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The cartographic representation of the dynamical tendencies in the vegetation: a case study from the Abruzzo National Park, Italy*

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Abstract. A map of the dynamical tendencies in the vegetation illustrates the dominance of fundamental ecological processes (fluctuation, primary and secondary succession, regeneration, degeneration, regression) by picturing them as cartographic units. Informations for this map are drawn from phytocoenotic characteristics (floristic composition, vertical structure, texture, regeneration strategy, etc.) and historical documents. This study presents a map of the Mainarde complex (central Apennines, Italy), a branched chain formed by ancient glaciers with several peaks over 2,000 m a. s. l. Human impact in the study area is decreasing, and the vegetation is undergoing different dynamical processes over large areas. Ten cartographic units were adopted: 1) Recreative secondary succession; 2) Primary creative succession; 3) Primary replicative succession; 4) Regression; 5) Degeneration under continual disturbance; 6) Degeneration under drastic, periodic disturbance; 7) Regeneration after continual disturbances; 8) Regeneration after drastic, periodic disturbances; 9) Fluctuation in primary vegetation; 10) Anthropogenic fluctuation. The vegetation complex in the survey area shows a good potential for reconstitution. Study of this area confirms that identification of the present dynamical tendencies is a useful tool, especially in protected areas. The map of dynamical tendencies in the vegetation of Val Pagana - Le Forme (1:10,000) is enclosed.

Key-words: Anthropogenic pressure, primary succession, secondary succession, regression, degeneration-regeneration, fluctuation, Apennines

Introduction

Different kinds and intensities (in space and time) of anthropogenic pressure on vegetation cause a secondary differentiation which is often accompanied by changes in landscape heterogeneity (i.e., an increase or decrease of the original complexity), also due to the interruption of long-lasting anthropogenic influences.

In order to present in a map the nature and genesis of the vegetation's spatial organization, one should utilize and extend concepts of phytosociological cartography and dynamic ecology (Falinski 1990).

Vegetation dynamics is the inner dynamics of phytocoenoses (Pawlowski and Zarzycki 1972; Falinski 1986). The effects of all crucial ecological processes can be the subject of dynamic vegetation maps. These maps cannot express the whole variety of phenomena, but can represent the role and fate of individuals, populations, and phytocoenoses in the dynamic processes (phytoecological maps).

A map of dynamical tendencies as expression of the vegetation's present dominant processes

A map of dynamical tendencies is to some extent a substitute for the map of vegetation dynamics, and should be constructed only for selected ecological processes, the diversity and intensity of which can be found by comparative vegetation analysis and recorded by field mapping and/or by remote sensing and teledetection analysis (Küchler and Zonnenveld 1988; Falinski 1990; Falinski and Pedrotti 1990).

The map of dynamical tendencies, while in many ways similar to that of vegetation dynamics, differs because it presents some new concepts and information sources.

In this kind of map, in fact, the cartographic unit is the process itself (with its relative stages, phases or degrees), and only a single mapping is needed, because the information lies in the characteristics of the respective phytocoenose and no longer in the vegetation changes detected by repeated observations as in the case of dynamic maps.

The vegetation dynamics map based on the vegetation's present dynamical tendencies represents the dominance of fundamental ecological processes (primary and secondary succession, regression, degeneration-regeneration and fluctuation) that can be recognized by floristic composition, vertical structure, texture, regeneration strategies, historical data, etc.

A dynamical tendencies map gives information about the vegetation and plant communities' current structural differentiation, and the state of their preservation (naturalness), or conversely the degree of their transformation; moreover, it gives a predictive evaluation of the vegetation's future development, assuming a permanence of the present environmental conditions.

This predictive evaluation is just derived from the vegetation's present status, including the structural, floristic and biological characters of the phytocoenose and the history, kind, and intensity of the natural or anthropic factors which determine the present dynamical tendencies.

