Holocene forest pollen vegetation of the Po plain - Northern Italy (Emilia Romagna data)

CARLA ALBERTA ACCORSI, MARTA BANDINI MAZZANTI, ANNA MARIA MERCURI, CECILIA RIVALENTI, GIULIANA TREVISAN GRANDI

Dipartimento di Biologia Animale, Sezione Orto Botanico
Università di Modena
V.le Caduti in Guerra 127, 41100 Modena, Italy

to Daria Bertolani Marchetti

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A picture of the Holocene forest vegetation of the Emilia Romagna plain based on pollen records is presented. Available pollen data were elaborated with criteria partially obtained by phytosociological methods. Holocene pollen flora of the investigated area consisted of 88 AP pollen types (belonging to 31 Families and 53 Genera). Mean percentage and mean pollen cover spectra showed the evolution of forest consistence and composition in the Holocene. Forest consistence was lower than expected (mean AP sum = 64; 53; 40; 43; 34% from the Preboreal onwards). In the Preboreal *Pinus* was dominant. From the Boreal onwards deciduous mixed Oak wood spread, in which first *Tilia* (Boreal - Atlantic), then *Ulmus* and later *Ulmus* and *Carpinus* rivaled *Quercus* for the leadership. *Alnus* and *Salix* were more or less abundant. *Abies* was widespread and quite abundant from the Boreal to the Subboreal; *Fagus* actually became significant in the Subatlantic; both *Abies* and *Fagus* grew at higher altitude, the former in some areas creeping towards the plain. In the Subboreal - Subatlantic some Mediterranean evergreens (*Quercus ilex, Phillyrea, Olea)* appeared in the pollen rain. Man's influence on forest vegetation was suggested by forest clearance and by the increase or appearance of plants, from the Subboreal onwards, some of which already grew wild in the pollen catchment area, and others which may have been introduced (e.g. *Vitis, Castanea, Juglans, Olea, Platanus, Morus, Aesculus*).

Key words: Holocene Forest Pollen Vegetation, Pò Plain, Emilia Romagna.

RIASSUNTO **Vegetazione forestale su base pollinica della Pianura Padana nell'Olocene (dati dell'Emilia Romagna)**

Il lavoro presenta una sintesi dei dati pollinici disponibili inerenti la vegetazione forestale olocenica della pianura Emiliano-Romagnola. I dati pollinici sono stati elaborati utilizzando in parte criteri importati dalla Fitosociologia. La flora pollinica risultante è costituita da 88 tipi pollinici arborei e arbustivi, appartenenti a 31 Famiglie e 53 Generi. Gli spettri pollinici, esposti con dati percentuali e con valori di copertura, mostrano le variazioni delle specie arboree e arbustive durante le fasi dell'Olocene. Nel Preboreale domina *Pinus*; dal Boreale si affermano boschi misti di latifoglie in cui a *Quercus* si affiancano, in particolare, prima *Tilia*, poi *Ulmus*, poi *Ulmus* e *Carpinus*. *Alnus* e *Salix*

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sono continui e più o meno abbondanti. *Abies* ha notevoli presenze dal Boreale al Subboreale; *Fagus* diventa significativo dal Subatlantico; ambedue sembrano riflettere una distribuzione collinare-montana, il primo con digitazione verso il basso. Nel Subboreale - Subatlantico compaiono reperti di Mediterranee sempreverdi: *Quercus ilex, Phillyrea, Olea*. L'intervento dell'uomo sul paesaggio forestale è indicato dalla progressiva riduzione della copertura arborea e dall'aumento di specie, in parte già presenti nell'area dell'apporto pollinico, in parte forse introdotte (ad esempio *Juglans, Vitis, Olea, Castanea, Platanus, Morus, Aesculus*).

