

SPONTANEOUS RENATURALIZATION PROCESSES OF THE VEGETATION IN THE ABANDONED FIELDS (CENTRAL ITALY)

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ABSTRACT – Some methodologies utilised for the analyses, with different scales, carried out in the study of the renaturalisation processes that determine in the territories that are not more utilised for agro-pastoral practices, are here described. In fact, during the last fifth teen years a progressive process of abandonment of the hilly and mountain territories, not more economically remunerative according to the present technological and market requests, have taken place. Therefore, in these territories, quick recovery processes by spontaneous vegetation are developing, having a great scientific and applicative importance, these processes caused, as result, a deep transformation of the plant landscape. These processes have been studied trough the methodologies of the phytosociological, synphytosociological and geosynphytosociological analyses in order to interpret the dynamic successions and to predict the time for the recolonisation according to diachronic studies associated to population dynamic analyses. To these studies are connected analyses on the architectural model of growth of *Spartium junceum*, species particularly active in the vegetation recovery processes, that have been carried out in Central Italy territories. These analyses allow a better comprehension of the role of this species.

KEY WORDS – Diachronic analysis, geosynphytosociology, plant landscape, population dynamics, vegetation series.

INTRODUCTION

The phenomenon of the “economic marginalization” that has progressively affected larger areas of Italian agricultural territory since the war has become evident through the abandonment of the agro-pastoral practices that for centuries have been the form of management for these areas. The statistical data show how in just the central and southern regions of Italy the agricultural area in use has suffered a reduction of around 2.1 million hectares, of which at least 1.8 million is in the hills and mountains. The reasons for this abandonment are to be found essentially in the changed socio-economic conditions of the Italian population, having many causes

and evident also at the community and extra-community level, that have resulted in the depopulation and the consequent loss of rurality of the Apennine population. This transformation process has led to the need to verify the "sustainability" of the affected areas, that has to be thought of both in environmental terms as much as in economic and demographic ones.

To assess the first aspect, that of the environment, it is of fundamental importance to understand what level of influence man has had on the natural ecosystems, and thus to understand the difference between the original state and the present. Such a valuation is certainly not easy to perform because of the lack of certain knowledge of the model of the potential landscape, the identification of which can be attempted through the integrated analyses of the historic series regarding the variations in space and time of environmental situations and the impact of man. It is anyway possible to put forward hypotheses that are in the majority absolutely generic, as they are mainly limited to the structure of the landscape. The scholars of the vegetation have for a long time argued over the concept of climax vegetation and therefore the potential plant landscape. It is thought anyway that the potentiality to which it is possible to refer to in concrete terms is only the actual one, that is the one that is realized or which is predictable to be realized in the near future in the territory under consideration, that having been profoundly transformed by human activities will not ever return to the original conditions (Biondi *et al*, 2001b).

The variations occurring in the agricultural, timbering and shepherding landscape, immediately perceptible with a simple observation (Fig. 1), allows us to discover a regenerative capacity in the natural processes that occurs on an unforeseen time-scale, significantly shorter than that hypothesised. What will be the scenaria that will be reached in the hill and mountain landscapes, outside of the large centres of agricultural production, in the next few years? Will the new environmental equi-



FIGURE 1 - An example of abandoned fields invaded by the shrubbery of common broom (*Spartium junceum*) in the hilly bioclimatic belt of the Umbria-Marche Apennines.

libria produce better stability or, on the contrary, result in hydrogeological ruin? In what way must one intervene to guide the natural processes that are developing? To adequately answer these questions, that are only a part of those legitimately proposable, it is first of all necessary to have a solid basis of the knowledge of the processes, indispensable for carrying out the planning of the renaturalization of the landscape. Indeed, it is inconceivable not to have plans regarding such an important part of the national territory, that is so deeply involved in transformation processes. For a country with such a high population density as Italy, it is necessary to define the significance of the conservation of nature in terms of planning strategy. It is also necessary to define the role of man in the planning and reconstruction of the biological equilibria, taking into account that human activity has not always resulted in a reduction of biodiversity, but in very many circumstances has notably increased it, as with the traditional agricultural, timbering and shepherding activities. It must therefore be considered that the abandonment of such practices induces transformations that we must guide and evaluate for their true significance.

MATERIALS AND METHODS

In order to study the dynamic processes of naturalisation that are the major responsible in the transformation of the hilly and mountain plant landscape, the analysis were carried out through the approaches that are described below.

a. Phytosociological, synphytosociological and geosynphytosociological approaches

They consist in the application of the Braun-Blanquet method in the study of the plant communities and the integrated methodologies for the individuation of the vegetation series and the description of the landscape models (Géhu & Rivas-Martinez, 1981; Biondi, 1995, 1996; Géhu, 1988; Rivas-Martinez, 1987; Blasi *et al.*, 2001; Theurillat, 1992).

The phytosociological investigations performed on the abandoned territories have led to the individuation of integrated dynamic models of the landscape, the interpretation of the plant landscape for the individuation of the landscape units (geosigmeta) and the recognition of the role of the most active species in terms of the vegetation recovery.

b. diachronic analyses

This kind of analysis was carried out through the utilisation of several series of old air photographs belonging to different period in order to observe the transformation of the landscape in time and to evaluate the time necessary for the establishment of the succeeding phases and the modalities of colonisation, allowing the interpretation of the environmental response to the processes of abandonment and the prediction of its evolution (Biondi *et al.*, 2000).

c. Autoecological studies

These studies were conducted on the interpretation and the description of the architectural models of growth (Oldeman, 1979, 1990; Champagnat, 1947) and the mechanism of recolonisation (Ballerini *et al.*, 2002) carried out by some species, such as *Spartium junceum*, that are particularly active in these process-

es. Moreover, population dynamics studies, carried out on permanent plot occupied by shrub population (*Juniperus oxycedrus*, *J. communis* and *Spartium junceum*) for the evaluation of space occupancy and their evolution in the time. This allows to imagine various future scenarios that are not at present known (Baldoni *et al.*, 2004).

d. plant landscape maps

The maps of the plant landscape were realised with the support of GIS methodologies which allows, at the same time, to insert all the information in an archival system of the GIS data for the production of a database that can be queried. The "plant association" attribute is assigned to each polygon that comes from the field phytosociological analyses. In this way, a computer-based vegetation map is obtained with different details according to the scale (Biondi *et al.*, 2005).

RESULTS AND DISCUSSION

Phytosociological, synphytosociological and geosynphytosociological investigations

The phytosociological investigations performed on the abandoned territories have led to the individuation of integrated dynamic models of the landscape that in some cases have also considered the time necessary for the establishment of the succeeding phases, allowing the interpretation of the environmental response to the processes of abandonment and the prediction of its evolution. The role of the most active species in terms of the vegetational recovery has also been noted and emphasised through investigations of the demographic and autoecological aspects.