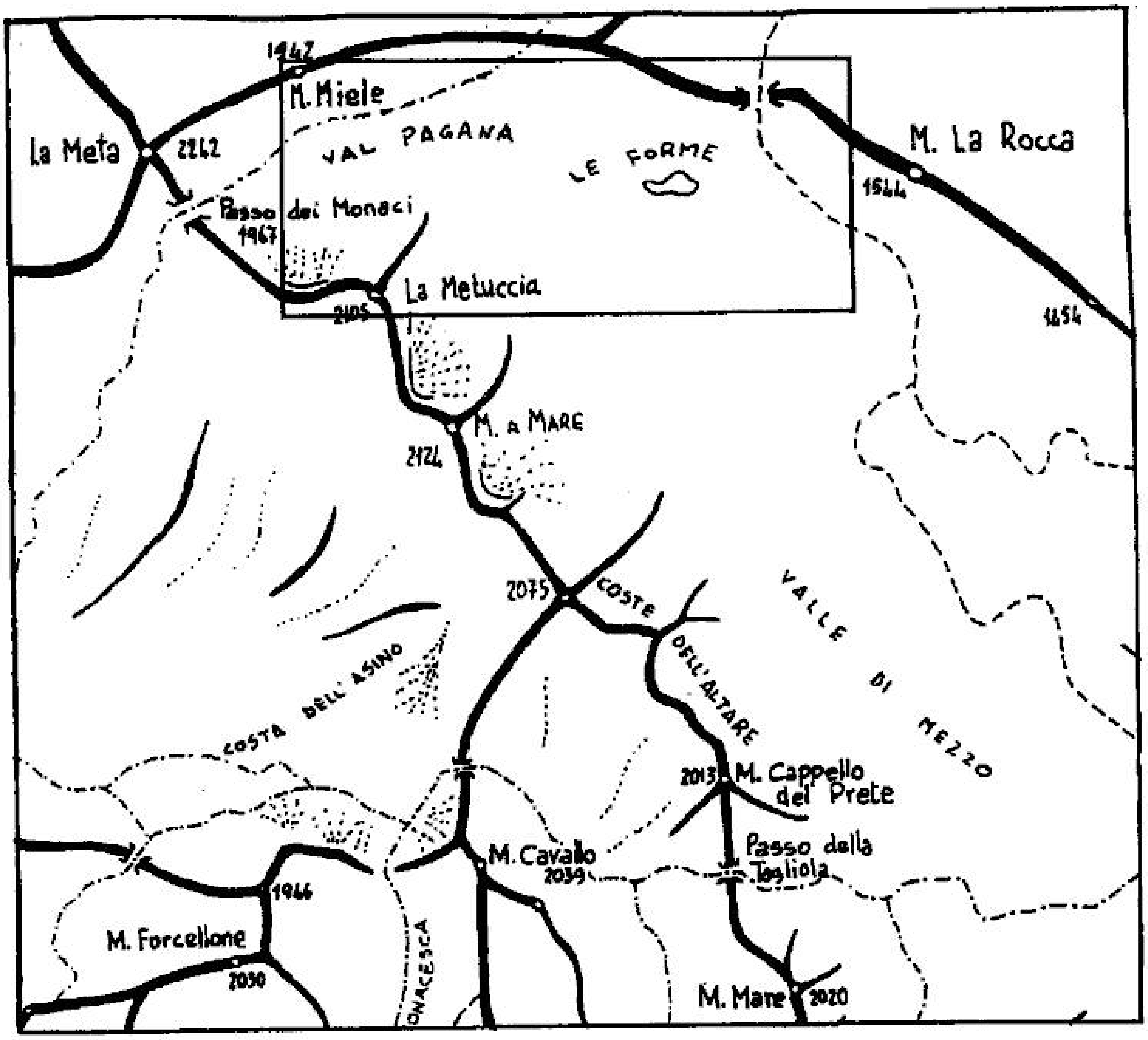

Fig. 1 - General features of the Mainarde mountain complex (central Italy): note the system of glacial cirques, morenic valleys, branching chains and peaks over 2,000 m a.s.l. The upper box defines the limits of the Val Pagana - Le Forme study area.

The final information in this kind of map does not concern potential vegetation. Nevertheless, the concept of dynamical tendency includes the fact that, with the permanence of present conditions, each process determined on the map will develop through successive phases, the final stage of which may be unknown.