1. INTRODUCTION

The Po Valley is an important area in Italy and its vegetation, past and present, natural and /or anthropic, has had a prominent role in Italian history and still has today. "Present vegetation" wrote Bertolani Marchetti in 1980, talking about the Emilia Romagna plain "developed following a restless succession of events ... The valley bed hides chains of mountains and faults which are still active under a flat and monotonous appearance, and its various sediments, silt, clay, sand and gravel with their different permeability alone, create a number of environments differing in ecology. ... Man has had a profound effect on the natural environment of the plain, even during the very short time of his presence, which has lasted only a few minutes in the daily time span of its geological history".

Past vegetation of the Po Valley has been investigated by several palaeobotanists and a number of data have been reported in the last forty years, concerning various vegetal remains, differing in location and age. The present Conference fulfills the need of an up to date synthesis of palynological research carried out until now. Even if some papers may be somehow out of date, especially concerning methodological aspects, the value of reliable pollenanalytical data remains unchanged in time.

Pollen analyses concerning the Emilia Romagna plain, or the area where it now lies, began before 1960 on Pleistocene and Holocene sediments (e.g. Firbas & Zangheri, 1934; Dubois & Zangheri, 1957ab). In the next decade analyses were carried out on Messinian and Holocene sediments (e.g. Bertolani Marchetti, 1966; Zangheri, 1966). From 1970 up to 1985 palinologists studied a number of sites ranging in age from the Messinian to the Holocene and have recently focused their research on the Holocene and in particular on the Subatlantic. Altogether 50 sites were investigated: 8 were from the Messinian age, 10 Plio-Pleistocene, 5 Pleistocene and 28 Holocene.

We had been thinking for some time about collecting all available pollen data to produce a global set and a mean picture of the Emilia Romagna past vegetation. We had already considered Holocene pollen anthropogenic indicators in connection with the record of seeds/fruits and woods (Accorsi *et al.*, 1992a). In preparation for the Conference we began to rearrange all pollen data beginning from the older ones, that is from the Messinian spectra, but a number of time consuming problems due to different methods of elaboration and format of data initially confined us to the Holocene. We chose this period because most pollen data of our region come from this age, and because they reach, with some medieval pollen spectra, the threshold of today's vegetation, which is the other main topic of the Conference.

The present paper deals, therefore, with pollen data concerning Holocene forest vegetation of the Emilia Romagna plain. It deals only with tree/shrub pollen to focus the attention on the forest composition and also to include some not so recent papers which did not involve herb pollen.

A large amount of the research was carried out by late Prof. Daria Bertolani Marchetti,

one of the best known Italian palinologists, who knew and loved the past and present Po Valley vegetation and the "pedunculate Oak" (*Quercus robur* L. s.s. = *Q. pedunculata* Ehrh.) the tree she chose as the symbol of its Holocene vegetal landscape. To Daria Bertolani Marchetti, teacher of us all, we dedicate this work.

2. METHODS

2.1. Papers considered

We considered all published papers to our knowledge reporting Holocene pollen data concerning sites of the involved area (Po plain; Emilia Romagna Region; from 0 to 100 m a.s.l.). Only in a very few cases, in our analyses, unpublished data were considered too. Very preliminary short abstracts were excluded. The sites, the Holocene phases involved in every site and the relevant references are listed in Table I. More information about sites (Geographic location, dating availability, the record of vegetal remains other than pollen etc.) are shown in Tables II-VI, each of them regarding a single Holocene phase.

2.2. Chronology

The chronology of the spectra primarily followed the Authors' indications. When there were no indications, we dated the spectra, taking into account the general pollen picture of the region.

2.3. Pollen types considered

All pollen types quoted in the papers were considered. They were divided in two groups: 1) pollen types routinely identified by the Authors; 2) pollen types only occasionally identified. As for group 1, quantitative values (Tables VII-XVIII), were calculated as described below. As for group 2 only the presence was shown (Table XVII). Table XVII lists all pollen types recorded in the sites. Tables VII-XVI, XVIII list only pollen types belonging to group 1. Pignatti' s Italian Flora (1982) was used for plant names.