In recent years, research into the dynamism of the vegetation has been added to that of the so-called classical phytosociology. While the latter represents the first level of analysis of the vegetation that is focused on the recognition of the associations, the former belongs specifically to the integrated phytosociology, or sin-phytosociology that has resulted in the definition of the series (or sigmetum) of vegetation. This is made up of the collection of all the associations (communities) linked by dynamic connections that occur in a homogeneous space with the same vegetation potentialities: the "tessella" or "tessera", which represents the starting biogeographical/environmental unit of the mosaic making up the vegetal landscape. The investigations at this last level of analysis are achieved through the phytosociology of the landscape, or the geosinphytosociology, within which the vegetation series make up self-repeating groups in a homogeneous territory for geomorphological, climatic and vegetational characteristics. These groups are termed the geosigmeta within which a climatophilous series and at least two climatophilous series can be determined. The first grows on the soil that only receives water from precipitation, while the edaphophilous series can be edapho-hygrophilous, on the land with a greater availability of water, and edapho-xerophilous, that is found in particularly dry situations with respect to the average conditions of the area (Géhu & Rivas-Martínez, 1981; Biondi, 1995; Géhu, 1988; Rivas-Martínez, 1987; Theurillat, 1992). The model is a simple one of a valley where on its defining slopes there is the climatophilous series, while in the areas where there is no soil or where the soil has been eroded to uncover the rocks, the edapho-xerophilous series is established; on the

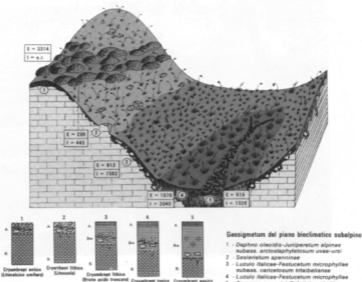


FIGURE 2 - Landscape unit (geosyngnetum) of the sub alpine belt of Gran Sasso d'Italia. A type of soil, represented by its profile and an average value of epigeal (E) and hypogeal (H) phytomass, corresponds to each association (from Biondi *et al.*, 1999).

other hand, in the central area at the base of the valley, where the water courses run and where the substratum is anyway more humid with respect to the other areas, the edapho-hydrophilous series can be found. With the integration between the dynamic series of vegetation and soil or biomass typologies, complex units of the vegetal landscape are found (Fig. 2) that make up integrated models of great predictive value (Biondi, 1995; 1996; Biondi *et al.*, 1999; Venanzoni & Kwietkowski, 1996).

In the vegetation series, the number of associations of which it is made can vary notably either for the natural conditions or for the effect of the type of management used. It is indeed man that through the use of the territory determines the major presence of the vegetal community inside the vegetation series. In this, as a function of the human influence, it is possible to recognize: more or less natural communities, like the woods; stable semi-natural communities, like for example the perennial grasslands that maintain the same characteristics as long as they are managed in the same way; or unstable, or of brief duration and rapid evolution, semi-natural communities, like the weeds in the fields.

The landscape interpretations expressed by the syngmeta and geosyngmeta are based upon these concepts. They constitute dynamic models with a high ecological value as they are defined through the statistical combination of species that repeat themselves in the territory with respect to the environmental characteristics represented by the interaction of the ecological factors to which the communities are sensitive. From the distribution of the vegetal associations it is consequently possible to recognize zones homogeneous for a complex of physico-chemical, biological and anthropic factors, that taken together outline a hyperspace, constituting the ecological niche of the community, defined by the needs of the plant population present in the territory.



FIGURE 3 - View of a part of the territory of Offagna.

This logical route, essentially deductive, has been validated by recent researches through statistical correlations between floristic compositions of a community and quantitative analytical data, of the pedological and biomass factors, that have resulted in the quantification of the concept of ecological valency of associations and in the description of the coenoclines on the basis of which the vegetation series are distributed in the geosigmetum composition (Biondi & Zuccarello, 2000; Zuccarello *et al.*, 1999; Andreucci *et al.*, 2000; Biondi *et al.*, 2001a).

Phytosociological research in the study of the vegetation of Central Italy has allowed the individuation of the main series present that have been analysed in detail, especially in some areas for which the institution of parks and natural reserves has allowed and requested particularly detailed studies.

The landscape of the Marche hills, outside of the Apennines, in the Provinces of Ancona (Biondi & Allegrezza, 1996) and Ascoli Piceno (Allegrezza *et al.*, 2006), as for example in the area of Offagna (Fig. 3), is mainly made up of deposits of very fine material, the pelites, of the Plio-Pleistocene, rich in clay minerals that alternate with pelitic-arenaceous, arenaceous-pelitic and sandy- conglomerate bodies.

In the summit areas of the same hills there are present, however, banks of sand, more or less cemented, and sometimes conglomerates that can reach a thickness of more than 20 m (Fig. 4).

The plant landscape is directly correlatable with the substrata characteristics. In this way, on the highest sectors of the hills there are good conditions of drainage that result in drought in some periods of the year. Under these conditions the edapho-xerophilous series of the downy oak grows, called *Roso sempervirentis-Quercus pubescentis* sigmetum. For this reason, as is apparent in the photograph of the Municipality of Offagna (Fig. 3), the medieval towns, the villas and the buildings were built mainly in this area, as the rock is sufficiently stable and appropriate for the support of their foundations. On the sides of the hills in which the clays prevail, the more humid substratum allows the growth of the climatophilous series of the hop hornbeam, called *Asparago acutifolii-Ostrya carpinifoliae* sigmetum.



FIGURE 4 - Geological scheme of the hilly Ancona territory (from Centamore *et al.*, 1991- redrawn and simplified).

This is the area in which the appropriate soils prevail for the agriculture that is prevented only where the slope is excessive. On the sides in which the arenaceous-pelitic formations emerge, instead the Turkey oak series of *Lonicero xylostei-Quercus cerridis* sigmetum grows. Finally, in the fall lines and along the ditches, with the constantly wet substratum, the edapho-hygrophilous series of the elm *Symphyto bulbosi-Ulmo minoris* sigmetum is found (Fig. 5).

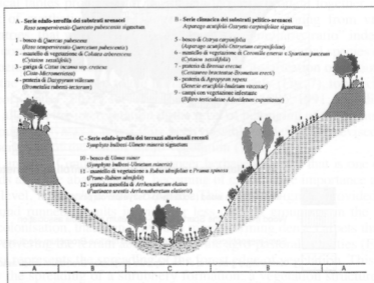


FIGURE 5 - Landscape unit of the hilly Ancona territory with the arenaceous, pelitic-arenaceous and alluvial substrata (from Biondi & Allegranza, 1996).

In the hilly bioclimatic belt of the Umbria-Marche Apennines, the most representative vegetation series are those of the downy oak (*Peucedano cervariae-Quercus pubescentis* sigmetum), that is found mainly in the hilly areas connecting the marly-arenaceous formations, and that of the hop hornbeam (*Scutellario columnae-Ostrya carpinifoliae* sigmetum) present on the calcareous sides of the ridges.

The downy oak series in this area has recently been further defined following the investigations conducted in the woods dominated by this species present in the Central Apennines (Allegrezza *et al.*, 2002) that has allowed their inclusion in the association *Peucedano cervariae-Quercetum pubescentis* and at the same time to specify that the thermophilous association *Roso sempervirentis-Quercetum pubescentis* in the Umbria-Marche Apennines is found only in a few areas of the calcareous ridges, in the hottest aspects on the drained soils.

