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Palynological evidence and forest events in the upper Tuscan/Emilian Apennines in the context of the whole Apennines holocene history

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Abstract
The vegetational events of the Apennines Holocene were surveyed in synthesis on a palynological basis. Our interest was here focused on the Tuscan-Emilian Apennines, that have been illustrated by Chiarugi and subsequently studied by means of ^{14}C carbon dating. For northern Italy, the Liguria-Parma area was studied first followed by the Tuscan-Emilian area. The northern Apennines generally seems to resemble Central Europe. For peninsular Italy, the more Mediterranean area, we considered the Central and Southern Apennines, extending to Central-Eastern Sicily (Madonie Mountains). For the peninsular Apennines, an Alpine-Central European tendency descending along the cold routes of the mountain chain take place in a full Mediterranean area. A glaciation center is located at Monte Cimone/La Nuda in the northern Apennines and another not less important site is located in the peninsular Apennines at Gran Sasso in Abruzzo. Regarding *Abies/Fagus* competition, the fall in the *Abies* curve and rise of the *Fagus* curve occurs at different times in different areas, depending on specific climatic and local ecological conditions. These and other differences must be investigated with the aid of absolute dating that can verify the similar chronology of different events.

Riassunto
Evidenze palinologiche e vicende forestali nell'alto Appennino Tosco-Emiliano nel contesto della storia ologenica dell'intero Appennino. Una sintesi delle vicende vegetazionali dell'Olocene Apenninico viene condotta su base palinologiche. L'interesse è rivolto specialmente all'Appennino Tosco-Emiliano che, illustrato dal Chiarurgi, è stato successivamente ed è tuttora oggetto di ricerche palinologiche corredate da datazioni ^{14}C Per l'Italia settentrionale, si è preso prima in esame l'area Ligure-Parmense, poi quella Tosco-Emiliana. L'Appennino settentrionale sembra avere in generale affinità centro Europee per l'Italia peninsulare, più Mediterranea, si è preso in considerazione l'Appennino centrale e meridionale, con estensione alla Sicilia centro orientale (Monti Madonie). Per l'Appennino peninsulare, il fatto di una certa tendenza alpino/centroeuropea, che scende lungo le vie fredde della catena montuosa, si manifesta in piena area mediterranea. Si noti che, oltre a quello che ha lasciato traccie al massiccio Monte Cimone/La Nuda, un grande centro di glaciazione si è avuto al Gran Sasso in Abruzzo. Nel quadro di generali vicende di competizione Abete/Faggio, si deve riscontrare che il momento della caduta della curva di *Abies* e dell'avvento di *Fagus* può verificarsi in date diverse per diverse aree secondo le loro particolari condizioni climatiche ed ecologiche in genere. Queste ed altre differenze devono essere esaminate con l'aiuto di datazioni assolute che permettano di verificare la simultaneità di eventi anche diversi.

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Introduction.

The Apennines chain begins at the Colle di Cadibona (Liguria), which separates it from the Alpi Marittime, and runs from northern Italy to Calabria and down to the Peloritain Mountains in Sicily. It covers a wide latitude and intersects a complex system of lateral chains.

The highest Apennines peaks are in Emilia (Monte Cimone 2165 m a.s.l.) and Abruzzo (Gran Sasso, 2914 m a.s.l.). Recent geomorphologic studies have unveiled new evidence of glaciation along the mountain chain.

The Apennines chain is connected in the north to the continental part of Italy, and it extends southward with its peninsular part between two different seas. The Tyrrhenian Sea and the Adriatic Sea influence a large part of the two opposite slopes of the chain, with climatic characteristics peculiar to each. Thus, Apennines vegetation, influenced by different factors and complicated by possible migrations of plants and vegetational formations along the routes formed by these chains and by the presence of refuge areas, cannot always be readily interpreted. Moreover, tens of centuries of the influence of man has played an important role and at times led to a strong masking effect.

Palynological studies can provide a valid contribution to the reconstruction of relatively ancient events. This paper investigated the Late

Quaternary, since we feel that this period is more related to the present vegetational structure.

A large part of the Late-Glacial and Holocene palynological literature deals with the Tuscan-Emilian Apennines. Several studies have been performed in the Ligurian Mountains and others in central and Southern Italy. Some diagrams deal with the Madonie Mountains in Sicily (Fig. 1).

This paper is centered around the Tuscan-Emilian Apennines, which places its events between those of the Liguria-Parma territory and those of the peninsular part of the chain down to Sicily.

Liguria-Parma Apennines

The Holocene palynological scenarius of the Apennines begins in Liguria, investigated in several papers (Braggio Morucchio & Guido, 1975 and 1978; Braggio Morucchio et al., 1978, 1980a, 1980b, 1983 and 1991; Cruise 1990a, 1990b and 1991; Gentile et al., 1988; Guido & Montanari 1979 and 1991; Lowe 1992; Montanari 1987; Montanari et al., 1979, 1982, 1985).

Monte Aiona (1701 m a.s.l.) has a series of small ponds, including the Agoraie di Mezzo (Braggio Morucchio and Guido, 1975; Cruise, 1990a, b). The first site was dated by Chiarugi based on Postglacial forest cycles. The bottom of the diagram shows a period of *Abies* with scanty *Fagus*, not preceded by the development of the Mixed Oak woods. There are small percentages of *Pinus*, *Picea*, *Castanea*, *Quercus* and *Betula*. This is followed by a mixed community of *Abies* and *Fagus* that then evolves towards a pure *Fagus* wood. These events seem to follow the Boreo-Atlantic along the Subboreal and Subatlantic periods.

According to the dating carried out by Cruise, the lake of Agoraie di Fondo contains sediments dating 4,180±60 B.P. at a depth of -700 cm. A dating of 2050±50 B.P. carried out at a level 375 cm higher indicates a very high sedimentation rate, about 3 m over 2 thousand years. The lower vegetational belts contain *Abies* and *Fagus* in fluctuating curves, with low percentages of *Quercus*; this is followed by a low presence of *Abies*, at a level less than *Fagus*; and lastly by the predominance of *Fagus* in an abundant not-arboreal complex. Based on absolute datings, the intersection of the ascending curve of *Fagus* with the descending curve of the Silver fir occurs with some delay with respect to that in the Tuscan Emilian Apennines, specifically, passing from 2,000 B.P. in the Ligurian Apennines to around 4,000 B.P. in the Tuscan Emilian Apennines.

This permanence of favourable conditions for Silver fir may possibly be related to the vicinity of the area to the sea, which provides humid air currents and a warming of the climate. These conditions still exist today and probably participate in determining the current vegetation even at the community level.

A current verification related to a not too distant past as to a not excessively early Holocene is validated by comparisons between ancient and current *Fagus* woods in the Ligurian Apennines (Guido and Montanari, 1979) and in the study of current pollen rains in moss polsters, carried out in many types of woody forests (Guido and Montanari, 1991). Since *Fagus* is usually under-represented in pollen rain, there is a good degree of correspondence between the ancient and current *Fagus* woods and between the pollen images of the current wood with their vegetational structure. These first findings should prompt researchers studying present day vegetation to also make use of palynological investigation. A good example of this nexus is given in the paper by Gentile et al. (1988), on the basin of the Lago di Riane in Liguria.

Changing viewpoints, we must stress that palynologists who tend to assemble diagrams from a prevalently stratigraphic basis should take into account the knowledge on current, and not only local vegetation, to broaden and better define the field of interpretation of the diagrams.

The abundance of the Silver fir in the Ligurian Apennines can be found in many papers, including that citing the pollen diagrams in Val Vobbia, in a small sequence which as been dated 4,461 B.C. (Montanari et al., 1985).