The first map of dynamical tendencies in the vegetation was developed for the Bialowieza National Park (NE Poland). Mainly a product of teledetection mapping, it also included all data from studies on permanent plots (Falinski 1986). This map (scale 1:650,000 ca.) presents the dominant ecological processes occurring in the territory.

Falinski and Pedrotti (1990) extended this approach to a wide territory, mapping the dynamical tendencies in the vegetation of Bosco Quarto (Gargano, SE Italy) from direct field observations and teledetection. The map (scale 1:10,000) presents more accurately two dominant processes (degeneration and regression) due to human impact. The intensity of these processes is expressed by phases.

A third dynamical tendencies map in the vegetation of a north Italian bog (Canullo, Pedrotti and Venanzoni 1990), after a phytosociological survey and a population approach, detected different phases of secondary succession in abandoned meadows (1:2,000 scale).

The dynamical tendencies in the Mainarde mountain complex

The Mainarde mountain complex, recently added to the Abruzzo National Park (central Apennines, Italy), contains interesting vegetation with several rare species (Conti *et al.* 1990; AA.VV. 1992). This area was subject to various forms of anthropogenic pressure (selective felling and thinning, charcoal burning, coppice management, animal grazing, tourism) which have now partially ceased.

Protection management will probably ensure at least a reduction in man's influence on the vegetal cover. Therefore, this territory represents a good test for the development and verification of concepts and methods of dynamical tendencies mapping, and a good sample-area to standardize methodology.

Description of the study area

The Mainarde complex, a branched chalk chain in the southeast of the Abruzzo National Park (central Apennines, Italy),, has several peaks over 2,000 m