2.4. Data elaboration

2.4.1. Mean percentage forest pollen spectrum of each site

All the pollen data concerning the sites (pollen diagrams, pollen spectra, pollen type lists) were collected and divided into the five Holocene phases: Preboreal, Boreal, Atlantic, Subboreal, Subatlantic (Beaulieu *et al.*, 1994).

For each phase and for each site the sum of trees + shrubs + lianes was calculated (AP sum). Then the pollen data were elaborated as follows.

For each site, and for each taxon of group 1 (that is taxa quantified by the Authors, see 2.3.) a ***"Mean forest pollen percentage"*** was calculated. Percentages were calculated on a pollen sum consisting only of AP pollen (trees + shrubs + lianes). In this way we obtained a ***"Mean percentage forest pollen spectrum of each site"*** for each Holocene phase.

2.4.2. Mean cover forest pollen spectrum of each site

The percentages of the various taxa and therefore the "mean percentage forest pollen spectrum of each site" above described could not be very precise for the different methods the data were presented by the Authors and for the subsequent difficulty in getting the percentage from their papers. So we arranged the data not by percentage but by ***"Mean forest pollen cover"***, referring to 7 *pollen cover classes*. *Pollen cover classes* were obtained by Phytosociological methods (Pignatti, 1976) with little adjustment as described below:

Pollen Cover Classes	Pollen percentages
5	81-100%
4	61-80%
3	41-60%
2	21-40%
1d	11-20%
1c	5.1-10%
1b	2.6-5%
1a	1.1-2.5%
+	0.5-1%
r	<0.5%

The "Mean cover pollen forest spectrum of the site" is therefore the list of the taxa recorded in that particular site flanked by the class value the taxon totaled in the site in the given Holocene phase. It represents a mean pollen picture of the woody landscape in that site in that Holocene phase. Tables VII-XI report the ***"Mean cover forest pollen spectra"*** of the sites of each Holocene phase.

2.4.3. Mean percentage forest pollen spectrum of each Holocene phase

Having obtained the picture of each site, we calculated a ***"Mean percentage forest pollen spectrum of each Holocene phase"***, that is the list of all the pollen types recorded and quantified (pollen types of group 1) flanked by a percentage. These percentages were obtained as follows:

Mean % of the taxon in the phase = x1 + x2 + x3 +..... xn * 100/n

whereas

x1, x2, x3, x4, x5....xn = mean value of the pollen cover class the taxon showed in sites 1,2,3,4,5.... etc. of the Holocene phase

n = number of sites

Mean values of the cover classes:

Pollen Cover Classes	Mean Value of percentage
5	90%
4	70%
3	50%
2	30%
1d	15%
1c	7.5%
1b	3.8%
1a	1.75%
+	0.75%
r	0.25%

Example: in the Preboreal phase *Pinus* had the following cover values in the 6 sites: 5, 5, 5, 5, 2, 5. The corresponding mean values of the classes are: 90%, 90%, 90%, 90%, 30%, 90%. So the ***"Mean Preboreal percentage"*** of *Pinus* is 80% (480 / 6).

2.4.4. Mean cover forest pollen spectrum of each Holocene phase

The aforementioned ***"Mean percentage forest pollen spectrum of each Holocene phase"*** was also presented as ***"Mean cover forest pollen spectrum"*** that is replacing percentages with cover values.

Example: in the aforementioned example in the Preboreal phase the mean percentage of *Pinus* was "80%", therefore the ***Mean pollen cover*** of *Pinus* was "4".

In conclusion we obtained, for each Holocene phase a Mean forest pollen spectrum expressed in two forms: 1) *"Mean percentage forest pollen spectrum"*; 2) *"Mean cover forest pollen spectrum"*. The two spectra are reported in the end columns of Tables VII-XI.

