic value of the grazed vegetation may vary with regard to dynamic vegetation processes that can be triggered following changed conditions of utilisation. Phytosociological data of secondary grasslands can reveal the possible natural

Tab. 2 – Examples of *Is* attributed to the same plants by different authors in different geographic areas and environmental contexts.

Species	Cozic,1987	Floret, 1988	Daget & Poissonet, 1969	Poissonet *et al.*, 1981		Hubert, 1978	Dubost e Jouglet, 1981*	Cavallero *et al.*, 1992	Cavallero *et al.*, 1989 Daget & Poissonet, 1969 Delpech, 1968 in Floret, 1988	Grignani *et al.*, 1993	Talamucci in Roggero *et al.*, 2002	Scoppola & Pelosi, 1995	Roggero in Roggero *et al.*, 2002	Koohafkan, 1982 in Floret, 1988	Aidoud & Dedjaoui, 1982	Le Houerou & Ionesco, 1973 Le Houerou & Ionesco, 1987	De Vries, 1950 Delpech, 1960 Poissonet, 1967 in Vivier, 1971
Agrostis stolonifera L.	2	3	3	2	3			3						3	3	3	
Dactylis glomerata L.	5	5	5	4	5	5	5	4			5		5	5	5	5	5
Festuca arundinacea Schreber	3	3	3	3			3	4	5		3		3	4			
Lathyrus pratensis L.	2	3	3	2	3					3	3	2			3		2
Lolium perenne L.	5	5	5	5			5	5		5	5	5	5	5		5	5
Lotus corniculatus L.	3	3	3	3	4	4	3	3	4	3	2	3	3	3	3	3	2
Medicago lupulina L.	3	3	3	2	3		3	2		3	4	2	3	3		3	3
Onobrychis viciifolia Scop.	2	4	4	2	4					3		4	2	5		5	4
Phleum pratense L.	5	5	5	5			4	5		4	5	5				5	5
Poa bulbosa L.			2	2	3		2			3				2		2	2
Poa pratensis L.	4	4	4	4			4	4			4	4	4	4	4	4	
Poa trivialis L.	3	4	4	2	4	4	4	4		4	3	4		4		4	2
Sanguisorba minor Scop.	2	2	2	1	2	3	3			2	1		0	5	2	5	2
Trifolium campestre Schreber	3	2	2	2	3	2	1		2	2	2	3	2	4		4	1
Trifolium pratense L.	4	4	4	4			4	4		4	4	4	4	4	4	4	4
Vicia cracca L.	2	3	3	2	3			2		3		2	3			4	
Vicia hirsuta (L.) S.F. Gray	2	3	2	2	4	4			4	2				3			
Vicia sativa L.	2			2	4	4	2		5					3		3	3

* Is of Dubost & Jouglet (1981), that were expressed on a 0 to 10 scale, have been divided by 2 and approximated to integers.

evolution of the vegetation in connection with the land use (Biondi, 2001). Models representing vegetation series allow the inclusion of different herbaceous vegetation typologies related to vegetal landscape contexts. The integration of phytosociological data with grazing values, in addition to the current distribution of grasslands, allows the potential area and therefore the grazing potential of a given landscape, to be estimated.

The VP attribution to the plant association, by converting cover data obtained by the phytosociological method, could represent a first level of assessment of the potential use of natural grasslands of large spatial extent. However, the same plant associations can have different levels of precocity and production, especially in mountain areas. In this case, it is necessary to identify the different pastoral *facies* and attribute a VP to each of them (Lambertin *et al.*, 1995).