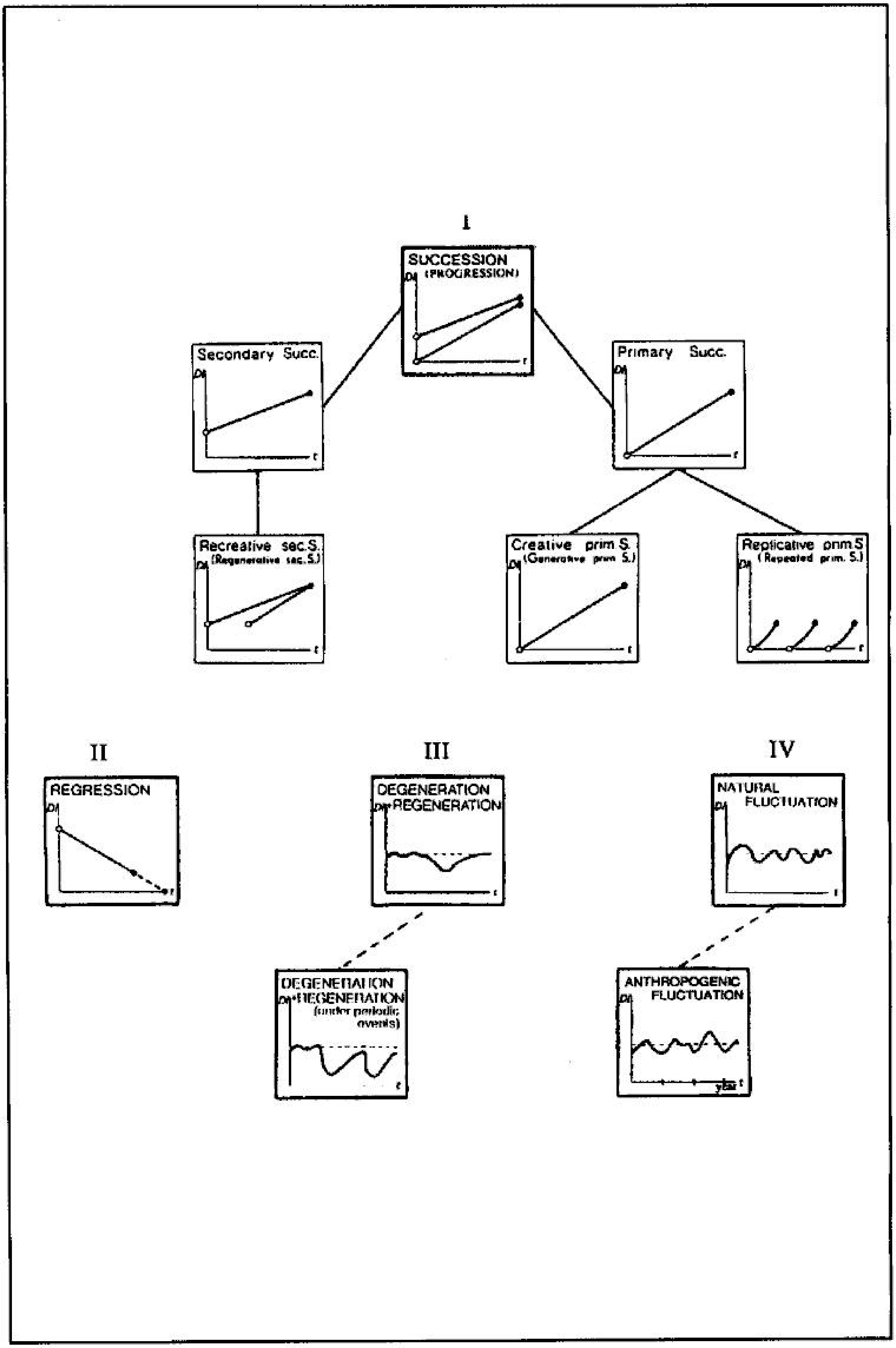

Fig. 2 - Principal processes identified in the vegetation of the study-area; the graphic representation follows the ideas of Falinski (1986, 1989, modified) with additional distinction. DI - Dynamic Index (given as biomass, volume, coverage, diversity, leaf area index, physiological indexes, etc.).

a.s.l. (La Metuccia, M. a Mare, M. Cavallo, M. Forcellone, Coste dell'Altare and M. Mare), the highest of which is La Meta (2,242 m). The complex's morphology was modelled by ancient glacial activity (Fig. 1).

The annual mean rainfall is about 1,500 mm (with winter and autumn maxima and a considerable reduction in summer due to the Mediterranean influence), and the mean annual temperature is 8.6°C. This climate is typical of the Apennine mountains of central Italy.

A glacial-morenic valley rising from 1,400 m (Le Forme valley) to 2,100 m a. s. l. (M. La Metuccia) in the northern part of the Mainarde complex was mapped for dynamical tendencies in its vegetation. This survey area (approx. 3,850 x 1,850 m, i. e. 700 hectares), will be here forth mentioned as Val Pagana - Le Forme (Fig. 1).

The vegetation of this area is mainly characterized by beech forests (*Chelidonio-Fagetum* community) with some penetration of *Taxus baccata* in rocky conditions. The presence of *Juniperus communis*, *Daphne oleoides* and *Arctostaphylos uva-ursi* on the subalpine belt is to be considered as a trace of dwarf-shrub vegetation. The high altitude pastures above timberline belong to the *Seslerietalia apenninae* Order, and secondary pastures of the *Brometalia* Order are diffuse in the valley. The abandoned areas host several patches of scrub vegetation (*Prunetalia* Order).

The forests have been subject to an intense exploitation over the centuries (selective felling and thinning, coppicing, charcoal burning) and many surfaces were affected by other anthropogenic pressures (animal grazing and fires). Man's semi-nomadic activities involving cattle, sheep and goat grazing caused a number of clearings in the forest (secondary pastures, mainly on dolines), a modification of the timberline, a noticeable reduction of dwarf-scrub in the sub-alpine belt and a large disturbance of high-altitude pastures.

Human impact is still noticeable, but the vegetation freed from zoo-anthropic pressure is undergoing different dynamical processes over a large part of the territory.

Material and methods

Vegetation analysis and mapping

The map of dynamical tendencies in the vegetation of Val Pagana - Le Forme (1:10,000) was obtained in 1989-1990 by field-transects, excursions, and fundamental analysis of the vegetation; the ortophotomap was used to define the boundaries of each cartographic unit and to realize the basic map. Air-photos analysis was also employed.

Vegetation analysis was carried out in the field by means of structured phytosociological records (using Braun-Blanquet scales by layers) and, simultaneously, by determining the basic ecological process prevailing in each observed community.