The study on the Laione peat bog near Piampaludo, at 987 m a.s.l. in the western Ligurian Apennines (Braggio Morucchio et al., 1978) also includes the current vegetation aspects of the site: studies on the vegetational assemblages, vegetational map, current pollen rains, in addition to the

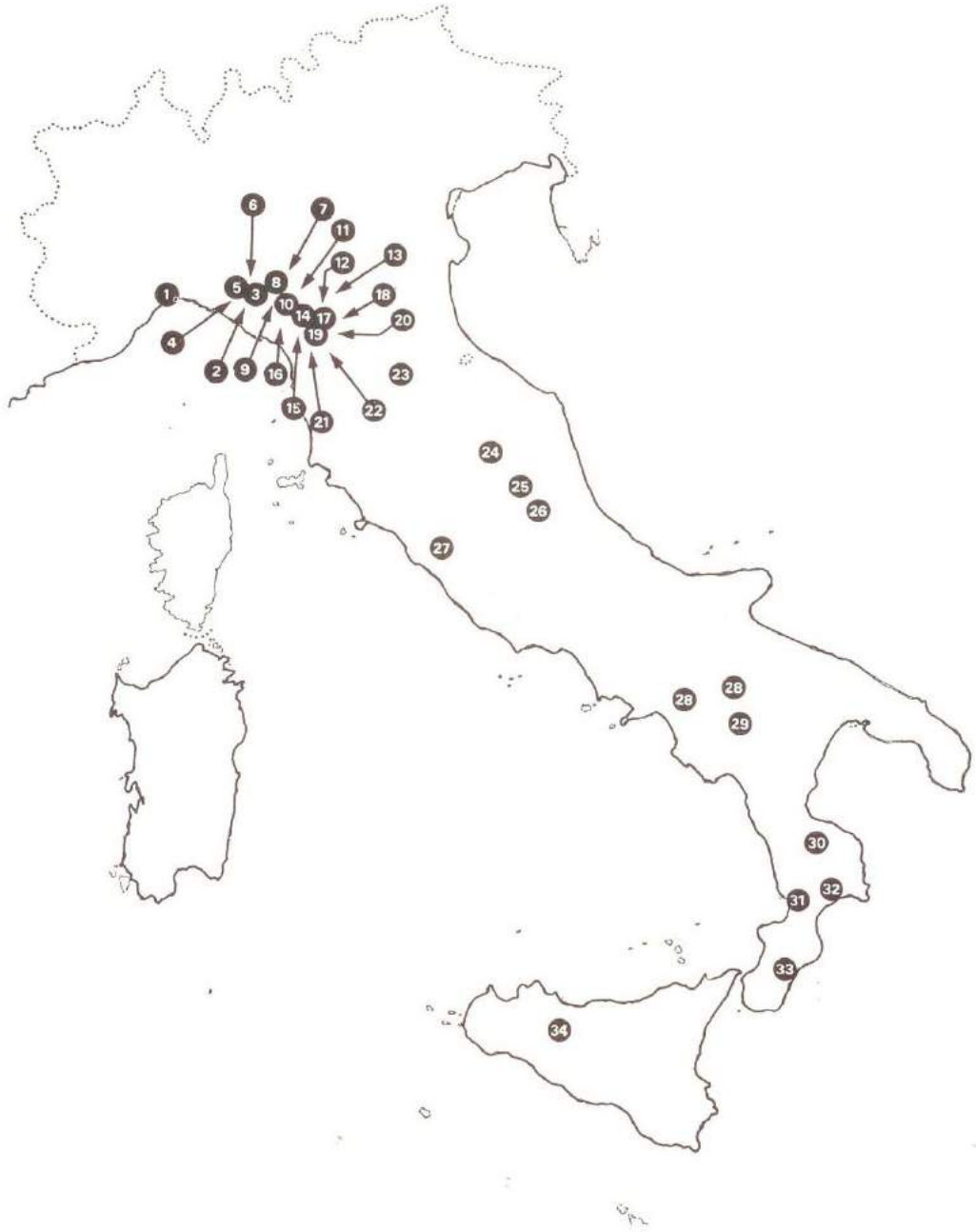

Fig. 1. List of cited sites and their locations:
1) Pimpaludo, 2) Monte Maggiorasca, 3) Pramollo, 4) Lago Moo, 5) Laghi delle Agoraie, 6) Torbiera Buche di Monte nero, 7) Lago Capello, 8) Lagdei, 9) Lagoni, 10) Lago del Monte Acuto, 11) Lago Calamone, 12) Chioggiola di Pavullo, 13) S. Pellegrino di Pavullo, 14) Lago Scuro Superiore, 15) Piana di Corfino, 16) Foce Mosceta, 17) Pian Cavallaro, 18) Lago Pratignano, 19) Lago Baccio, 20) Lago Baccioli, 21) Lago Nero, 22) Lago del Greppo, 23) Passo Porcareccio, 24) Colfiorito, 25) Pantani, 26) Campotosto (Bacino di Mascioni), 27) Lago di Monterosi, 28) Monte Vulture, 29) Lago Zapano, 30) Sila Grande, 31) Serre Calabre, 32) Sila Piccola, 33) Canolo Nuovo, 34) Madonie

palynological profile down to a depth of 350 cm. By comparison with the Post-glacial forest cycle diagram of Chiarugi, the history of the Laione peat bog seems to take place in the recent Anathermic to Catathermic, with some small differences due to the vicinity to the sea (9 km).

At Lago di Casanova, Cruise (1990b) reports a dating at the base of the sequence of 5,040±100 B.P. based on ^{14}C, a questionable value in the context of a *Pinus* and *Abies* vegetation followed by an expansion of proportions typical of open areas (*Graminaeae, Artemisia, Sanguisorba, Helianthemum, etc.*) that the Author interprets as "typical of the Last Glacial."

However both Cruise and Lowe (1992) must be given merit for having a large set of datings, in papers that span from Liguria eastward towards the Tuscan-Emilian Apennines. However, we do hope that future ^{14}C datings will be carried out without destructions.

Proceeding eastward, studies are available for the upper Valle del Nure (Piacenza), in the Ligurian-Emilian Apennines, the site of Pramollo and Lago Moo, from 1,100 / 1,300 m a.s.l. (Braggio Morucchio et al., 1991). Absolute dating on samples taken at a depth of 380 cm, thus at a few meters from the base, give a value of 5,632 ± 210 B.P. This would place the series sequences between the Late Boreal / Early Atlantic. The diagram includes a clayey part with prevalent *Pinus* and a long *Sphagna* section with a prevalence of *Abies* and traces of *Fagus*. The Mixed Oak runs with low values and without large variations. For the same site (Prato Mollo), but not the same drilling, Cruise (1990b) dates the base at 4,300 / 4,130 B.P. at the start of the peat formation, and a very different profile of the *Abies* curve, with relatively large percentage values and a slow decrease towards the top. The Lago Moo diagram seems to be less real for a number of reasons. Perhaps a granulometric study of the sediments could yield information on the sedimentation mode and possible irregularities.

At Monte Maggiorasca, still in the Ligurian-Emilian Apennines, some profiles from in Val d'Anzola and Valle di S. Stefano d'Aveto have been examined (Bertolani Marchetti et al, 1985). The scope was to verify whether the clayey sediments could have been from glacial or landslide deposits. Better results were obtained from the peat bog from Ovest Rocche and Prato Grande, in Val di Anzola. The Ovest Rocche site has a pollen diagram with evident *Fagus*, low *Pinus* and a Mixed Oak woods without *Tilia*, thus thermophilous, at values of about 10%. *Castanea* is always present. Agricultural practices by man is revealed by the presence of *Cerealia* pollens. The profile from Prato Grande shows the presence of *Abies*. The Silver fir increases up to about the middle of the diagram and then decreased up to the top, in antagonism to *Fagus*. The Mixed Oak woods includes *Tilia*: two of its expansions could coincide with the warm Roman period and with the Middle Ages climatic optimum. The recent character based on the Arboreous curves tends to rule out a moraine sediment deposition.

A sequence from the ancient moraine lake of Lagdei (1,254 m a.s.l.), in the Province of Parma, (Bertoldi, 1980), was taken to a depth of 12.50 m. The diagram reaches the Last Glacial. The part we are interested in, the Holocene, starts from the depth of -7 m, in comparison with the Apennines cycles of Chiarugi. Starting from the bottom, the Author identifies a D zone where Post-glacial reforestation begins. *Pinus* predominates and *Abies* and Mixed Oak woods curves have a slow percentage growth. The presence of *Picea* decreases whereas *Corylus* and *Betula* enter with a continuous presence. The Mixed Oak woods proceeds through the E zone into the F zone, where it is definitively affirmed. The climate is considered warm and dry. Note the appearance of *Castanea* and *Ostrya*. A consistent G zone has the definitive predominance of *Abies*, now present in high percentages. *Fagus* appears and becomes consistent in the H zone; *Quercetum* has alternating phases with the Silver fir. In the I zone, the climate evolves towards oceanic conditions, favouring the complete predominance of *Fagus*. The *Castanea* curve, which had sporadically appeared before, becomes continuous in the upper part of this zone. The L zone is not identified. The M zone follows, where *Fagus* completely dominates the mountainous belt and assumes the presence of an underlying Mixed Oak woods.