This method has been applied to the grassland coenosis of the association *Brizo mediae-Brometum erecti* Bruno in Bruno *et* Covarelli 1968 corr. Biondi et Ballelli 1982, which are widespread in the Umbro-Marchigiano Appennine, both in the hill and mountain belt. Several variants (i.e. pastoral *facies*) related to altitude, slope, soil type and grazing management, were distinguished in which grazing value (VP) varied between 23 and 44 (Bagella 2001a & 2001b). After the *facies* were identified and the VP calculated, the potential and minimum stocking rate per unit area were estimated (Tab. 4). However, this information is not sufficient to plan the grassland management, as it is also necessary to identify and quantify the area which can be attributed to each *facies*, to spatialise the potential stocking rate, using a convenient scale, and hence prevent over or undergrazing situations. For this reason, phytosociological, agronomic and management data were processed using a Geographical Information System and a phytosociological and phytopastoral map was created (Bagella, 2001b, 2001c). Using the

Tab. 3 – Example of calculation of the grazing value of a mountain rangeland based on phytosociological relevées (from Bagella 2001a, rel. 4, 5, 1 in tab.2)

		abundance/ dominance			*% abundance/ dominance (central value)*			*relative abundance/ dominance (CSP %)*			*specific contribution to VP* 100CSP*Is*0.2		
Is	Rel. n.	1	2	3	1	2	3	1	2	3	1	2	3
	Area (m^2)	40	40	20									
	Coverage (%)	100	100	100									
	Slope (°)	5	5	0									
	Exposure	SE	SO										
	Altitude (m)	1280	1280	900									
	Charact. and diff. species of association												
1	Luzula multiflora (Ehrh.) Lej.	+	+	+	0.5	0.5	0.5	0.3	0.3	0.3	0.1	0.1	0.1
1	Briza media L.	+	+		0.5	0.5		0.3	0.3		0.1	0.1	0.0
1	Centaurea triumfetti All.	+			0.5			0.3			0.1	0.0	0.0
2	Plantago lanceolata L. var. sphaerostachya Mert. et Koch			1.1			2.5			1.3	0.0	0.0	0.5
1	Filipendula vulgaris Moench		+			0.5			0.3		0.0	0.1	0.0
	Charact. species of *Phleo ambigui-Bromion erecti* all.												
1	Knautia purpurea (Vill.) Borbas	1.1	1.2	1.1	2.5	2.5	2.5	1.5	1.7	1.3	0.3	0.3	0.3
2	Trifolium montanum L.	+	1.1	1.1	0.5	2.5	2.5	0.3	1.7	1.3	0.1	0.7	0.5