The leading association is the *Peucedano cervariae-Quercetum pubescentis* that includes the relatively mesophilous oak woods present on the marly-arenaceous, marly and clay-marly soils of the hilly heights of the region, mainly in the internal sectors of the Marche synclinorium, part of the temperate bioclimate, hilly bioclimatic belt and ombrotype from humid to sub-humid. Within the association there is the thermophilous subassociation *ruscetosum aculeati*.

The hop hornbeam series refers to the wood of the association *Scutellario columnae-Ostryetum carpinifoliae* with which two main xerophilous grasslands are linked, those spread on the steep slopes, and the semi-mesophilous distributed on the slightly sloping surfaces (Fig. 6). The dry grasslands belong to the association *Asperulo purpureae-Brometum erecti* while the semi-mesophilous to the association

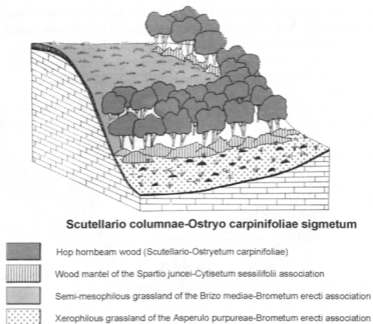


FIGURE 6 - Climatophilous series of hop hornbeam that develops in the hilly bioclimatic belt or the calcareous area of the Umbria-Marche Apennines (from Ballelli & Biondi, 1982 redrawn).

Brizo mediae-Brometum erecti. The vegetation mantle that surrounds the woods is made up of formations of the common broom (*Spartium junceum*) and *Coronilla emerus* of the association *Spartio juncei-Cytisetum sessilifolii*. This is present in two aspects, of which one is cooler, extremely close to the woods, and the other heliophilous and pioneer, that invades the fields and the abundant grasslands. The first is composed by *Cytisus sessilifolius*, *Coronilla emerus* ssp. *emeroides*, *Spartium junceum* and *Lonicera etrusca*. The pioneer and heliophilous aspects have however different configurations, depending upon the dominant species. In particular, in the cooler areas, placed at higher levels, it is *Cytisus sessilifolius* that dominates, in contrast in the hotter areas, with soil-poor and rock-rich substrata, *Corynus coggygria* and *Juniperus oxycedrus* are widespread, while the broom is common on the relatively deeper soils.

Particularly meaningful is the role of shrub communities. The evolutionary dynamism of the vegetation linked to the abandonment is most evident in the spreading of high grasses and shrubs that invade the grasslands and fields that are no longer cultivated. This dynamic process takes its origins from an ecotonal space, positioned between the forest and the grassland, that is occupied by an intricate vegetation of shrubs and vines, the mantle preceded by herbaceous formations, the vegetation edge. Both of these phytocoenoses spread when the anthropic activities come to an end, invading the grasslands. The study of this type of vegetation, introduced by Tüxen (1952), for the aspects regarding the shrub vegetation, and by Dierschke, (1974) for those of the herbaceous vegetation, have definitively opened the road to the phytosociology of the landscape, allowing the realization of interpretative models of the dynamics of the vegetation.

Regarding the Italian shrub vegetation, the syntaxonomic revision of the associations of mantles described for the national territory has recently been completed (Poldini *et al.*, 2002). The methodology used is based upon a comparison of the phytosociological tables produced for the Italian territory brought together in one unique matrix of synthetic columns, together with those coming from various European countries, that were then classified using the "similarity ratio" index and the method of complete linkage (Podani, 1993). Once the differential species of the Italian phytocoenoses had been individuated, the same classification operation was repeated with the matrix reduced to the Italian columns only (Fig. 7), to which was applied the theory of the "Fuzzy set" (Feoli & Zuccarello, 1986; 1991; Biondi *et al.* 2004) that has allowed the interpretation of the level of belonging of the columns to the diverse groups or syntaxa. It has thus been possible to define the revised syntaxonomic description of the Italian shrub vegetation (Table 1).

For the hill areas of Central Italy the pioneer herbaceous plant that is one of the first that spreads after the abandonment, becoming of quantitative importance also at the landscape level, is *Brachypodium rupestre*. This caespitose grass, provided with long underground runners, results in more or less circular groupings in the initial phases of the colonisation, that then grow and merge forming dense carpets that end up completely covering the terrain abandoned by the agro-pastoral activities (Fig. 8).

This process represents the spreading of the forest edge of vegetation. This stage is followed by the spreading of a shrubby formation: a vegetation structure with its own morphological and floristic characteristics, dominated by different shrubs, depending upon the climatic and edaphic conditions (Biondi *et al.*, 1988).

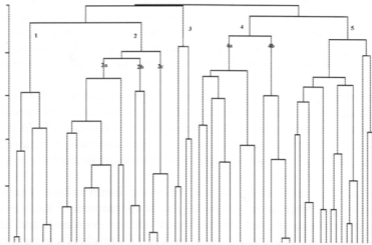


FIGURE 7 - Classification of the 69 Italian associations of mantle (*Rhamno-Prunetea*).

1. Edapho-xerophilous associations of *Cytision* alliance; 2a. Edapho-mesophilous associations of *Cytision* alliance; 2b. Semi-mesophilous-(sub)mountain associations of *Cytision* alliance; 2c. Mantle associations of North-East Italy (*Fraxino ornii-Berberidenion*); 3. High mountain Apennine mantle associations (*Berberidenion*); 4a. Edapho-mesophilous associations of *Pruno-Rubention ulmifolii* sub-alliance; 4b. Edapho-mesohygrophilous associations of *Pruno-Rubention ulmifolii* sub-alliance; 5. Heterogeneous group of coenosis (*Fraxino ornii-Berberidenion*, *Berberidenion*) (from Poldini *et al.*, 2002).



FIGURE 8 - Picture of an agricultural hilly territory, on the calcareous ridge of the Umbria-Marche Apennines, with various stages of abandonment and recovery of the vegetation. In the upper part, there are remnants of wood, preceded by edges of mantles, and on the slope there are post-cultivation grasslands of *Brachypodium rupestre* (light area in the photograph) and of *Helichrysum italicum* (in grey) that are distributed on the basis of the micromorphology of the slope. In the less steep areas (at the bottom) the terrain is still being cultivated.

In the Marche hill areas there is mainly the common broom (*Spartium junceum*) or the red juniper (*Juniperus oxycedrus*), but sometimes also *Coronilla emerus* or *Cytisus sessilifolius*.

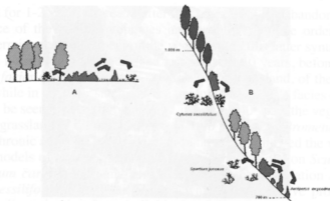


FIGURE 9 - Scheme of the intercorrelated connections between the vegetation mantle, the wood and the grasslands (A): the mantle serves as a centre for the spreading of the seeds of the shrub species that colonise both the clearings in the wood and the grasslands. In (B) there is a scheme of the distribution of the dominant shrub species of the hilly bioclimatic belt of the Apennines: *Spartium junceum* colonises the deeper soils and *Juniperus oxycedrus* the shallower soils, while *Cytisus sessilifolius* dominates the shrubbery in the higher sector of this bioclimatic belt, in transition with the beech wood.