As no data were available from direct studies on permanent plots, distinction of the phases in each process was omitted and the historic perspective was taken from a Forestry Administration management system project which assessed the 1972 structural state of the vegetation.

The ecological processes were distinguished according to the synthetic system proposed by Falinski (1986, 1989) and described with specific conceptions and criteria (see also Fig. 2).

Different directional processes, which develop through a series of well-defined communities, were distinguished by interpreting the state of the initial habitat (*primary succession* and *secondary succession*) and by identifying process reversal through analysis of historical documents and biotope degradations (*regression*).

Recreative secondary succession is the reconstruction of a widely damaged phytocoenosis by vegetative and generative diaspores from other phytocoenosis ("external forces"). The directional process is defined as *creative* when a new stable biocenosis (after biotopic changes as drainage, pollution, soil destruction, etc.) is thus established.

Repeated reconstruction of the same biocenosis (at a given stage) indicates the *replicative* character of the directional process after repeated destruction by external factors (floods, fires, landslides, etc.). Knowledge of the spatial and temporal scale of disturbances is fundamental for defining this feature.

The dynamics develops inside the same phytocoenosis after a disturbance impacts on the system producing only functional and structural reversible changes. The term *regeneration* means that the phytocoenosis reconstructs its functions and structures with its own components and diaspores. The latter process only follows a disturbance-induced functional and structural *degeneration* of the phytocoenosis; the complex of processes which respond to the term *degeneration-regeneration after periodic events* applies to ciclic disturbance.

Natural fluctuation defines the irregular, weak and reversible changes in the vegetation due to internal factors (such as natural self-thining, growth, spatial substitution, etc.) which ensure the stability of the ecosystem. When permanent records are not available, observation of spatial distribution (for exemple the reduction of clumped behaviour of herbaceous perennials) and natural phenomena (complexity of the vertical structure, mortality and rejuvenation), can aid recognition of this process.

Between one anthropogenic intervention and the next (such as mowing, grazing, plowing) vegetation affects small changes, which are called *fluctuations in anthropogenic communities*.

In order to identify the above defined ecological processes in Val Pagana-Le Forme the following informations for each sample-site were collected: the regeneration strategy of dominant species (vegetative sprouting, generative effort, growth); the source of diaspores and the reproductive ability; seedlings and sapling establishment; the penetration of ruderal-nitrophilous species (such as *Galium aparine* and *Stellaria media*), to index grazing pressure; the presence of scrub complexes (*Prunetalia* Order) as general index of the secondary succession in abandoned pastures; the previous state according to historical documentation.

Each cartographic unit is a homogeneous area characterized by comparable features such as stand origin, previous vegetation state, external disturbances, species composition, vertical structure and ecological processes.

This procedure permits, as it were, a snapshot of the phytocoenotic unit's present dynamic status expressed by the prevailing dynamical tendency.

Nomenclature follows Pignatti (1982).

Results

Field work identified four main ecological processes (succession, regression, degeneration-regeneration and fluctuation). In addition to these main processes, the study listed their variations, categorizing them in subdivisions according to effects and causal factors (Fig. 2). The Map of the vegetation's dynamical tendencies in Val Pagana - Le Forme (1:10,000; enclosed with this volume) represents these ecological processes, distinguished in 10 cartographic units described as follows:

1. *Recreative secondary succession*, that is, the present vegetation's tendency to reconstitute the original vegetation through "external contributions" (i.e. diaspores from other phytocoenoses), well-defined phases and communities. In the experimental area this process follows the abandonment of more or less large pastures (with or without trees) in the valley, or just below timberline, and in the subalpine belt. In all cases, pioneer shrubs and trees seem to belong only to the *Prunetalia* Order with *Juniperus communis* and *Prunus spinosa* widely spread.

2. *Primary creative succession*, from the inorganic substratum to a final stable community. This is limited to the small lakes of the morenic plate and to some glacial basins or valleys after big landslides where *Vaccinium myrtillus* and *Arctostaphylos uva-ursi* penetrate due to climatic inversion phenomena.