The Post-glacial events of Monte Nero, that can be considered as belonging to the Liguria-Parma

Apennines, are documented in the Buche peat bog, at 1,463 m a.s.l. (Bertoldi, 1984), by a diagram that touches 245 cm depth. The arboreous cover has a high percentage, dominated in the lower layers by Silver fir with probable underlying Mixed Oak woods. The central part of the profile has a diffusion of *Fagus* which overtakes *Abies*. The final phase, where *Fagus* is completely dominant, also marks the advent of *Carpinus, Ostrya, Populus* and of entities probably here related to man, such as *Juglans* and *Castanea*. The Author suggests that by analogy with the Lagdei sequence the diagram from the Buche di Monte Nero can be placed from the Late Atlantic to a part of the Subatlantic periods.

At Lago Capello, at 1,110 m a.s.l., in Val Baganza (Bertoldi et al., 1986), the sediments reveal a typical Post-glacial history, from the domain of the Silver fir, expansion of *Fagus*, and the appearance of cultivated plants that is correlated with the start of the Subatlantic period. We believe that the presence of Mediterranean entities, such as *Phyllirea, Olea, Myrtaceae*, etc, should be considered since their presence seems to be related to preferred routes of migration from Liguria or coastal Tyrrhenian areas instead of a fortuitous distant transport.

Lowe (1992) has recently published a paper on the Prato Spilla, in the Rio Cedra valley, affluent to the Enza river, at 1,550 m a.s.l. One of the drillings was dated 10,610±45 B.P. at its basis and 1,400±45 B.P. near the top. Another profile spans an interval from 12,360±55 B.P. to 3,300±45 B.P., and thus the site contains a completely holocenic series, from the fall of the *Pinus* and *Artemistia* curves, marking the passage from the Last Dryas to the Holocene, up to the definitive dominance of Beech, coinciding with other known pollen diagrams. The Author compares the Prato Spilla results with those of interest from Italy and Europe. Lowe states, the Prato Spilla C data suggest either that the general interpretation for North Italy during the Late glacial is incorrect or that there was much greater regional variation than is reflected in recent palaeovegetation reconstructions." We are not in complete agreement with the first part of this affirmation.

Apuan Alps and lunigiana Apennines

The Apuan Alps and Lunigiana Apennines merit a least mention. We have limited this to little more than a bibliographic review on a topic that would indeed warrant a broad discussion due to the great geobotanic interest of the region.

For the Apuane Alps, Braggio Morucchio et al. (1980a) have compiled a diagram from a basin of the glacial circle of Fociomboli, at 1,100 m a.s.l. The Silver fir seems to have a secondary role here or at least to develop late with respect to Tuscan-Emilian Post-glacial cycles. At Pania di Corfino (Lucca Apennines; Ferrarini, 1981), at 1480 m a.s.l., proceeding from the bottom of the diagram, there are phases with *Fagus/Abies*, then with only *Abies*, and lastly with a Blueberry Vaccinietum accompanied by an increase of *Pinus*, in the context of a continuous climatic deterioration. According to the Author and lacking an absolute ^{14}C dating, the diagram may represent a *Dryas* phase.

Diagrams on the Lunigiana Apennines have been constructed by Ferrarini (1963) for Lago Monte Acuto, at 1,576 m a.s.l. Lago Gora, 1,425 m a.s.l. and at Bacino di Pianacci at 1,100, all belonging to the Post-glacial period. Ferrarini (1963, 1970 and 1981), on the basis of his knowledge of the past and current vegetation of the area, drew considerations on the Post-glacial oscillations of the vegetational belts in the Holocene of the Northern Apennines and Apuan Alps.

Tuscan Emilian Apennines

The Tuscan Emilian Apennines rises with Monte Cimone, at 2,165 m a.s.l., flanked by the nearby Monte Cusna, which is a lower (about 1,100 m a.s.l.), but larger and a better cloud condensator. Due to its influence, there is high rainfall, running around 2 meters per year.

For the Tuscan-Emilian Apennines, an important diagram that illustrates its Postglacial forest cycles has been drawn by Chiarugi (1950). It is a synthesis of palynological research performed by the Author in the following high Apennines peat bog and lake basins:

Lago Nero (Pistoia) 1,740 m a.s.l.
Lago Baccio (Modena) 1,554 m a.s.l.
Lago del Greppo (Pistoia) 1,442 m a.s.l.
Lago Scuro Superiore (Reggio Emilia) 1,300 m a.s.l.
Lago Baccioli (Pistoia) 1,295 m a.s.l.

The basins more involved in the diagram are the Lago del Greppo and Lago Baccioli, individual diagrams of which are consecutive in time.

The name of some of these sites indicates their vegetational context that is the Vaccinietum. Indeed, in the local dialect, "baccioli" or "baggioli" are blueberries.

The importance of Chiarugi's work prompted us to continue his studies with the best means currently available. Radiocarbon dating and high power microscopes were employed, allowing a more detailed determination of pollen specifications and consequently a more reliable vegetational reconstruction with appreciation of non-arboreous plants which were previously only poorly considered. Further studies were undertaken, also extended to the Reggio Emilia territory, and a fellowship has been instituted on the topic with the aim of completing the absolute dating also of the sites described by Chiarugi.

The following Apennines basins have been investigated in this phase:

Pian Cavallaro in the Modenese Monte Cimone, 1,800 m a.s.l. (Bertolani Marchetti 1963 and 1978); Lago della Ninfa (Modena) 1,850 m a.s.l. (Mori Secci and Bertolani Marchetti, 1992), Lago di Pratignano (Modena) 1,307 m a.s.l. (Accorsi et al., 1981), Torbiera di S. Pellegrino near Pavullo nel Frignano (Modena), 675 m a.s.l. (Bertolani Marchetti et al., in press), Palude della Chioggiola near Pavullo nel Frignano (Modena) 710 m a.s.l. (Bertolani Marchetti et al., 1977), Bacino della Lagaccia (Modena) 1,100 m a.s.l (Giannini 1969/70); Lago Calamone (Reggio Emilia) m a.s.l (Bertolani Marchetti et al., 1987), Torbiera di Febbio (Reggio Emilia) 1,350 m a.s.l. (Trevisan Grandi and Bertolani Marchetti, 1991); Lago di Vrazzano (Modena) 700 m a.s.l. (Bertoldi and Buccella, 1983), siti al Passo del Porcareccio (Tuscan/Romagna Apennines) 1,400 - 1,500 m a.s.l. (Bertolani Marchetti et al., 1971; Paoli and Ciuffi Cellai, 1973).

Studies are underway at Lago Cerretano (Reggio Emilia), by Trevisan Grandi and co-workers. Moreover, the soils from Tuscan-Emilian-Romagna Apennines have been investigated (Bertolani Marchetti et al., 1971; Accorsi, Bandini Mazzanti and Forlani, 1976; Accorsi et al., 1976, 1977, 1982, 1989; Accorsi and Rodolfi, 1978; Cremaschi et al, 1981/82).

Other studies, which have provided preliminary results, concern the current pollen rains, to complete the paleoresearch. The pollen rain deposited on the bottom of the Lago Santo Modenese (1,600 m a.s.l.), examined on samples collected by scuba-divers, have been studied, in relation to the surrounding vegetation (Arobba et al., 1986).

The first investigation aimed at constructing the pollen reconstruction of the Vaccinietum in relation to their vegetation were carried out by Rivalenti et al., 1990.