1	Centaurea ambigua Guss.		+	1.2		0.5	2.5		0.3	1.3	0.0	0.1	0.3
2	Festuca circummediterranea Patzke	2.2	+		15.0	0.5		8.9	0.3		3.6	0.1	0.0
0	Hieracium pilosella L.	1.1	+		2.5	0.5		1.5	0.3		0.0	0.0	0.0
1	Galium lucidum All.	1.1	+.2		2.5	0.5		1.5	0.3		0.3	0.1	0.0
2	Koeleria splendens Presl	+.2	+		0.5	0.5		0.3	0.3		0.1	0.1	0.0
1	Avenula praetutiana (Parl.) Pign.	+	+		0.5	0.5		0.3	0.3		0.1	0.1	0.0
0	Eryngium amethystinum L.			+			0.5			0.3	0.0	0.0	0.0
0	Muscari atlanticum Boiss. et Reuter		+			0.5			0.3		0.0	0.0	0.0
0	Centaurea rupestris L.			+			0.5			0.3	0.0	0.0	0.0
2	Phleum ambiguum Ten.	+			0.5			0.3			0.1	0.0	0.0
	Charact. species of upper units												
2	Poa bulbosa L.	1.1	1.1	1.2	2.5	2.5	2.5	1.5	1.7	1.3	0.6	0.7	0.5
2	Bromus erectus Hudson	1.1	2.2	1.2	2.5	15.0	2.5	1.5	10.0	1.3	0.6	4.0	0.5
0	Dianthus carthusianorum L.	1.1	+.2	1.1	2.5	0.5	2.5	1.5	0.3	1.3	0.0	0.0	0.0
1	Cerastium arvense L. subsp. suffruticosum (L.) Nyman	1.1	+.2	+	2.5	0.5	0.5	1.5	0.3	0.3	0.3	0.1	0.1
2	Achillea collina Becker	1.2	+.2	1.2	2.5	0.5	2.5	1.5	0.3	1.3	0.6	0.1	0.5
2	Trifolium ochroleucum Hudson	1.1	+	1.2	2.5	0.5	2.5	1.5	0.3	1.3	0.6	0.1	0.5
0	Allium carinatum L.	+	1.1	1.1	0.5	2.5	2.5	0.3	1.7	1.3	0.0	0.0	0.0
0	Rhinanthus minor L.		+	1.1		0.5	2.5		0.3	1.3	0.0	0.0	0.0
0	Armeria canescens (Host) Boiss.	+		+	0.5		0.5	0.3		0.3	0.0	0.0	0.0
0	Cerastium pumilum Curtis	1.1	1.1		2.5	2.5		1.5	1.7		0.0	0.0	0.0
0	Thymus longicaulis Presl	+.2	1.2		0.5	2.5		0.3	1.7		0.0	0.0	0.0
2	Sanguisorba minor Scop.	+	+		0.5	0.5		0.3	0.3		0.1	0.1	0.0
1	Euphrasia stricta D. Wolff		+	+		0.5	0.5		0.3	0.3	0.0	0.1	0.1
0	Ranunculus bulbosus L.	+		1.1	0.5		2.5	0.3		1.3	0.0	0.0	0.0
0	Campanula rapunculus L.	+	+		0.5	0.5		0.3	0.3		0.0	0.0	0.0
0	Allium sphaerocephalon L.		+	+		0.5	0.5		0.3	0.3	0.0	0.0	0.0
1	Linum bienne Miller			1.1			2.5			1.3	0.0	0.0	0.3
1	Salvia pratensis L. subsp. bertolonii (Vis.) Briq.			+.2			0.5			0.3	0.0	0.0	0.1
4	Onobrychis viciifolia Scop.			+			0.5			0.3	0.0	0.0	0.2
3	Trifolium incarnatum L. subsp. molinerii (Balbis) Syme			2.2			15.0			7.9	0.0	0.0	4.8
1	Asperula cynanchica L.		1.2			2.5			1.7		0.0	0.3	0.0
0	Polygala nicaeensis Risso	+			0.5			0.3			0.0	0.0	0.0
0	Thesium divaricatum Jan		+			0.5			0.3		0.0	0.0	0.0
1	Galium verum L.			1.2			2.5			1.3	0.0	0.0	0.3