3. *Primary replicative succession*, after repetitive drastic disturbances which completely destroyed the vegetal cover (in permanently cyclical pioneer conditions). This tendency is evident in slopes under the repeated effects of erosion, snow or small landslides (Falinski 1991). Some areas between the timberline and the sub-alpine belt (southwestern corner of the map), could be considered a critical example of this process leading to a very special vegetation rich in glacial relicts (AA. VV. 1992) and with a characteristic structure (crook-stem, creeping-stem, dwarf shrubs, etc.; see Dolukhanov 1978).

4. *Regression* of the vegetation, through well-defined phases and phytocoenoses leading to a decrease of cover. This is an occasional process on steep slopes, especially where man's action (felling or zoopressure) has caused the instability of the sites.

5. *Degeneration*, a structural simplification and/or variation in floristic composition and in functional aspects of the same phytocoenosis, *under continual disturbance*. In this map degeneration is the principal dynamical tendency of forests in more accessible sites under constant grazing pressure (with penetration of ruderal-nitrophilous species), while only a modest surface of secondary pasture and dwarf-shrub is in degeneration caused by repeated fires in a fragile geomorphological context. Fire management seems to be a recent factor limited to small areas in the low-scrub of the subalpine belt, which has not caused directional processes (such as replicative or creative secondary succession).

6. *Degeneration*, as defined above (5), but in this case *under drastic periodic events*, in wide or limited areas. This rapid variation in the phytocoenoses of Val Pagana - Le Forme is due to coppice management and small snow slides in small valleys, which produce a structural simplification, a wider role of eliophilous species and functional changes in the forest herb layer.

7. *Regeneration after the effects of continual disturbances* and

8. *Regeneration after drastic periodic events*. In the regeneration process the phytocoenose itself (by means of its components and diaspores) reconstitutes the original vegetation. Those two distinct aspects are the forest vegetation's main tendency after the interruption of anthropogenic pressures (wood exploitation, coppice management, animal grazing), and occasional natural influences (snow slides). Saplings (or vegetative shoots) of native species determine the shrub layers, which often lie under a monolayered canopy; self-thinning produces a selective functional stratification which gradually restores the floristic structure. Regeneration occurs widely in areas where weaker forest management and grazing were probably due to poor site accessibility or special protection of some parts of the forest.

9. *Fluctuation in natural communities* is the natural process which allows the permanence of a dynamically stable community. Natural fluctuation is found only in some primary pastures over the timberline of M. La Metuccia (southwestern corner), where man's impact has been progressively reduced in the last decades, and in a very small forest area in a quite inaccessible site (northeastern corner).

10. *Fluctuation in anthropogenic communities*, in communities stabilized by continual anthropic interventions. In the survey area this process concerns herbaceous communities in which regular pasture and maintenance for touristic purposes are still the stabilizing factors.

Conclusions

The map of the dynamical tendencies in the vegetation represents the latest evolution in the concept of dynamic maps (developed by Lüdi 1921; Aichinger 1951; Gaussen 1954; Gribova and Samarina 1963; Ozenda 1966, etc.) and of the vegetation series (Rivas-Martinez 1985; Pedrotti 1988). It is very useful to describe the wide range and intensity of anthropogenic pressure, as well as the spatial distribution and regularity of major ecological processes occurring in the vegetation.

The map of dynamical tendencies in the vegetation of Val Pagana-Le Forme (Abruzzo National Park, scale 1:10,000) expresses mainly the structural differentiation in the forest surface, as primary and secondary pastures are more homogeneous.

Primarily, the map discussed here displays three co-dominant processes: degeneration and regeneration in forest communities and secondary succession in communities of abandoned pastures. In smaller areas these processes are accompanied locally by fluctuation in forest and synanthropic communities, primary succession in the high slopes and lakes of the glacial cirque, and regression in unstable peaks and slopes.

In spite of previous and continued anthropic influences, the experimental area shows a good potential for reconstitution of the vegetation complex, which is quite resilient (see e.g. Maarel van der and Werger 1978) and thus its recent inclusion in the Abruzzo National Park seems to be appropriate.

This map of dynamical tendencies in the vegetation exemplifies a standardized methodology for further applications such as predictive interpretations of current processes, and could be a useful tool for correct territory management (depending on territory management goals and knowledge of factors active in the area). Achievement of territory management goals requires information from permanent study-areas. Also important should be a quantification of the map's predictive value through some check-algorithm for each research step (Falinski 1986, 1990; Nimis 1991).