A pollen diagram of peat layers near Abetone, plotted by Chiarugi in 1950 (Fig. 2), but still valid today, highlights the forest Postglacial cycles of the Tuscan-Emilian Apennines. Following a steppe phase with *Artemisia* and *Salix* (Dryas III), a thermal rise appears as recorded by the diffusion of pine and birch and successively by the presence of a Mixed Oak forest (boreal period). Paralleling the climatic deterioration (Subatlantic), beech, which had been in competition with *Abies*, predominates completely.

As also seen in other diagrams, a peak in *Picea* occurs at the start of the Subboreal. *Betula* dominates for a period from the fall of the Mixed Oak wood and the rapid and strong increment of the Silver fir, that with decreasing pulsations marks the start of the catathermic period. Taking place along the Subboreal and the Subatlantic. The Author could not at the time back his findings with absolute datings, but he made some reliable considerations on the basis of climatic oscillations of central Europe and on different sediment features of the profiles. The late Prof. Ezio Tongiorgi of the University of Pisa, during a palynological discussion with Bertolani Marchetti, had referred that his datings confirmed the age hypothesised by Chiarugi, 9,000 B.C.; the base

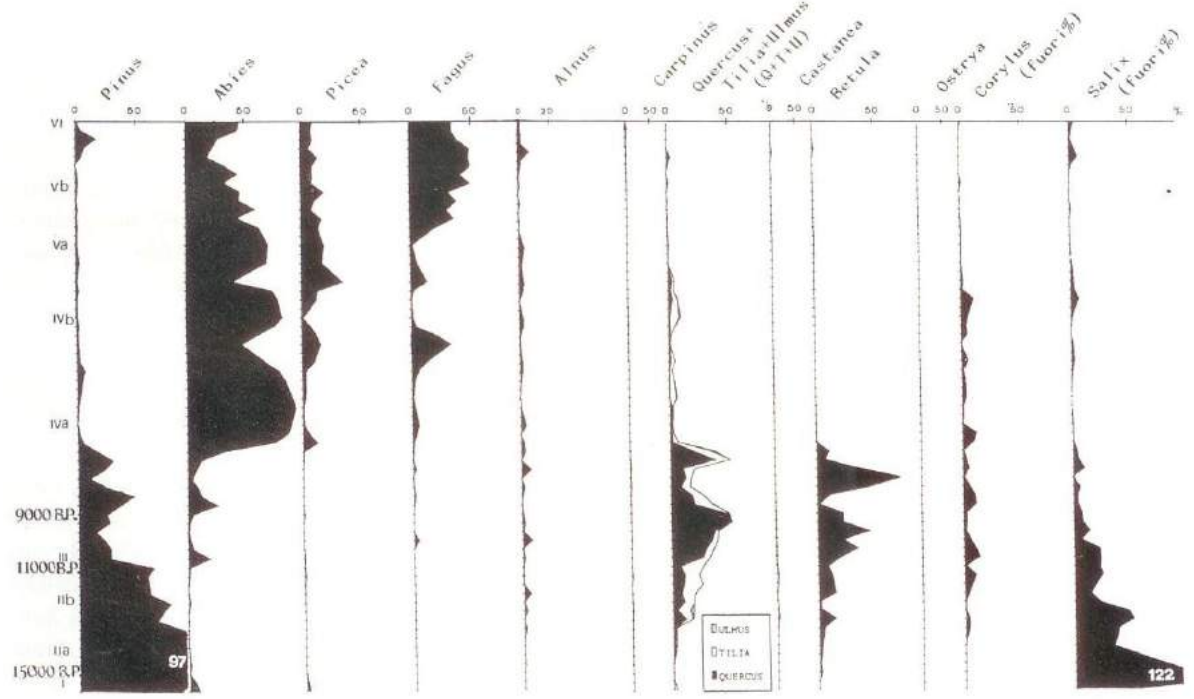

Fig. 2. General pollen diagram of the late-glacial and Post-glacial forest cycles obtained from the Lago del Greppo and Lago Baccioli sequences in the Tuscan Apennines, near Abetone Pass, performed by Chiarugi (1935, 1950). The dating has been established from Chiarugi in correlation with the summer caloric radiation (11,000 B.P.) and the Oak mixed forest maximum (9000 B.P.). Radiocarbon dating (Prof. E. Tongiorgi verbal communication, 1965) established the lower level at 15,000 BP. and confirms the hypothesised ages for the upper part of the diagram from 9,000 B.P.

of the diagram was actually 4,000 years younger, as reported in Fig. 2.

Of the successive investigations, the pollen diagram for the Pian Cavallaro sequence, at 1,800 m a.s.l. on the northern slope of Monte Cimone (Bertolani Marchetti 1963, 1978, 1980- pp. 154-159) is of interest for its vegetation history and pedological and archaeological events. Theantagonism of the *Quercetum mixtum* with *Abies alba* with the definitive predominance of Silver fir occurs in the diagram. The *Vaccinietum* curve corresponds with a steppic phase (greatly oxidised paleosol at -50 cm begins with the decline of the curve of *Abies* and is bounded by a fire that destroyed the moor. A carboniferous layer full of frustrukes occurs at this level. Thus, a grasslands is established, bringing with it grazing of herds and arrowheads made with the knots from flint brought by shepherds, leaving behind fragments their handwork. The manufactured products have been dated around 2,000 - 1,500 B.C.; the peak of the Silver fir is synchronous with the passage from Atlantic to Subboreal at around 3,000 B.C.

Lago della Ninfa, at 1,850 m a.s.l. (Mori Secci and Bertolani Marchetti, 1992), ecologically destroyed by a series of poorly planed works, has conserved a peat layer; pollen analyses on this layer and macrofossile findings, such as a cone of *Picea*, have revealed the presence of *Picea* in a period of great diffusion (Ciarugi, 1936a), dated at ^{14}C at 4,000 B.P.

At Pratignano, 1,307 m a.s.l. (Accorsi et al., 1981) drilling were not made at the lake as a conservation measure. Indeed, a large raft of roots of plants, peat and muds floats on the surface the pond, habitat of the rare carnivorous plant *Drosera rotundifolia* among others, representing the only station on our region. Instead, drilling was performed in a small lateral basin down to the rock level at a depth of -2m. Below - 90 cm, a dominance of *Pinus* was found, whereas *Abies* increases in the upper part. *Fagus* has a low percentage, almost constant and remains at not too high values and sometimes includes *Quercus cerris* and *Q. pubescens*. *Juglans* and *Castanea* are also found, in addition to lacustrine and swamp entities and plants of local meaning. Overall, the climate is mitigated in the lower half of the profile, that could refer to an ancient Subatlantic, whereas in the upper part, more oceanic and colder, could theoretically coincide with the thermic deterioration from 400 / 500 B.C. The study of the area around the Lago di Pratignano was performed by several specialists in addition to palynologist in an interdisciplinary research, as also for other Apennines lakes (Lago Calamone and Chioggiola).

The S. Pellegrino di Pavullo peat bog in Frignano (675 m a.s.l.) has been the object of a recent communication presented at the International Congress of Palynology at Aix-en-Provence (Bertolani Marchetti, et al., 1992, in press). The profile, 20 m deep, was backed by ^{14}C datings performed on the upper part on peat layers and gyttja; ranging from greater than 10,000 B.P. up to 2,500 B.P. The events of the lower part of the diagram can be easily correlated with others already known. The sequence probably begins deposition after 15,000 B.P., because it does not reach the *Salix* and *Artemesia* tundra phase of Chiarugi's diagram. Climatic-vegetational features represented in the diagram are generally similar to known events. The S. Pellegrino di Pavullo peat bog presents some peculiarities. Forest events are represented by low value curves, as if they reflected distant formations. In these oscillations one can perhaps note a Lanscombe phase that comes before that known for the glacial decline. The evolution of the *Quercetum* should be considered strictly related to the situation at the S. Pellegrino basin. The Mixed Oak woods appears first as a mountain *Quercetum*, rich in *Tilia*, up to the Subboreal. As *Tilia* disappears, *Quercus pedunculata* supervenes together with other plants of *Quercetum - carpinetum*. Moving through the catathermic, the *Quercetum* curve, usually tied to thermic conditions, is seen to rise instead of fall. The final situation is a plain *Quercetum* climax (Bertolani Marchetti,1969/70) that occurs at 700 m a.s.l. *Quercus pedunculata* is still present in the area together with many of its characteristic plants, including *Humulus lupulus*, a species that precedes settlement by the plain *Quercetum* or lives in its clearings.