		abundance/ dominance			*% abundance/ dominance (central value)*			*relative abundance/ dominance (CSP %)*			*specific contribution to VP* 100CSP*Is*0.2		
Is	Rel. n.	1	2	3	1	2	3	1	2	3	1	2	3
	Charact. species of *Molinio-Arrhenatheretea* class, *Arrhenatheretalia* ord. and *Cynosurion* all.												
3	Trifolium repens L.	2.2	1.1	1.2	15.0	2.5	2.5	8.9	1.7	1.3	5.3	1.0	0.8
2	Festuca rubra L.	2.2	3.3	2.3	15.0	38.0	15.0	8.9	25.2	7.9	3.6	10.1	3.2
2	Lotus corniculatus L.	1.1	+.2	1.1	2.5	0.5	2.5	1.5	0.3	1.3	0.6	0.1	0.5
2	Anthoxanthum odoratum L.	+	1.1	2.2	0.5	2.5	15.0	0.3	1.7	7.9	0.1	0.7	3.2
2	Cynosurus cristatus L.	4.4	3.3	3.3	63.0	38.0	38.0	37.3	25.2	20.1	14.9	10.1	8.0
1	Stachys officinalis (L.) Trevisan	+	+	+	0.5	0.5	0.5	0.3	0.3	0.3	0.1	0.1	0.1
5	Lolium perenne L.	1.1	1.1	3.3	2.5	2.5	38.0	1.5	1.7	20.1	1.5	1.7	20.1
2	Agrostis tenuis Sibth.	2.2	2.2	1.1	15.0	15.0	2.5	8.9	10.0	1.3	3.6	4.0	0.5
2	Leontodon hispidus L.	+	+.2	+	0.5	0.5	0.5	0.3	0.3	0.3	0.1	0.1	0.1
4	Trifolium pratense L.	+	+		0.5	0.5		0.3	0.3		0.2	0.3	0.0
1	Rumex acetosa L.	+		+	0.5		0.5	0.3		0.3	0.1	0.0	0.1
1	Bellis perennis L.		+			0.5			0.3		0.0	0.1	0.0
0	Colchicum lusitanum Brot.			1.1			2.5			1.3	0.0	0.0	0.0
	Other species												
1	Aira caryophyllea L.	+	1.2	+	0.5	2.5	0.5	0.3	1.7	0.3	0.1	0.3	0.1
1	Trifolium campestre Schreber	+.2	+.2	+	0.5	0.5	0.5	0.3	0.3	0.3	0.1	0.1	0.1
1	Cynosurus echinatus L.	+	+	1.1	0.5	0.5	2.5	0.3	0.3	1.3	0.1	0.1	0.3
0	Tanacetum corymbosum (L.) Sch.-Bip.		+	1.1		0.5	2.5		0.3	1.3	0.0	0.0	0.0
1	Asphodelus albus Miller	+		+.1	0.5		0.5	0.3		0.3	0.1	0.0	0.1
0	Bunium bulbocastanum L.	+	+		0.5	0.5		0.3	0.3		0.0	0.0	0.0
0	Potentilla rigoana Wollf.	1.1	+.2		2.5	0.5		1.5	0.3		0.0	0.0	0.0
0	Veronica arvensis L.	+		+	0.5		0.5	0.3		0.3	0.0	0.0	0.0
0	Veronica prostrata L.	+	+		0.5	0.5		0.3	0.3		0.0	0.0	0.0
2	Anthyllis vulneraria L.		+			0.5			0.3		0.0	0.1	0.0
0	Helianthemum nummularium (L.) Miller subsp. grandiflorum (Scop.) Sch.& Th.			1.2			2.5			1.3	0.0	0.0	0.0
1	Sherardia arvensis L.			+			0.5			0.3	0.0	0.0	0.1
0	Ornithogalum pyramidale L.			+			0.5			0.3	0.0	0.0	0.0
1	Plantago media L.			1.1			2.5			1.3	0.0	0.0	0.3
1	Danthonia decumbens (L.) DC.			1.1			2.5			1.3	0.0	0.0	0.3
0	Prunella laciniata (L.) L.			+.2			0.5			0.3	0.0	0.0	0.0
0	Myosotis alpestris F. W. Schmidt		+			0.5			0.3		0.0	0.0	0.0
0	Orobanche purpurea Jacq.			+			0.5			0.3	0.0	0.0	0.0
0	Minuartia verna (L.) Hiern		+.2			0.5			0.3		0.0	0.0	0.0
0	Senecio tenorei Pign.	+			0.5			0.3			0.0	0.0	0.0
1	Petrorhagia saxifraga (L.) Link			+.2			0.5			0.3	0.0	0.0	0.1
	Total				169	151	189	100	100	100	38	36	47