The shrubs that take over the zones previously colonised by *Brachypodium rupestre* arise from the vegetation mantle that spreads to occupy the grassland when the anthropic activities cease (Fig. 9). The species that spread and colonise the abandoned terrain are obviously the more heliophilous ones and also the less water-demanding. The shrubbery, while gaining structure, favours in turn the conditions for the establishment of the less demanding pioneer wood plants, such as the flowering ash (*Fraxinus ornus*), the hop hornbeam (*Ostrya carpinifolia*) and the downy oak (*Quercus pubescens*).

Diachronic analyses of the vegetation recovery processes on the abandoned fields

There have been analyses of the Apennine territories occupied by the hop hornbeam series (Biondi *et al.*, 2000) with the aim of identifying the phases of the dynamic processes that are found during the succession, for the definition of the times and the dynamics of the most active populations in the processes of recovery (Biondi, 1990; Canullo, 1992, 1993; Canullo *et al.*, 1992; Ballerini *et al.*, 2000; Ballerini & Biondi, 2002; Ballerini *et al.*, 2002).

This research has been realised in the "permanent areas of study" chosen in a way so as to represent diverse periods of agricultural activity abandonment, and therefore of different naturalisation. The field studies in this area have been integrated with diachronic analyses, obtained through interpretation of past aerial photographs from the years of 1956, 1978 and 1990 (Fig. 10).

It has thus been possible to map the agro-vegetational variation across these years. With this system, it has been possible to quantify the time necessary for the growth of the different dynamic successions that follow different routes depending upon the particular conditions determined by the anthropic activities.

The first part of the diachronic vegetation analyses has allowed the estimation of the time needed for the change from the vegetation infesting the fields to the grassland, of the association *Asperulo purpureae-Brometum erecti*, making clear also



FIGURE 10 - Aerial photographs of the area under consideration in the diachronic analyses of the vegetal landscape (in the Locality of Case Meloni, in the Municipality of Fabriano). The top photograph, taken in 1956, shows the area as completely cultivated; in the next, taken in 1978, there is evidence of abandonment and the recovery of the wood on the grazed areas outside of the agricultural zones. In the final photograph, of 1990, the major part of the fields have been abandoned and taken over by the post-cultivation grasslands and by the shrubbery.

through which *facies* the process is realized. The starting situation is represented by the community infesting the cultivation, mainly made up of terophytes belonging to the alliances *Fumario-Euphorbion* (vineyards) and *Caucalidion lappulae* (seeded and

uncultivated for 1-2 years). Already after 3-4 years from the abandonment, the massive presence of the hemicryptophytes and geophytes of the order *Agropyretalia repentis* determine the assignment of the vegetation to this latter syntaxon. This condition in the more humid situations can last even for 10 years, before then evolving towards the *facies* of *Brachypodium rupestre* of the grassland, of the class *Festuco-Brometea*, while in the drier situations the evolution towards a *facies* of *Helichrysum italicum* can be seen instead. In both cases, in around 40 years the vegetation evolves towards the grassland of the association *Asperulo purpureae-Brometum erecti*.

The diachronic analyses of the vegetation have also allowed the valuation of the speed and models of expansion of the woods of the association *Scutellario columnae-Ostryetum carpinifoliae* and of the shrubs of the association *Spartio juncei-Cytisetum sessilifolii*. In the situations in which the evolutive process originates through the dissemination from individuals of forest species, the tree vegetation grows directly on the uncultivated fields constituting, in the first phases, the shrub stage of the secondary succession that evolves towards the wood. This process happens frequently enough in the areas examined, favoured by the depth of the soil of the more-or-less terraced fields.

The forestal or pre-forestal species that have the biggest part in the recolonisation are: *Fraxinus ornus*, the seeds of which cover distances of many metres from the mother plant; and *Quercus pubescens*, the acorns of which fall up to a few metres outside the projection of the foliage; meanwhile in the more favourable situations *Ostrya carpinifolia* also participates in the recolonisation. This process can occur according to the schemes of advancement represented by the frontal and dispersive models. In the frontal model, the dissemination of forestal species starts from a wood front bordering the uncultivated field.

The colonisation by the phanerophytes stops for a number of years a few metres from the edge of the wood because of the absence of vegetative propagation and the long time interval needed for the fruiting of the pioneering plant. The phanerophytes can grow together with the shrubs of the mantle, but prevail on these while they grow, while the species of the mantle establish themselves at the edges of the newly formed pre-wood and advance frontally towards the grasslands (Fig. 11). In the dispersive model the dispersion of seeds comes about from isolated trees; the colonisation on the part of the wood stops for a number of years a few metres away from the disseminating plants and then restarts when the new individuals fruit (Canullo, 1993). The woods that arise from this model constitute pioneering *facies* within which the nemoral species are little represented (Fig. 12).

The advancement of the wood, over the interval of observation (35 years) was limited to a few metres in the case of *Quercus pubescens* (ballistic dissemination) while distances of up to 20 m had been reached in the case of *Fraxinus ornus* and *Ostrya carpinifolia* (anemochorous dissemination).

In other situations, that in the Apennines are definitely the most frequent as they involve terrain with reduced quantities of soil that is not terraced, the colonisation of the uncultivated fields is carried out by the species of the vegetation mantles, and in particular by *Spartium junceum* that in the pedoclimatic context that characterises the area under study is the most spread of the pioneering shrubs (Fig. 1). This situation is highly relevant, so much so that it characterises the present-day hill and sub-mountain landscape of the Central Apennines. The process occurs according to

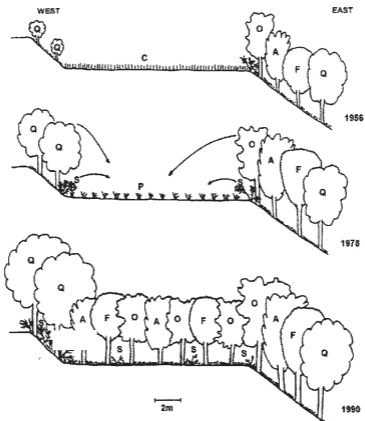


FIGURE 11 - Cross-section of the vegetation of an abandoned field, on a terrace. The colonisation starts from a wood front through frontal advance, with the constitution of a pre-wood and not of a true covering, in so much as the pre-forest species are favoured by the depth of the soil (years: 1956, 1978 and 1990; A = *Acer obtusatum*, C = cultivated, F = *Fraxinus ornus*, O = *Ostrya carpinifolia*, P = grassland, Q = *Quercus pubescens*, S = *Spartium junceum*) (from Biondi *et al.*, 1997).