The Palude della Chioggiola, near Pavullo nel Frignano (Modena) at 710 m a.s.l. (Bertolani Marchetti, et al., 1977) was destroyed during the construction of an enterprise zone. It was the second

station of *Drosera rotundifolia* in the Apennines, discovered subsequent to that at Pratignano. The site was studied by an interdisciplinary staff. The lower part of the diagram points out a climatic improvement, with peaks of Pine and Silver fir, followed by a warm, dry phase in which the forest cover decreases. Phases with milder climate, with an expansion of Mixed Oak woods come next. The climate then again worsens, as indicated by the *Abies* peak, followed by a new thermic improvement tied to the greater percentage of Mixed Oak woods. From -50 cm upwards, agricultural activity is revealed by the presence of *Cerealia*. Lacking ^{14}C dating, we set the age of the base of the profile to 2,800 B.P. by analogy with other diagrams. The other events take place in historical era. The Drosera pollen, whose production is very scarce, is sporadically found along the profile.

The Bacino della Lagaccia (Modenese Apennine), 1,100 m a.s.l. (Giannini 1969/70), is located in a Beech wood, in Lamarine, near Boccassuolo. It is a landslide lake, and thus the history contained in its profile, 12 m deep, describes successive re-settlements of the vegetation. Immediately after the landslide, the basin collected only anemophylous pollen of *Pinus* and *Graminae*. The successive colonisation was from the nearby Silver fir and overlying Birch, in the dryer positions, whereas at the higher levels, from Silver fir and again Beech. A period of warmer climate brings a mountain Mixed Oak wood with *Tilia*, at -5.5 m, whereas another increase of *Quercetum* is répresented by a greater percentage of Mixed Oak woods together with *Carpinus* and *Ulmus* at -3.3 m.

Given the unstable geological nature of the zone, the events of the basin are probably recent, and at least in part fall within historical times. The initial landslide and the first silty sediments can be attributed to a period with many rains and flooding, perhaps at the end of the Subatlantic "*sensu strictu*." The study of the Lago Calamone (Reggio Emilia), 1,409 m a.s.l. (Bertolani Marchetti, et al., 1987) was an interdisciplinary research. Palynological research was carried out on two drillings: one below Lago Verde (1,460 m a.s.l.) and the other at the nearby Lago Calamone. The upper lake had a more ancient story, with an abundant forest cover, including *Pinus, Abies, Fagus* and Mixed Oak woods and with a slightly greater amount of *Tilia*. The lower third of the profile has *Sphagna*; the panorama is of a peat bog located in a woody basin surrounded by an *Alnus* forest, which declines in recent times. Lago Calamone is important for its ecology; the lower layers (from -250 to -100 cm) presents *Myriophyllum alternifolium* tied to oligotrophic water, whereas the upper levels contain *Myriophyllum spicatum* typical of eutrophic or mesotrophic waters. The change is concurrent with a strong fall in arboreous plants. We can thus state that it represents a natural source of pollution, due to the washing out the humus from the soil not protected by the woods.

The study of the Torbiera di Febbio (Reggio Emilia), at 1,550 m a.s.l. (Trevisan Grandi, and Bertolani Marchetti, 1991) is carried out in the Prà Cavo site on the slopes of Monte Cusna. This work is part of a group of palynological studies that should parallel the work of the previously cited fellowship. Two sequences were taken, at the center and margin of the basin, and they provided a diagram having marked analogies with the *Fagus* curve. This profile has a sharp rise followed by a temporary fall during a dry phase in which the Mixed Oak woods and hygrophytes are temporarily low. The diagrams, not dated with ^{14}C, belong to the Postglacial period, probably Late Atlantic.

The Torbiera di Vrazzano (Modena), at 700 m a.s.l. (Bertoldi and Buccella, 1983), is a small basin for which plant remains were identified, consisting in leaves and seed of Silver fir, Beech fruits, etc. According to these Authors the forest events falling in the late Subboreal are masked by anthropic activities: an accurate study of these pollen samples was performed.

The sites at Passo del Porcareccio (Tuscan-Romagna Apennines), 1,400 / 1,500 m a.s.l. (Bertolani Marchetti et al., 1971; Paoli and Ciuffi Cellai, 1973) have pollen diagram with a constant presence of Pine (*Pinus sylvestris*) as a pioneer plant. *Fagus* is present in growing percentages at the upper levels, gaining their current predominance in the nearby forest of Casentino. Of the other type of trees, we note *Taxus*, a Tertiary plant that has survived to present times. A certain analogy can be

drawn with the diagrams of Chiarugi (1936b), of Ferrarini (1981) for the northern Apennines and Apuane Alps, of Paganelli (1958b) for the Pantani and of Marchetti (1936) for Campotosto.

The pollen diagram of soils of stable formations, especially forests, merit an extensive comment. Indeed, the site of origin of pollen rains, deposited and percolating down in soils, are rather nearby. Thus, soil studies are particularly indicated for the construction of vegetational maps. Moreover, they are useful for the reconstruction of historical events of the site where samples were collected. We hope that future research on these topics will be numerous and extended to a wide network of samples, given the favourable outcome of the first results.

Peninsular Apennines

For the Umbro-Marchigiano Apennine, palynological studies of peat bog basins, such as that at Colfiorito, at 750 m a.s.l. (Paganelli, 1958a) and at Pantani, at 1.589 m a.s.l. (Paganelli, 1958b), have documented Post-glacial vegetational events. The homogeneous lacustrine sedimentation at Pantani shows in succession from its bottom *Pinus* phases (*Pinus mugo*, then *P. nigra v. austriaca*), *Salix*, start of the rise in Mixed Oak woods and the presence of *Abies* and *Picea*. *Fagus* appears after these events. At around -80 m, the descending *Pinus* curve intersects the ascending Mixed Oak woods curve. One may hypothetically place the maximum elevation of the vegetational belt at this point. These phases seem to represent the anathermic continental period proposed by Chiarugi for the Etruscan Apennines. The *Fagetum/Abietum* occurs next, related to the catathermic oceanic period of Chiarugi (1950). The history does not proceed further upwards, but it achieves its final situation at Piano di Colfiorito, that again favours the Mixed Oak woods and marks the return of the continental climate. Paganelli reports unpublished data of the late Prof. Marchesoni, that also reveal in superficial sediments at a deposit at Piano Piccolo di Castelluccio di Norcia (1.232 m a.s.l.) a regression of *Fagus* and a complete disappearance of the Silver fir and rise of the Mixed Oak woods.

Obviously, at such a great distance from the glaciation centers, the chronology cannot be related to the Blytt-Sernander period, but we can accept the more simple division adopted by Chiarugi. The latter classification gives the a general sense of relationships with more generalised events which must be taken into account. This topic will also be further discussed in the conclusions.

The diagram of the Mascioni peat bog (Fig. 3), in the areas of Campotosto in the Abruzzo Apennines (Marchetti, 1936), includes the catathermic and anathermic periods of Chiarugi, separated from a humified level. A *Pinus* forest (*Pinus mugo* Turra and *P. silvestris* L.) phase with a smaller presence of Silver fir occurs, representing a cold humid period related to lowering of the vegetational boundaries. Subsequently, the Mixed Oak wood increases, and non-Alpine but southern mountain pines appear, such as *Pinus pinaster* Aiton, in a dry climatic phase with maximum heat and elevation of the vegetational belts. An oceanic catathermic period follows, with humidity probably related to distributed rainfall. In this phase, *Fagus* predominates along with Silver fir, sometimes with the same percentages. A new continental climatic trend may be hypothesised on the basis of a new diffusion of the Mixed Oak woods contemporary with a modest presence of Chestnut.

Chiarugi (1937) studied a lacustrine sequence at the Lago Zapano, on the northern moraine of Monte Sirino in Lucania, pointing out catathermic events. *Abies* regresses in relation to *Fagus*, whose expansion has a recent peak. At this point, *Alnus cordata* (Loiselle.) Desf. expands. Chiarugi cites this plant as an important phytogeographic element of the ancient Mediterranean flora. The increase of this species occurs in various diagrams on southern Italy, and it can be used to correlate the various diagrams. In this sequence, the presence of *Castanea* manifests early with a curve that becomes continuous and that underscores its indigenous nature.