vegetation map as a basic layer (Ballelli *et al.*, 1976), different sectors with similar grazing value, forage production and management have been identified among the grazed coenosis. For each sector, the actual, potential and minimal carrying capacity were estimated on the basis of VP. This information facilitated the quantitative evaluation of the current management and the formulation of new management hypothesis for the grassland. The uneven spatial distribution of the stocking rates was recognized to be one of the most important factor of the grassland degradation and the re-establishment of shrubs.

Conclusive remarks

The large amount of vegetation data currently available in grasslands vegetation maps and phytosociological tables could be integrated with

Tab. 4 – Potential and minimal stocking rates of different pastoral *facies* of the *Brizo mediae-Brometum erecti* association.

Pastoral *facies*	VP	annual mean potential stocking rate UBA ha-1 12*VP/500
Festuca circummediterranea, Thymus longicaulis & Carex caryophyllea	23	0.55
Bromus erectus, Thymus longicaulis & Carex caryophyllea	24	0.58
Festuca circummediterranea, Bromus erectus & Knautia arvensis	29	0.70
Festuca rubra, Agrostis tenuis & Cynosurus cristatus	36	0.86
Festuca circummediterranea, Bromus erectus & Cynosurus cristatus	37	0.88

grazing values data so as to make them initially exploitable for drawing thematic maps, by using Geographical Information Systems. Assessments in the field are always necessary in order to identify the homogeneous areas from an agronomic perspective, because the plant association, as already shown, does not always coincide with the grazing *facies*.

In order to make the application of this method easier, a database containing the *Is* of 1796 taxon of the Mediterranean rangelands in relation to different geographical areas has been filed (Roggero *et al*., 2002). This database is a first collection of data for the agronomic characterisation of the natural grasslands in Mediterranean environments and therefore is subject to supplement and updating. It is available as pdf format on the web site of the Faculty of Agricultural Sciences of Ancona: (http://www.agr.univpm.it/).

References

Aidoud A. & Dedjaoui D. (Coll. Djebaili S. & Poissonet J.), 1982. Evaluation des ressources pastorales dans les Hautes Plaines steppiques de Sud Oranais: productivité et valeur pastorale des parcours. Biocoenosis 1:43-61.

Bagella S., 2001a. Valore pastorale delle associazioni vegetali: un esempio di applicazione nell'Appennino umbro-marchigiano (Italia). Fitosociologia 38(1): 153-165.

Bagella S., 2001b. Gestione e conservazione delle praterie dell'Appennino umbro-marchigiano. In Greppi & Enne eds. Atti del 36° Simposio Internazionale di Zootecnia "Prodotti di origine animale: qualità e valorizzazione del territorio" Portonovo (Ancona) 27 Aprile 2001: 1-8.

Bagella S., 2001c. La carta fitosociologica e fitopastorale: uno strumento per la gestione delle praterie. Atti del Congresso della Società Italiana di Fitosociologia. Lipari, 13-15 giugno 2001.

Ballelli S., Biondi E. & Pedrotti F., 1976. Carta della vegetazione del Foglio Fabriano. LAC, *Firenze*.

Biondi E., 1994. The phytosociological approach to landscape study. Ann. Bot. 52: 135-141.

Biondi E., 2001. Paesaggio vegetale e potenzialità pastorali. Atti del 36° Simposio Internazionale di Zootecnia "Prodotti di origine animale: qualità e valorizzazione del territorio" Portonovo (Ancona) 27 Aprile 2001: 5-22.

Braun-Blanquet J., 1928. Pflanzensoziologie. Grundzuge der Vegetatiokunde. Biologische Studienbucher 7. Berlino: Ed. Berlin. 330 pp.

Cavallero A., Grignani C., Reyneri A., Bianchi M. & Battaglini L.M., 1989. Sistemi pascolivi in valle Belbo: confronto tra tecniche di pascolamento con impiego di ovini e bovini. In "Sistemi Agricoli Marginali Valle Belbo". Roma: CNR-IPRA. 155-200.

Cavallero A., Talamucci P., Grignani C., Reyneri A., Ziliotto U., Scotton M., Bianchi M., Santilocchi R., Basso F., Postiglione L., Carone F., Corleto A., Cazzato E., Cassaniti S., Cosentino S., Litrico P.G., Leonardi S., Sarno R., Stringi L. Gristina L., Amato G., Bullitta P., Caredda S., Roggero P.P., Caporali F., D'Antuono L.F., Pardini A., Zagni C., Piemontese S., Pazzi G., Costa G., Pascal G. & Acutis M., 1992. Caratterizzazione della dinamica produttiva di pascoli naturali italiani. Riv. di Agron. 26: 325-343.