the frontal and nucleation models. The frontal model consists of the ecotonal protrusion of the mantle, that takes over the grassland forming a shrubbery of *Spartium junceum* (according to the dynamic scheme shown in Fig. 9) that spreads mainly by seed and proceeds at a speed of around 2-3 metres/year thanks to the precocity of the fruiting of *Spartium junceum* (Biondi *et al.*, 1997; Biondi *et al.*, 2005)

The trailing edge of the shrubbery, the oldest, is characterised by the regression of the broom that leaves space for the entry of other shrub species of the class *Rhamno-Prunetea*, allowing therefore a better structuring of the vegetation of the mantle. Moreover, other shrub species and some pioneering trees are able to grow under the close cover formed by the broom, exploiting the pedogenic evolution and the humidity of the substratum. Later, the trees take over from the broom plants that survive for a few years, even if dominated, but losing the capacity for maturation of

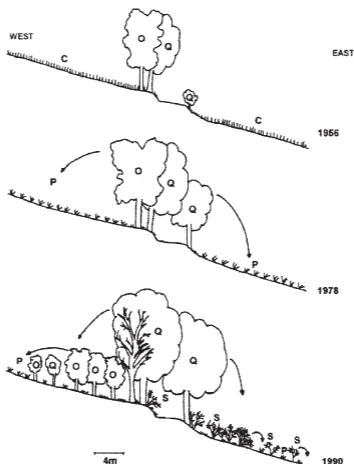


FIGURE 12 - Dispersion model realized by the dissemination from isolated trees; the colonisation by the wood stops for a few years at a few metres from the disseminating plants, and then restarts when the new individuals fruit (years: 1956, 1978 and 1990; A = *Acer obtusatum*, C = cultivated, F = *Fraxinus ornus*, O = *Ostrya carpinifolia*, P = grassland, Q = *Quercus pubescens*, S = *Spartium junceum*) (from Biondi *et al.*,1997).

their fruits. The most active forestal species is *Fraxinus ornus*, that is advantaged by its capacity of anemochorous dissemination. A progressive time and space sequence therefore arises between grassland, shrubbery, mantle, pre-wood and wood that determines the fast recovery of the forestal vegetation. In the model for nucleation, the colonisation by *Spartium junceum* occurs through centrifugal expansion originating from isolated individuals (Fig. 13), as well as by frontal advance starting from the edge of the wood.

It is therefore possible to predict that analogous seed dispersal mechanisms will determine the presence in the area of forestal species such as *Fraxinus ornus*, *Quercus pubescens* and *Ostrya carpinifolia* that will later take over, while the population of broom will collapse partly because it becomes old and partly because it is shadowed by the trees.

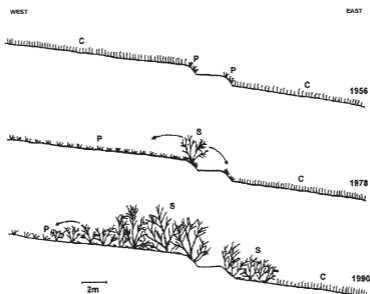


FIGURE 13 - Nucleation model starting from broom bushes (years: 1956, 1978 e 1990); C = cultivated, P = grassland, S = *Spartium junceum* (from Biondi *et al.* 1997).

The pedological study, carried out in the same area, has shown that the vegetation of the recently abandoned fields grows on Entisols (Xerorthents Type) with an Ap C profile not much different from the soils still under cultivation. In parallel, with the evolution of the vegetation towards the wood, without modifying appreciably their own physical characteristics (particularly their structure) as the dynamic evolutive processes settle in, the soils demonstrate again a diagnostic alteration horizon of profile type A Bw C. The increase in the thickness of the *solum* and its enrichment in organic substance and clay, along with everything that these variations bring at the level of other fundamental characteristics of the soil (cation exchange and useful water capacities), allow these same soils to be classified as part of the Inceptisols (Xerochrepts Type) (Biondi *et al.*, 1997; Biondi *et al.*, 2005).

Autoecological studies: the broom

From the studies carried out, it has been seen that the most common mechanism of recolonisation of the shrub vegetation on abandoned fields and grasslands in the Umbria-Marche Apennines occurs by frontal advance of the vegetation mantle (Biondi *et al.*, 1997; Biondi *et al.*, 2005). In this process, the broom plays an essential role in the heliophylous phase of spreading of the pioneering shrubbery. For this reason, it is considered a necessity to undertake the autoecological study of this species in precise terms, with the first analysis being that of the knowledge of the architectural model (Ballerini *et al.*, 2002). This is in order to understand how the broom manages to cover the terrain, and therefore to interpret the structure as a function of the intra- and inter-species competition that accompanies the dynamics of the population.

To construct an architectural model (according to Oldeman, 1990) of *Spartium junceum* the growth unit (g.u.) was analysed, i.e. the axial growth starting from a bud in a single continuous period of growth, which includes also the sylleptic branching (Lauri, 1991) that derives from ready lateral buds that are able to grow in the same cycle of growth in which they were formed without an intervening rest or winter dormancy period.

Three different types of shoots can be individuated (Fig. 14), known as “categories”:

- a) *main shoots* - originating from buds that have been through the winter period (proleptic shoots; Oldeman, 1979);
- b) *stipular shoots* - produced from ready lateral buds, not visible to the naked eye and positioned at the base of the shoots in a dorsal (external) position and protected by the persistent part of the leaf stem from the axil of which the main shoot grew;
- c) *syллеptic shoots* - produced along the axis of any vigorous shoot, in distal positions with respect to those stipular, by the ready lateral buds at the axil of the persistent part of the leaf stem of the newly formed nodes (anticipated shoots; Champagnat, 1947).

The study of the architectural model of the broom has involved investigations into the phylotaxis, into the budding and into the differences between the buds as a function of the type of branch and the growth of the shoots, both as total growth and speed of elongation, in plants of different ages. In this way, the characterisation of the growth of the aerial parts has been achieved, demonstrating some adaptive advantages of the model. It has been shown that the young individuals specialise in the lengthening of the branches rather than a higher rate of budding that could dilute their resources across too many centres for growth, while this behaviour can be necessary for an increase in the competitiveness towards the herbaceous plants in the first phases of the colonisation of abandoned terrain.



FIGURE 14 - An example of the complex growth unit (g.u.) of *Spartium junceum* that shows all three categories of branches: primary (a), basal secondary (b), sylleptic (c) (from Ballerini *et al.*, 2002).

Under these conditions, the broom takes on a slender architectonic form and an ovoid foliage. In contrast, the adult or scenscent individuals preferentially form a high number of branches with respect to their lengthening, which becomes uniform across the different categories.

In this way, the plant tends to obtain upon maturity a spread architectonic form with an external corona of short flowering branches and an internal cavity growing through the years (Ballerini *et al.*, 2002). With the numerical data obtained from the study of the architectonic model, it has been possible to realize a programme that simulates the growth of the broom (Neri & D'Onofrio, 2002) (Fig. 15).

The demographic studies of populations of *Spartium junceum* have been performed in a permanent area situated in the Alto Esino through a census of individuals in 1994, with a following check on the data in 2000. The permanent area is set up in a way that allows an analysis of the processes of frontal advance of the mantle within the hop hornbeam series.