Holocene pollen diagrams have been drawn for some volcanic lakes of the Lazio and Lucania regions (Bonatti, 1961, 1962, 1963; Frank 1969; Magri 1989; Magri and Follieri 1992; Watts, 1985). Palynological studies have also been carried out for Piana del Fucino (Magri and Follieri, 1989). A note

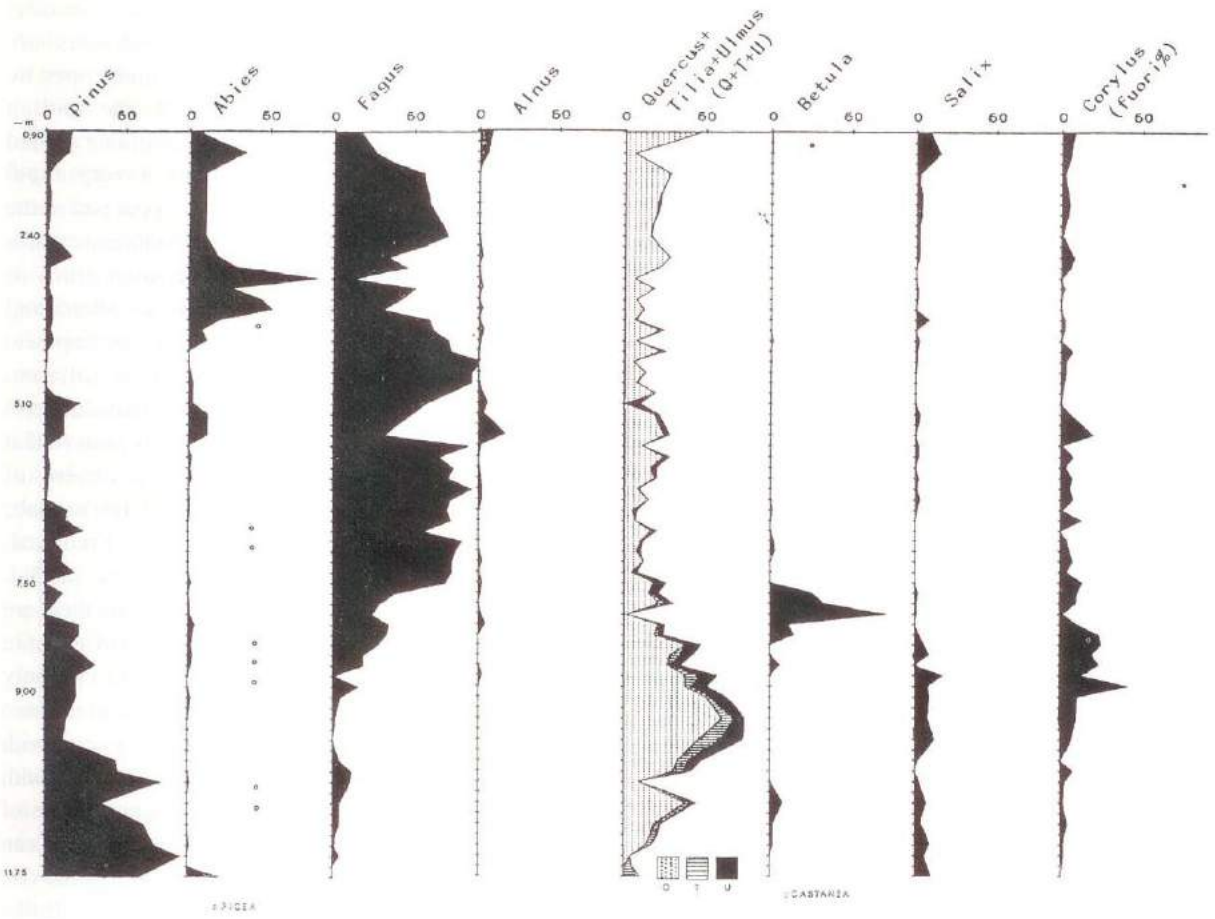

Fig. 3. Pollen diagram of the peat-basin of Mascioni (by Marchetti, 1936; modified) referred to the most important forest plants (*Corylus* has been excluded from the percentages). The history covers a time of 12,000-15,000 years, which include the anathermic and catathermic periods. The mediocrat curve (*Quercus-Tilia, Ulmus, Ostrya, Carpinus*) clearly depicts the phase of climatic improvement. The Oak-forest curve shows a maximum elevation of the vegetational belt at 9 m.

by Chiarugi (1937) illustrates catathermic forest events at Lago Zapàno, whereas Ferrarini reports the pollen analyses for Vulture, in Lucania (1978b), for Calabria in the Sila Grande (1978a) and for Sila Piccola, in collaboration with Padula (1969). Still for Calabria, Grüger (1977) performed a series of investigations at Cànolo Nuovo, starting from the Last glacial; its top layer is dated 12,000 B.P. and thus includes the period reviewed here.

The diagram by Frank also begins in Würmian times, and reaches a Subboreal Holocene, based chronologically on sedimentation velocity that overall seems reliable. The results of these studies agree with those by Bonatti for other crater lakes in Lazio. The general preliminary schema of Bonatti (1961) is represented for the greater part of the Holocene, which identifies a *Corylus* phase (from 12,000 B.P.) followed by an *Abies* forest (from 10,000 B.P.), and *Quercetum* from about 8,000 B.P., ending with *Pinus* from 4,000 B.P. and then again Mixed Oak woods from 2,000 B.P. These last two phases indicate the appearance of Chestnut. Perhaps this can be identified with Chiarugi's anathermic and catathermic periods. The most ancient levels, with a long *Artemisia* phase followed by a *Gramineae* phase have been attributed to glacial conditions. The Holocene of central Italy has been the object of recent studies by Magri (1989), Magri and Follieri (1989; 1992), that attempted to concord the events of the classical diagram (elaborated using the concentrations of taxa chosen as most significant) with the general climatic-vegetational features. This concordance is found for arboreous *Angiospermae*. Instead, *Artemisia* behaves differently at the three sites examined, persisting longer below Castiglione (until 5,500 B.P.), whereas at Fucino and Lagaccione, it seems to decline roughly at the end of the glacial period. The Authors state that this steppe vegetation is related to dry rather than cold climatic conditions.

The diagrams of Fucino, Lagaccione and Valle di Castiglione illustrate a rich forestation at the Pleistocene-Holocene boundary, more intense at the first two sites, consisting mainly of evergreen, caduceus Oaks and *Corylus*. Forest expansion reaches its maximum from 5,500 to 3,500 B.P., as also reflected by the total pollen concentration values. The steppic components are scanty; tendencially humid ecological conditions are represented by *Fagus*, and more humid ones by Fucino. A general collapse of the pollen concentration, dated at Valle di Castiglione around 3480±50 B.P., is interpreted as a very rapid degradation of the forest cover. The upper part of the diagrams have high percentage of Arboreous plants and the presence of anthropic indicators, such as *Cerealia, Vitis, Olea* and *Castanea*. Magri and Follieri point out the dishomogeneous development of vegetation at the three sites, with different distributions in space and time for the individual taxa and different floral lists. These Authors believe that the variations found with respect to other events of south-central Europe are sufficiently large to make the subdivision of the Holocene into Preboreal, Atlantic Boreal, Subboreal and Subatlantic invalid. According to Bradly (1984), who states the there are general variations and also others related to more limited territorial areas, we feel that we can only attribute a purely chronological subdivision to these areas, and the response of the individual areas with different ecological features could be identified with numerous absolute datings. However, the use of Chiarugi's terms "anathermic" and "catathermic" can always be applied since the Postglacial thermal rise and its decline are generalised features. Recall that the pattern of glacial and interglacial periods of peninsular Italy is influenced by its Mediterranean position, and by the presence of the Apennines chain, carrying to central European conditions (Bertolani Marchetti, 1986).