Cavallero A., Rivoira G. & Talamucci P., 2002. Pascoli. In Baldoni R. & Giardini L. (eds.) Coltivazioni erbacee-Foraggere e tappeti erbosi. Patron editore, Bologna: 239-294.

Corrall A.J. & Fenlon J.S., 1978. A comparative method for describing the seasonal distribution of production from grasses. Journal of Agricultural Science 91: 61-67.

Cozic Ph., 1987. Une méthode de diagnostic pastoral de la composition de la végétation à la charge animale a prèconiser. Cemagref-Inerm Grenoble 211: 173-197.

Daget Ph. & Godron M., 1995. Pastoralisme: tropeaux, espaces et sociétés. Hatier. Paris 510 pp.

Daget Ph. & Poissonet T., 1969. Analyse phytologique des praisies. INRA, Montpellier Document 48, 66 p.

De Vries D.M., 1950. Grasland typen enhunoecologie. Neth. Kruidk. Arch. 57: 28-31.

Delpech R., 1960. Criteres de jugement de la valeur agronomique des praires. Fourrages 4: 83-98.

Dubost M. & Jouglet J.P., 1981. La vegetation des alpages et sa productivite fourragere, approche phyto-ecologique. Recherches en Brianconnais CEMAGREF INERM, Grenoble.

Floret C., 1988. Methodes de mesure de vegetation pastorale. Pastoralisme et Development. 24 mai au 9 juillet. Rabat-Montpellier .

Géhu J.-M. & Rivas-Martinez S., 1981. Notions fondamentales de phytosociologie. Ber. Internat. Simp. Int. IAVS. Sintaxonomie. Rinteln 31.3-3.4 1980. Vaduz: J. Kramer. 1-33.

Grignani C., Cavallero A., Acutis M. & Dufour C., 1993. Le tipologie pastorali della provincia di Imperia: risultati di un quadriennio di ricerche sulle loro caratteristiche vegetazionali, produttive e di utilizzazione potenziale. Progetto finalizzato IPRA. Sottoprogetto 2. Rapporto a conclusione del Progetto di ricerche sugli “Scenari Alta Valle Arroscia-Alta Valle di Vara”. CNR-IPRA, 69-91.

Hubert D., 1978. Evaluation du role de la végétation des parcours dans la bilan écologique et agro-économique des Causses. Thése USTL Montpellier, CEPE/CNRS, Doc. 89. 247 pp.

Lambertin M., Lapeyronie P. & Molenat G., 1995. De l’écofaciès de paturage une gestion raisonnée des alpages basée sur l’evolution de la valeur des végétations. Renc.Rech.Ruminants 2: 69-71.

Le Houerou H. N. & Ionesco T., 1973. Appétabilité des espéces végétales de la Tunisie steppique. Projet FAO/TUN-71/525, 68 pp.

Pearson C.J. & Ison R.L., 1997. Agronomy of grassland systems. Cambridge University Press, 189 pp.

Poissonet J., Poissonet P. & Thiault M., 1981. Development of flora, vegetation and grazing value in experimental plots of a *Quercus coccifera* garrigue. Vegetatio 46: 93-104.

Roggero P.P., Bagella S. & Farina R., 2002. Un archivio dati di Indici specifici per la valutazione integrata del valore pastorale. Rivista di Agronomia 36 (2): 149-156.

Sarno R., Talamucci P., Cavallero A. & Stringi L., 1989. Distribuzione della produzione dei pascoli in ambienti marginali italiani, guida alla valutazione della produttività. CNR – IPRA. Roma.

Scoppola A. & Pelosi M., 1995. I pascoli della riserva naturale del Monte Rufeno (Viterbo, Italia Centrale). Fitosociologia 30: 123-43.

Theurrilat J.P., 1992. L’analyse du paysage végétal en symphytocoenologie: ses niveaux et leurs domaines spatiaux. Bull. Ecol. 23 (1-2): 83-92.

Vivier V., 1971. L’interprétation agronomique des inventaries botaniques des praires permanentes à l’aide de grilles floristiques et de indices spécifiques. Fourrages 48: 45-55.