The permanent area is situated on the eastern aspects of Serra Santa mountain (1423 m), which is part of the Umbria-Marche Apennine ridge, in the Locality of Vallemonici, in the Municipality of Fabriano (Province of Ancona). It is made up of 8 squares, each with 6 m sides, positioned consecutively on a colluvium following

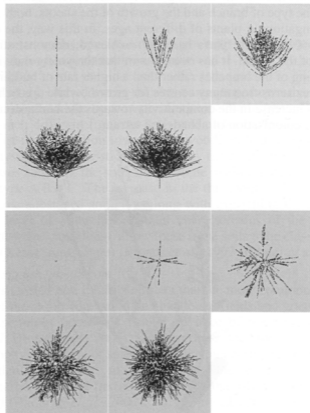


FIGURE 15 - Graphical simulation of the growth of a broom individual: front view (top) and view from the top (bottom) (from Onofri & Neri, 2002).

the line of maximum slope. The average altitude is 755 m; the exposure of the slope is towards the North-East. The squares are denominated by a letter from A (uphill) to H (downhill); they have been arranged in such a way as to include a succession of vegetation, including the edge of the wood of *Ostrya carpinifolia* (in the higher part), shrubby structures dominated by *Spartium junceum*, to the herbaceous structures of *Bromus erectus* (in the lower part).

In the permanent area phenological and population dynamics analyses have been performed.

The phenological investigation was carried out in the vegetative season of 1994 and included the entire population of *Spartium junceum* in the permanent area. Graphs have been constructed of the phenological data (Fig. 16).

The production of the leaves proceeds from the end of February to the middle of August. In the first cycle, a strong decrease in leaf production is noted from the mid-

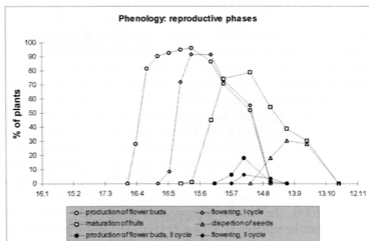
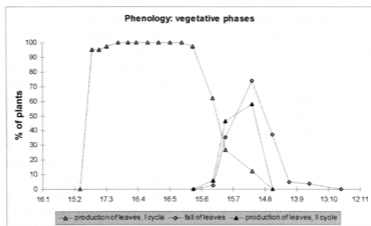


FIGURE 16 - Phenological diagram of the vegetative phases (top) and of the reproductive phases (bottom) of *Spartium junceum* (from Ballerini et al., 2000).

dle of June, as in this period the sexually mature plants cease leaf production to form the floral raceme. The foliation phase, with respect to both the first and the second cycles, suddenly stopped in mid-August. By the end of August anyway, the majority of the plants have completely lost their leaves, a peculiar characteristic of this species being the brief persistence of the leaves on the plant.

The production of flower buds starts around the middle of April. The complete flowering period is made up of two cycles, partly overlapping, and is very long: within the population, plants in this phenological stage have been found from the middle of May to the first ten days of September. The seed dispersion occurs rather quickly, as the mature legume opens soon and allows them to fall.

The second cycle of bud opening occurs in only 54.3% of the plants that begin new leaf production, while very few reach the second flowering (9.8%). It was not possible to follow distinctly the two phases of the maturation of the fruit in this population.

From the data available it is anyway possible to conclude that, with respect to the reproduction capacity of the species, the contribution of the second cycle is very little.

Concerning the dynamics of the population of broom at the end of the vegetative season of 2000, there were 77 plants in the area, against the 81 of 1994 (Ballerini *et al.*, 2000; Ballerini & Biondi, 2002). This was caused by a strong regression of the population in the entire first half of the area – that closer to the wood – that was not compensated for by the its expansion in the lower part, as this was still managed as grazed grasslands. This resulted in an increase in the average age of the broom plants in the permanent area, in the 6 years that had passed, which increased appreciably from 10.8 to 14.5 years (Fig 17). The cause of this phenomenon is to be found in the above-mentioned impediment to colonisation arising from grazing that had strongly limited the development of the population.

Concerning the broom, it was verified that in around 20 years the population reaches its maximum expansion. Later, the competition between the individuals becomes very strong, a decrease in their number is seen, and they tend towards a distribution of a uniform type (evident above all in square D). This phase, that we can define as stable, can be maintained for a long time as the population remains almost constant.

The situation changes when the broom shrubbery is reached by the pre-forest species, and in particular by the flowering ash. This species succeeds indeed in establishing itself even under the dense cover formed by the broom, corresponding to the stabilisation phase of the final population. Then the flowering ash individuals show greater growth than the broom and take on a dominant position.

At the end of the vegetative season of the year 2000, the reduction in the plants of the broom population, from 81 to 77, was caused by the strong decrease suffered by the population in the whole of the first half of the permanent area. This decrease in individuals was not compensated for by the expansion of the population in the lower areas of the slope, because in this area the grazing prevented the settling of new individuals.

In the year 2000, the broom disappeared completely from square A, with a decrease in number in squares B, C and D (Fig. 18) and a small increase in squares E and F were noted, while the population expanded considerably in squares G and H. In square B the individuals of *Spartium junceum*, a particularly heliophilous species, can survive only in the few spaces that are not covered by the flowering

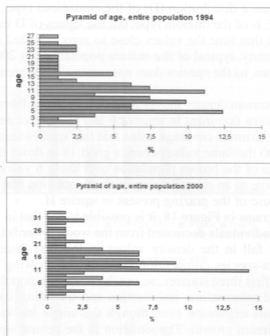


FIGURE 17 - Comparison between the pyramids of age in the population of *Spartium junceum* with reference to the situation in 1994 (top) and in 2000 (bottom).

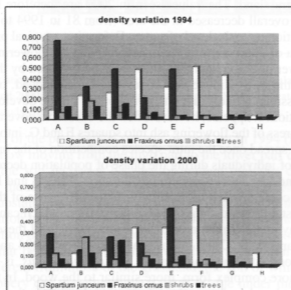


FIGURE 18 - Variations of density in the populations under consideration between 1994 and 2000: the letters of the alphabet along the X-axis indicate the squares and the permanent area of study (from Ballerini & Biondi, 2002).

ash, and they assume a distribution (D) of the contagious type. The distribution in squares C, D and E is of the random type, but the values of D increase with respect to 1994; indeed, at that time the values close to zero indicated a distribution tending towards uniformity, typical of the mature population. In 2000, the distribution is even more random, as the species does not survive in the areas overshadowed by the flowering ash.

The area of maximum density moves about 6 m, passing from square F to square G. The broom remains dominant in squares F and G where it reaches an 81% coverage. This is the maximum coverage value that this species reaches: in square D in 1994, while in 2000 the same value occurs a good 18 m down the slope.

The average age of the broom population over these 6 years went from 10.8 to 14.5 years, indicative of an overall aging of the population that could not colonise the grassland because of the grazing present in square H.