Watts (1985) carried out drillings at the crater lakes of Monticchio, near Melfi (Potenza), at 1,327 m a.s.l., Ferrarini (1978b); a study performed at the same site revealed a decline of Silver fir accompanied by an increase of *Fagus*. He also reports the terminal presence of Chestnut, attributed to anthropic intervention.

The diagram by Watts (1985) includes the last glacial in its lower section, and indicates a Postglacial period in the upper part. Absolute datings based on ^{14}C refer to the oldest part. According to the Author, the most recent datings (8,290±280 B.P.) could mark the start of the Holocene. It begins in the diagram with the diffusion

of *Betula* and *Quercus*, after a long Pleistocene dominance by *Pinus*, *Juniperus*, *Gramineae*, *Artemisia* and *Chenopodiaceae*. *Fagus* appears here in weak percentages; *Quercus* and *Abies* are also represented. The Postglacial events are also identified by the presence of *Ulmus*, *Tilia*, *Fraxinus excelsa*, *Ostrya*, *Carpinus*, etc., and by a *Fagus* with decreasing percentages and by an increase in Silver fir, with a fall of *Quercetum* in its upper half. The presence of Olive, seems probable. *Juglans* and *Castanea* are located at the upper layers, related to the presence of man; agricultural activities are reflected by the nearly certain presence of *Cerealia*. The Holocene part of the diagram seems towards its top to indicate more humid and probably cooler climatic conditions. A recent peak in *Alnus* can be attributed to *Alnus incana*, still present in the area.

Some contributions to the geobotanic history of southern Italy are given by the data on the Sila by Ferrarini (1978a) and Ferrarini & Padula (1969); the former includes Silver fir predominating over *Fagus* and the latter with *Pinus laricio* antagonistic and sometimes prevailing over *Abies* and *Fagus* (Fig.4). A dating performed at the base of this profile on *Abies* wood gave a value of 1,200 B.P., and thus it falls in historic times.

Again for Calabria, the lower levels of the Canolo Nuovo diagram (Grüger, 1977) (Fig. 5) reaches the Last glacial; the sector we are interested in overlooks a steppic phase (*Gramineae* and *Artemisia*) during the Dryas, dating around 125,000 B.P., from which it is separated by a sedimentary' *hyatus*. The Holocene part has *Fagus* predominating over Silver fir, a marked presence of *Betula* and relatively high percentages of mediocrates (at around 6,000 B.P.). An abundant diffusion of *Alnus cordata* can be compared with that known from other diagrams of the region.

For Aspromonte in Calabria, we can cite the study by Schneider (1984), that considered current pollen rains for an improved evaluation of recent pollen diagrams. Schneider found that the dominant species in the current vegetational cover generally take on the highest values, even in the surface samples; that the herbaceous species are not in high percentages, except for *Gramineae*, *Compositae;* and that *Chenopodiaceae* are overestimated. Climatic changes can also influence the production of pollen of arboreous plants, and the ratio between the presence of local and alloctonae pollen may depend on the situation of the forest plants and climate.

Sicily

The Holocene of Sicily is not documented by many pollen analysis sites due to the very arid climatic conditions. The Monti Madonie are located near the Tyrrhenian coasts, in the North central part of Sicily. The generally Mediterranean climate can be distinguished in a thermomediterranean subtype at the basal level, a mesomediterranean climate at the belt level, and a submediterranean climate at the mountain belt. The wet habitats which provided suitable conditions for palynological research were exclusively related to the Numidian Flish formation, characterised by an alternation of quarzarenites and clayey siltites that form an acid substrate. The contact between the permeable layers and impermeable clayey layers forms stratum springs that drain sediments into small underlying basins (see Bertolani M., in Bertolani Marchetti et al, 1984a). The sites have been studied by means of interdisciplinary investigations and reported in two papers (Bertolani Marchetti et al., 1984a and 1984 b).

Of the sequences analysed, we can cite that at Pietra Giordano, at 1,400 m. a.s.l., in Gariga, and at *Genista cupani* Guss., at a depth of 185 cm. The lower two thirds of the diagram is dominated by *Fagus* in competition with *Quercus* (prevalently *Quercus petraea* and *Q. cerris*; *Q. suber-coccifera* to a less extent. At the upper third of the diagram, the decline of Arboreous plants is in correspondence with a strong predominance of hygro/hydrophytes. *Ilex* follows in scanty amounts throughout the diagram, with a small peak at the fall of the In fact Arborea. *Castanea* and *Juglans* are always present. In fact*Quercus* and *Fagus* seem, to belong to a Mixed Oak woods and not to two distinct but close overlapping belts. This hypothesis is confirmed in other slopes of the Monti Madonie, which at the same altitude have demonstrated similar situations, and, as also pointed out by Grüger (op. cit.), for

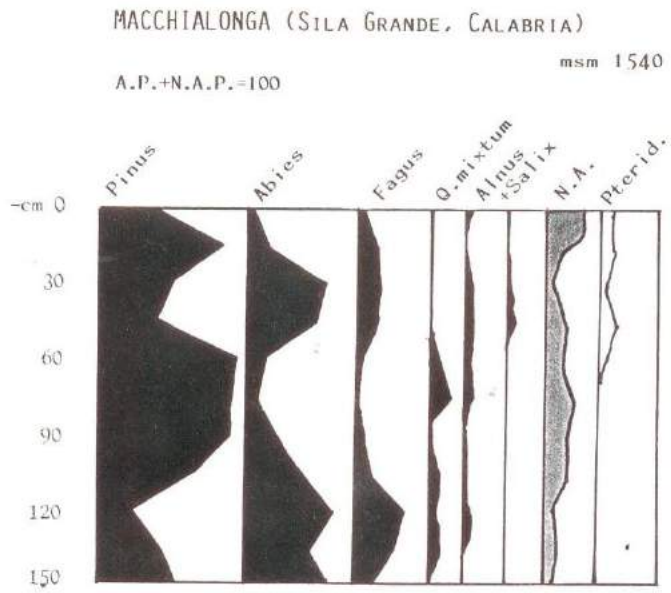

Fig. 4. Pollen diagram of Macchialonga (Sila Grande, Calabria, Italy) is RC-dated at 1,200 B.P. in its lower part, *Castanea* appears at the upper part of the pollen diagram. (by Ferrarini, 1978a; modified)

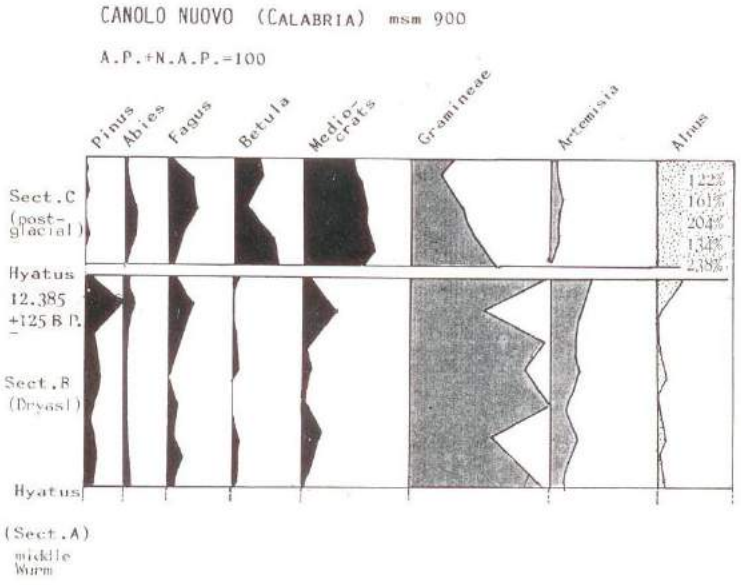

Fig. 5. Simplified pollen diagram of the upper part of Canolo Nuovo (Calabria, Italy) sequences (by Grüber, 1977; modified) The three sections are divided from each other by a *hyatus* of 120,000 years between A and B and of 10,000 years between B and C. Radiocarbon dating placed the lower part of the diagram in the middle of the last glacial. Section B refers to a Late-glacial, including a part of Dryas I with *Gramineae/Artemisia* steppe. Section C is Post-glacial, and it is characterised by thermal improvement and by a high percentage of *Alnus cordata*, in accordance with other diagrams of the same age from the same area.