This example suggests that identification of the vegetation's present dynamical tendencies might be a very useful predictive tool, especially when one can assume the effective cessation of anthropogenic influences or, at least, a controlled program of natural processes in protected areas.

References

AA.VV. 1992: Le Mainarde. Zona di ampliamento in Molise del Parco Nazionale d'Abruzzo. L'uomo e l'ambiente, 16. Univerzita degli Studi di Camerino.

Aichinger, E. 1951: Vegetationsentwiklungstypen als Grundlage unserer land- und forstwirtschaftlichen. *Arbeit. Angew. Pflanzensoziol.*, **1**: 17-20.

Canullo, R., Pedrotti, F. and Venanzoni, R. 1990: Les processus dynamiques dans la végétation de la tourbière de Fiavé (Italie du nord). *Phytocoenosis, 3(N.S.), Suppl. Cartogr. Geobot.*, **2**: 189-194.

Conti, F., Pedrotti, F. and Pirone, G. 1990: Su alcune piante notevoli rinvenute in Abruzzo, Molise e Basilicata. *Archiv. Bot. Biogeogr. Ital.*, **66**: 182-196.

Dolukhanov, A. G. 1978: The timberline and the subalpine belt in the Caucasus mountains, USSR. *Artic and Alpine Research*, **10**: 409-422.

Falinski, J.B. 1986: Vegetation dynamics in temperate low land primeval forests. Ecological studies in Bialowieza forests. *Geobotany*, **8**. Junk, Dordrecht.

Falinski, J.B. 1989: Le temp et l'éspace dans les recherches écologiques sur le dynamisme de la végétation. *Giorn. Bot. Ital.*, **123**: 81-107.

Falinski, J.B. 1990: Kartografia geobotaniczna, 1, 2. PPWK, Warszawa.

Falinski, J. B. 1991: La dynamique du paysage interpretée par la dynamique de la végétation. *Coll. Phytosoc.*, **17**: 425-457.

Falinski, J.B. and Pedrotti, F. 1990: The vegetation and dynamical tendencies in the vegetation of Bosco Quarto, Promontorio del Gargano, Italy. (Maps in scale 1:10,000 with comments). *Braun-Blanquetia*, **5**: 1-31.

Gaussen, H. 1954: Géographie des plantes. A. Colin, Paris.

Gribova, A.A. and Samarina, G.D. 1963: Logical principles and improvement of information content of vegetation maps. *Geobotanical mapping*: 15-25.

Küchler, A.W. and Zonnenveld, I.S. 1988: Vegetation Map ping. Handbook of vegetation Science, 10. Junk, Dordrecht.

Lüdi, W. 1921: Die Pflanzengesellschaften des Lauterbrunnentales und ihre Sukzession. *Beiträge geobot. Landesaufnahme*, **9**: 1-364.

Maarel van der, E. and Werger, M.J.A. 1978: On the treatment of succession data. *Phytocoenosis*, **7**: 257-278.

Nimis, P.L. 1991: Data quality in environmental sciences and the biomonitoring of air pollution. *Giorn. Bot. Ital.*, **125**: 126-135.

Ozenda, P. 1966: Perspectives nouvelles pour l'étude phytogéographique des Alpes du Sud. *Doc. cart. vég. Alpes*, **1**: 5-18.

Pawlowski, B. and Zarzycki, K. 1972: Dynamika zbiorowisk roslinnych. In *Szata Roslinna Polski* I (eds. W. Szafer and K. Zarzycki), pp. 481-501. Warszawa.

Pedrotti, F. 1988: La cartografia geobotanica in Italia. In *100 anni di ricerche botaniche in Italia (1888-1988)* (ed. F. Pedrotti), pp. 731-762. Societá Botanica Italiana, Firenze.

Pignatti, S. 1982: Flora d'Italia. Edagricole, Bologna.

Rivas-Martinez, S. 1985: Biogeografia y vegetación. *Real Ac. Ciencias exactas, Fisicas y Naturales Madrid*: 1-103.

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