From the histograms in Figure 18, it is possible to see that in 1994 the density of the flowering ash individuals decreased from the wood towards the grassland, while in 2000, a drastic fall in the density values in the first three squares is noted. Evidently, the intra-species competition between the growing flowering ashes is very strong in the first three squares, so much so that the population, having overcome the phases of colonisation, stabilisation and spreading, can be considered to be at the limit of its expansion even though the single individuals have not yet reached their maximum growth. The situation in the central squares D and E was substantially stable.

In Figure 19, it can be seen that the pattern of the coverage of the flowering ash has an inverse relationship with the variation in the density in the two periods under consideration: also in 2000, the coverage is maximal near the wood and diminishes moving towards the grassland. The values seen in 2000 are therefore higher as the individuals, although overall decreased in the area (from 81 in 1994 to 53 in 2000), reach a dominant position up to the level of square E, forming a typical pre-wood belt.

Moreover, the data of 2000 confirm the hypothesis that the flowering ash is able to grow under the cover of broom and that it can even be favoured by this condition, probably because of the microclimate conditions that occur. Indeed, outside of the shrubbery it is not possible to find situations so important for the development of the flowering ash population. It appears, however, that the excessive coverage of broom does not allow the ingress of the flowering ash into squares F and G, into which it will probably successfully spread once the intra-species competition of the broom population causes the death of individuals during the phase of population decrease.

The other shrub and tree species under consideration (Fig. 18 and Fig 19) enter into the vegetational context much more slowly; indeed, because of this the structuring of the pre-forest and wood stages need a longer time, which cannot as yet be predicted. It is anyway interesting to note that the total number of these species and their coverage in squares A, B, C and D was growing between 1994 and 2000, indicating that the pre-wood, still made up mainly by *Fraxinus ornus*, is beginning to structure itself in a more complex form, more similar to the wood. In this dynamic process the role of the hop hornbeam, the species that dominates the wood in contact with the permanent area, is still limited. Evidently the ecological characteristics are not yet at their best for the growth of this species that, under the observed conditions, demonstrates itself to be rather demanding.

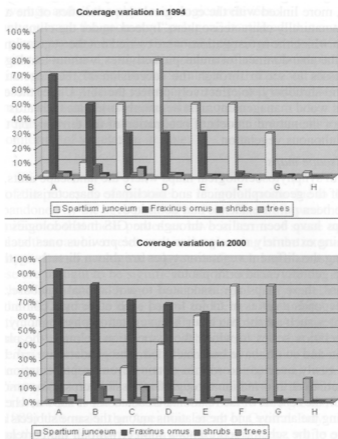


FIGURE 19 - Variation in the coverage of the terrain achieved by the populations under consideration between 1994 and 2000: the letters of the alphabet along the X-axis indicate the squares and the permanent area of study (from Ballerini & Biondi, 2002).

The results of the pedological surveys carried out in 1994 (Ballerini *et al.*, 2002) demonstrate how moving from the high part to the lower part of the slope, the overall depth of the soil increases because of evident previous colluvial phenomena, while that of the most superficial layer decreases. This correlates with the content of organic substance that is particularly more abundant in the higher part of the slope, in relation to the presence of the wood and of the shrubbery. The degree of overall evolution of the soil, the depth and the characteristics of the superficial layer are very similar between the soil of the wood and that within the shrubbery, while these are different from those of the grassland, the soil of which is less evolved.

The shrubbery can therefore have a positive role under the environmental conditions considered, as this vegetation structure proves very efficient for hydrogeological protection. It is able to protect the soil from erosion even in situations of notable slope; it favours pedological evolution, as well as creating microclimate conditions of benefit to the growth of the pre-forest species.

The biggest rectangles represent the tables directly linked to the graphic objects of the plant coverage and of the phytosociological relevés.

For the plant coverage the geometry "polygon" is utilised; this one represents a homogeneous plant coverage, in a physiognomic, physiognomic-structural and ecotonal sense (with a structural composition intermediate with respect to homogeneous typologies, such as grasslands with shrubs or with trees and so on) that is possible to find in the territory. These information are related with tables of validation of Physiognomy, structural Physiognomy and Ecotones.

The maps realised with this methodology represent instruments extremely precise for the monitoring of vegetation in time.

CONCLUSIONS

The study of the processes of spontaneous renaturalization due to the vegetation in the areas abandoned by the agro-pastoral activities have allowed the understanding of the significance that these processes have in terms of space and time. This has provided data that can have relevance in the planning of the interventions needed for the management of ecological relevance of such large areas of territory. In particular, these are thought to be significant for the recovery of the major wooded areas for which there should no longer be replanting of the types effected since the beginning of the 1900s across a large part of the Central Apennines, with the planting of non-native conifers that have caused great problems. Among these, the constitution of non-self-reproducing woods must be considered, that often at the end of their life-cycle have not arrived at an environmental condition substantially more evolved, as demonstrated by numerous examples of replanting with the Austrian Black Pine (*Pinus nigra*) planted around the years of 1914-1916 (Biondi & Ballelli, 1973). Another drawback is the construction of woods with a great fire risk (Biondi & Taffetani, 1989) that make the Apennine areas of Central Italy more prone to wood fires than the hilly and partly plain pre-Apennine areas, while on the basis of the climatic conditions, characterised by more rain, lower average temperatures and a reduced summer drought, and on the basis of the typologies of the natural woods, would be potentially at a reduced risk of fires. Therefore, the result is that the planting of conifers has indeed inverted the natural risk of fires in the territories under consideration. Other negative factors connected to this type of replanting are the widespread parasite attacks to which they are subjected, mainly by the processionary moth, and the inconsistency of their economic value that makes it problematic for their use as mature forest, as the costs of cutting are not covered by the returns obtained by the selling of the wood.

On the basis of the new data reported here, it is thought that the start of an experimental phase for the definition of the most appropriate intervention methodologies for the constitution of new woods is of fundamental importance. These must take into account the forest potential of the territories and respect the successive phases of the vegetation dynamics, that will have to be accelerated through the inclusion of pre-forest species and the possibility of thinning of the shrubbery when this competes too actively with the pre-forest. This experimentation will allow more natural woods to be obtained, both in terms of their constituent plants and the most stable structure of the phytocoenosis. This will allow better evolution of the soil with the reduction of erosion, and at the same time also provide a reduced risk of wood fires.

RIASSUNTO

Vengono descritte alcune metodologie di analisi impiegate, a scale diverse, per lo studio dei processi di rinaturazione che si determinano nelle aree non più utilizzate per scopi agricoli e zootecnici. Infatti, negli ultimi cinquanta anni si è assistito ad un progressivo processo di abbandono delle aree collinari e soprattutto montane, non più economicamente remunerative in base alle attuali esigenze tecnologiche e di mercato. In questi territori, pertanto, stanno avvenendo veloci processi di recupero spontaneo da parte della vegetazione di notevole interesse applicativo, che portano ad un veloce cambiamento del paesaggio vegetale. Tali fenomeni sono stati indagati con i metodi dell'analisi fitosociologica, sinfitosociologica e paesaggistica per l'interpretazione dei processi dinamici e dei tempi di ricolonizzazione in base a studi di carattere diacronico associati a studi di dinamica di popolazione. A questi sono state collegate indagini sui modelli di architettura di crescita della ginestra, specie particolarmente attiva nei processi di recupero della vegetazione, sui territori dell'Italia centrale, che permettono di meglio comprendere il ruolo di questa specie.