Calabria a mixed *Fagus* and *Quercus* vegetation during the cold oscillation. Sporadic pollen grains of *Taxus baccata*, a species not present today in that region, have been seen.

Absolute ^{14}C dating was obtained on wood samples collected at about –150 cm (Biondi, in Bertolani Marchetti, et al., 1984a). Radio-carbon dating was 9,200± 90 BP, placing it in a non-recent, perhaps pre-boreal, Holocene. The woods belonged to *Abies alba* and *A. nebrodensis*, *Fagus sylvatica*, *Quercus petraea*, *Q. cerris*. Near the site called Urgo di Pollicino, at 1,280 m a.s.l. (drilling depth, 410 cm), the vegetation was completely herbaceous due to anthropic demolition over the last centuries. The arboreal diagram presents expressions of alloctonous formations. *Fagus* lies close to *Quercetum*, and, to a lesser extent, *Ilex aquifolium* is represented in only part of the diagram, with a peak at -80 cm, coincident with the disappearance of *Fagus*. More than a climatic event, it may reflect anthropic deforestation of *Fagus*, favouring the colonisation by *Ilex* that thus behaves as a pioneer species. The above sites can also be correlated with other subsequently studied areas (Bertolani Marchetti, et al., 1984b). The Scorzone area, at 1,300 m a.s.l., has *in situ* a rich vegetation represented by *Osmunda regalis*, near the *Ilex* belt. The diagram has some bare areas, due to deforestation occurring at the same time as for *Fagus*, and a constant "Margio"-type profile, similar to the current aspect.

Conclusions

The Apennines chain, running from northern Italy along the entire peninsula, profoundly influences the Italian vegetational structure. A multitude of factors are at play: extension and latitude, complex orographic morphology, the various geological nature, a long history after emmersing from the sea, impact of glaciation, role as a route of immigration. Accordingly, we have also had to adapt to a "peninsular" lifestyle, living in a mosaic of fragments, different from that of the continent.

For the palynology, we can state that Apennines structure contains a number of sites (lacustrine lakes and others), with sediments that have collected pollen rains from all ages. Among these the most characteristics are small peat bogs, related to the regression of local mountain glaciers as the vaster northern Europe ones are correlated with the regression of the larger glacier cap. For these reasons, the Italian peat bogs have become protected territories, and must be considered precious historical vegetational archives.

The Holocene history of the Apennines have been dominated by forest entities and formations including *Pinus* (the Pines), Silver fir, *Fagus*, *Quercetum mixtum*, including different arboreous plants (*Tilia*, *Carpinus* and various species of *Quercus*) that can assume different significance. *Corylus* and *Betula*, with very prominent peaks in some diagrams, could mark the boundary between Post-glacial periods. In Sicily, in the Madonie mountains, *Ilex* gains importance; its diffusion seems to have been favoured by deforestation. The contrasts between *Quercetum* and Silver fir and between Silver fir and *Fagus*, and especially the intersection of their rising and falling curves, help to orient the chronology and relationships of the diagrams in lack of absolute datings. Some caution must be used in these deduction when local or regional conditions influence these events. For example, for the Ligurian Apennines, we noted a persistence of Silver fir protracted for 2,000 years, as later supported by absolute datings. The influence of the nearby sea on climate, the distance from a glaciation center such as Monte Cimone, greater exposure of this mountain to cold N-E air currents which still influence the Italian Adriatic coast, can justify the even remarkable differences in the diagrams. Thus, we believe that Lowe's statement (Lowe, 1992) that interprets the Late glacial in northern Italy as incorrect based on ^{14}C datings performed at Prato Spilla (Liguria-Parma Apennines) should be reconsidered. Moreover, we must consider that this site in the Liguria-Parma Apennine seems to be at the cross-roads of botanical migration and requires more in depth study. In this light, Bertoldi's (1980) findings of Mediterranean plants in the pollen sequences of the Parma Apennines can suggest climatic conditions and migratory conditions from the Tyrrhenian side of the Apennines chain rather than a transport of pollen granules from distant site. We cannot discuss this topic in depth here. However, note that the nearby

Apuane Alps as a key point in the Alpine-Apennines connection (Del Prete, 1980). Current floristic studies have demonstrated these features, and we hope that palynological studies will be able to furnish additional data.

Many Authors have indicated the Apennines as a probable route of large scale migration (see Del Prete, 1980; Del Prete & Tomaselli, 1988).

The topic of vegetational levels has been discussed in detail for the Apennines by Negri (1947), Chiarugi (1958a,b) and Pignatti (1979). Palynology can provide a contribution to this body of knowledge by highlighting the changes in the altitude of the vegetational belts, leading where possible to the creation of paleomaps (Bertolani Marchetti, 1978). Widely known changes are those that elevated *Quercetum* to 1,500 m a.s.l. in the Tuscan Emilian Apennines (Chiarugi, 1936b) (Fig. 6) in the period when the Apennines peaks, not very high, saw the fall of Alpine entities or associations in refuge niches (Bertolani Marchetti and Dallai, 1990). Lago di Massaciuccoli (Toscana), along the Tyrrhenian coast, was reached by a mountain Pine forest in the Last glacial (Marchetti and Tongiorgi, 1936). Another example can be found in the low hills near the city of Bologna; in a fossil pit dated 18,000 B.P. at the bottom and 4,700 / 4,300 B.P. at the top; it contains palynological evidence of a Pine forest followed by a Mixed Oak woods (Bertolani Marchetti,1980 and 1985; Pasini, 1970). Recently, Trevisan Grandi (1991) studied the soil in a *Fagus* station located at 500 m a.s.l. at Casina (Reggio Emilia), and demonstrated that *Fagus*, present only in the superficial part of the diagram, belonged to a relatively recent infiltration and not to an abandoned relict of woody cover which had risen.

A consideration based on Apennines palynological data is that is the northern part is more influenced by the Alpine glacial and Postglacial events. The peninsular part, fully extending into the Mediterranean, does not seem to completely reflect its position, which should be characterised by glacial and steppic interglacial woods, but centro-European features tend to persist. The Apennines "cold routes" are thus followed up the Monte Madonie by plants considered glacial relicts.

Instead, the "warm routes" consist of hilly belts that due to improved thermal features constructed a refuge for thermophilous plants in the glacial period. The hilly belt areas should be reconsidered and given its due importance when evaluating different vegetational levels.

A final consideration can be made for the Monti Madonie. The small peat bogs or lakes ("margi or urgi"), where we sampled the studied sequences, are not of glacial origin but arise from stratum springs.

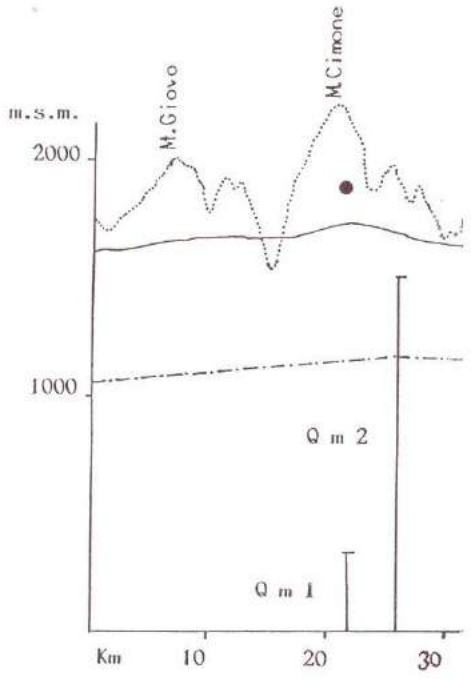

Fig. 6. Changes of the vegetational belts in Glacial and Post-glacial times.

Continuous line: Graphical representation of the medius nival boundary.

Hatched line: Graphical representation of approximate lower boundary of the glacial deposits.

Qm1 = Upper limit of Oak-mixed forest during glacial period.

Qm2 = Upper limit of Oak-mixed forest during the climatic "optimum" in the Post-glacial period (partial by Losacco, 1947, modified).

• = Altimetric position of a current phytosociological survey (Credaro and Pirola, 1985), with clearly ipsophil characteristics.

Acknowledgement

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