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TABLE 1 - Syntaxonomical list of the Italian shrub vegetation (from Poldini *et al.*, 2002).

- RHAMNO-PRUNETEA RIVIS** Goday et Borja Carbonell ex Tixen 1962
- Prunetalia spinosa* Tixen 1952
- Cytisus sessilifolius* Biondi 1988
- Gruppo di associazioni edafico-xerofilo
- Asparagus acutifolius-Corydethum albar* Allegrezza, Biondi, Fornica et Battaglia 1997
- Buxo sempervirentis-Prunetia* ass. nova hoc loco
- [= *Junipero oxycedri-Cotinetum cogglyriae* Allegrezza *et al.* 1997 non Biondi, Allegrezza et Guittan 1988]
- Rhamno saxatilis-Palauretum spinosa-christi* Biondi 199
- [= *Arbuteta a Palmaris spinosa-christi* (Pirone, Frattaroli & Corbetta, 1997)]
- Chamaecytisus spinosus-Juniperetum oxycedri* Pirone et Cutini in Pirone *et al.* 2001
- Gruppo di associazioni edafico-mesofilo
- Asparagus acutifolius-Spartinetum juncei* Poldini et Vidali 2002
- Lonicero etruscae-Prunetum mahaleb* Biondi, Allegrezza et Guittan 1988
- Gallo aparine-Prunetum mahaleb* Pedrotti 1994
- Junipero oxycedri-Cotinetum cogglyriae* Biondi, Allegrezza et Guittan 1988
- Cercido siliquastri-Rhoetum coriariae* Biondi, Allegrezza et Guittan 1988
- Spartio juncei-Cytisum sessilifolius* Biondi in Biondi, Allegrezza et Guittan 1988
- Junipero communis-Pyraethnium cocevae* Biondi, Allegrezza et Guittan 1988
- Cytisus sessilifolius-Coruaetum myrsifoliae* Biondi, Vagge, Baldoni et Taffetani 1997
- Spartio juncei-Ericetum arboreae* Vagge 2002
- Spartio juncei-Hippochaetum fluviatilis* Biondi, Vagge, Baldoni et Taffetani 1997
- Cytisus sessilifolius-Prunetum mahaleb* Pedrotti 1994
- Gruppo di associazioni semimesofilo-(sub)montano
- Chamaecytisus-Cytisophyllum* Cutini et Blasi 2002
- Lonicero etruscae-Amelanchieretum* Cutini et Blasi 2002
- Cytisus spinosus-Daphnetum tereticae* Di Pietro 2001
- Berberidion vulgaris* Br.-Bl. 1950
- Fraxino orn-*Berberidion Poldini et Vidali 1995
- Gruppo di associazioni subtemofilo
- Pruno mahaleb-Palauretum spinosa-christi* Poldini et Vidali 2002
- Frangulo ropestris-Cotinetum cogglyriae* Poldini et Vidali 2002
- Frangulo ropestris-Juniperetum communis* Poldini et Vidali 2002
- Frangulo ropestris-Prunetum mahaleb* Poldini 1980
- [Syn. Syntax.: *Prunetum mahaleb* Pedrotti et Minghetti 1994 non Neveol 1931 ex Th. Müller 1986]
- Clematido-Rubetum ulmifolii* Poldini 1980 [= Fitocenosa a *Rubus ulmifolius* e *Clematis vitalba*]
- Rubus ulmifolius-Igusretum vulgare* Poldini 1989
- Stadio a *Cotinus cogglyria* (Poldini, Vidali & Zanatta, 2002)
- Fitocenosa a *Prunus spinosa* subsp. *spinosa* e *Fraxinus ornus* (Poldini, Vidali & Zanatta, 2002)
- Gruppo di associazioni submesofilo
- Lonicero caprifolii-Rhamnetum cathartici* Poldini et Vidali 1995
- Corno maris-Viburnetum lantanae* Biondi, Vagge, Baldoni et Taffetani 1999
- Fitocenosa a *Palmaris spinosa-christi* e *Ulmus minor* (Poldini & Vidali, 1995)
- Berberidion vulgaris* Gehu, Foucault et Delclès-Dusollier 1983
- Gruppo di associazioni del settore dell'Italia nord-orientale e dell'Appennino
- Rhamno cathartici-Juniperetum communis* Poldini et Vidali 2002
- Mifu versalis-Aceretum campestris* Pedrotti 1982
- Rosa arvensis-Prunetum spinosa* Biondi et Casavecchia 2002
- Lonicero xylostei-Salicetum sperinae* Biondi et Casavecchia 2002
- Rosa arvensis-Mulnetum florentinae* Biondi, Allegrezza et Taffetani 1990
- Gruppo di associazioni dell'Appennino albaniano
- Junipero oxycedri-Amelanchieretum ovalis* Pedrotti 1994
- Rhamno alpina-Amelanchieretum ovalis* Pedrotti 1994
- Rubus idaei-Rhamnetum foliolosus* Biondi *et al.* 1999
- Pruno-Rubetum ulmifolii* O. Bolos 1954
- Pruno-Rubetum ulmifolii* O. Bolos 1954
- Gruppo di associazioni edafico-mesofilo
- Pistacio terebinthalis-Palauretum spinosa-christi* Blasi et Di Pietro 2001
- Lonicero etruscae-Cornetum sanguinea* Biondi, Bagella, Casavecchia et Pinza 2002
- Rosa sempervirens-Rubetum ulmifolii* Blasi, Di Pietro et Fortini 2000
- Lonicero etruscae-Rosetum sempervirentis* Cutini, Fabbio, Fortini, Armarini et Blasi 1996
- Junipero-Hippochaetum fluviatilis* Gehu et Scepola 1984
- Aggr. a *Palmaris spinosa-christi* e *Cornus sanguinea* (Blasi & Di Pietro, 2001)
- Ass. a *Palmaris spinosa-christi* (Cutini, 1996)
- Ass. a *Spartium junceum* e *Rubus ulmifolius* (Cutini, 1996)
- Gruppo di associazioni edafico-mesogrofilo
- Clematido-cornuosa-Crataegietum monogyna* Filigheddu, Farris, Bagella et Biondi 1994
- Vicio temefoliae-Prunetum spinosa* Filigheddu, Farris, Bagella et Biondi 1999
- Vico sardoa-Rubetum ulmifolii* Biondi, Farris et Filigheddu 2002
- Crataegum monogyna-Pyretum amygdaliformis* Biondi, Farris et Filigheddu 2002
- Crataegum laciniatae* Brullo et Marcano 1983
- Salic-Viburnetum rufi* (Passage) 1985) De Foucault 1992
- Frangulo ulmi-Prunetum avium* Biondi *et al.* 1998
- Frangulo ulmi-Viburnetum opulifolium* Poldini et Vidali 1995