2.4.5. Characteristic forest pollen combination

Finally, to give a description in brief of Holocene pollen rain, influenced by Phytosociological methods (Pirola, 1970; Pignatti, 1976) we produced a final mean pollen picture of each Holocene phase. All taxa recorded were listed with their values (presence class, mean percentage, mean cover) headed by the ***"Characteristic forest pollen combination"*** (= CFPC), which is the typical pollen assemblage of the phase. It is the list of the most frequent taxa found overall, which is equal in number to the mean number of taxa per site. The taxa included in the Characteristic forest poller combination were chosen in order of: a) presence; b) mean percentage in case of equal presence; c) anthropic significance or geobotanical importance in case of equal a and b; d) at random when a, b. c were equal. The Characteristic forest pollen combination includes both most frequent and most abundant taxa: its percentage sum was > 90% in all Holocene phases.

Presence Classes were again obtained by Phytosociological methods (Pignatti, 1976) with little adjustment:

Presence Classes	% of sites
I	1-20%
II	21-40%
III	41-60%
IV	61-80%
V	81-100%

2.4.6. Status of the *taxa*

The following terms were used to define the status of each pollen type, according to its percentage value:

1. Leading pollen = with a percentage from 5.1% upwards (Cover classes from 1c upwards)
2. Dominant pollen = with a percentage from 41% upwards (Cover classes from 3 upwards)
3. Main pollen = with a percentage between 11% and 40% (Cover classes: 1d, 2)
4. Partner pollen = with a percentage between 5.1 % and 10 % (Cover class: 1c)
5. Secondary pollen = with a percentage between 2.6% and 5% (Cover class: 1b)
6. Companion pollen = with a percentage between 1.1% and 2.5% (Cover class: 1a)
7. Minor pollen = with a percentage ≤1% (Cover classes: + and r)

The following terms were used to define Class presence:

a)	Ubiquitous	=	100 % of sites	
b)	Widespread	=	Presence classes	IV and V
c)	Frequent	=	Presence classes	II and III
d)	Quite frequent	=	Presence class	III
e)	Less frequent	=	Presence class	II
f)	Infrequent	=	Presence class	I

These mean synthetic floristic/vegetational pictures of the five Holocene phases are shown in Tables XII-XVI.

2.4.7. Similarity index

The similarity between the mean spectra of the phases was evaluated with the Sörensen index (Pignatti 1976); the same index was used to assess the monotony of the spectra of each phase by comparing the spectrum of each individual site with the Characteristic forest pollen combination of that phase.

2.4.8. Diagrams

Diagrams were drawn on the basis of the final percentage pollen spectrum of each phase. The General Diagram in Fig. 3 shows AP/NAP ratio and taxa or group variation; Diagram in Fig. 4 shows pollen group variation (AP = 100%); Diagrams in Figg. 5, 6 show Oak wood composition (Fig. 5: AP = 100%; Fig. 6: Oak wood = 100%); Diagram in Fig. 7 shows Characteristic pollen combination of the five Holocene phases.

3. RESULTS AND DISCUSSION

The method of elaboration used seems to produce reliable results because: a) the percentage pollen spectra obtained using the mean cover class values had totals very near to 100%; b) the general vegetational picture matches the opinions expressed by the Authors concerning their data; c) it has enabled the data to be recovered and summarized. The whole set of data is discussed in brief below.

3.1. Pollen sites

The pollen data presented here concern 28 sites (Fig. 1). The most widely investigated provinces are Modena (10 sites), Bologna and Ravenna (5 sites). Some pollen data are also available for the areas of Parma, Ferrara, Forlì, and Reggio Emilia (1-4 sites each). Only the area of Piacenza lacks pollen data. The pollen deposits mainly consist of river sediment sequences and archaeological deposits, sometimes soils. The type of pollen deposit and stratigraphy are not always clearly indicated in the palynological papers, but sampling strategy and method always followed criteria established by teams including geologists, geomorphologists, archaeologists etc. who considered the various stratigraphycal aspects.

3.2. Pollen types

Altogether 88 AP pollen types were recorded in the Holocene of the Emilia Romagna Plain. They belong to 31 Families and 53 Genera. Pollen was mostly identified at the Genus level, but finer identification was occasionally made. The number of taxa increases

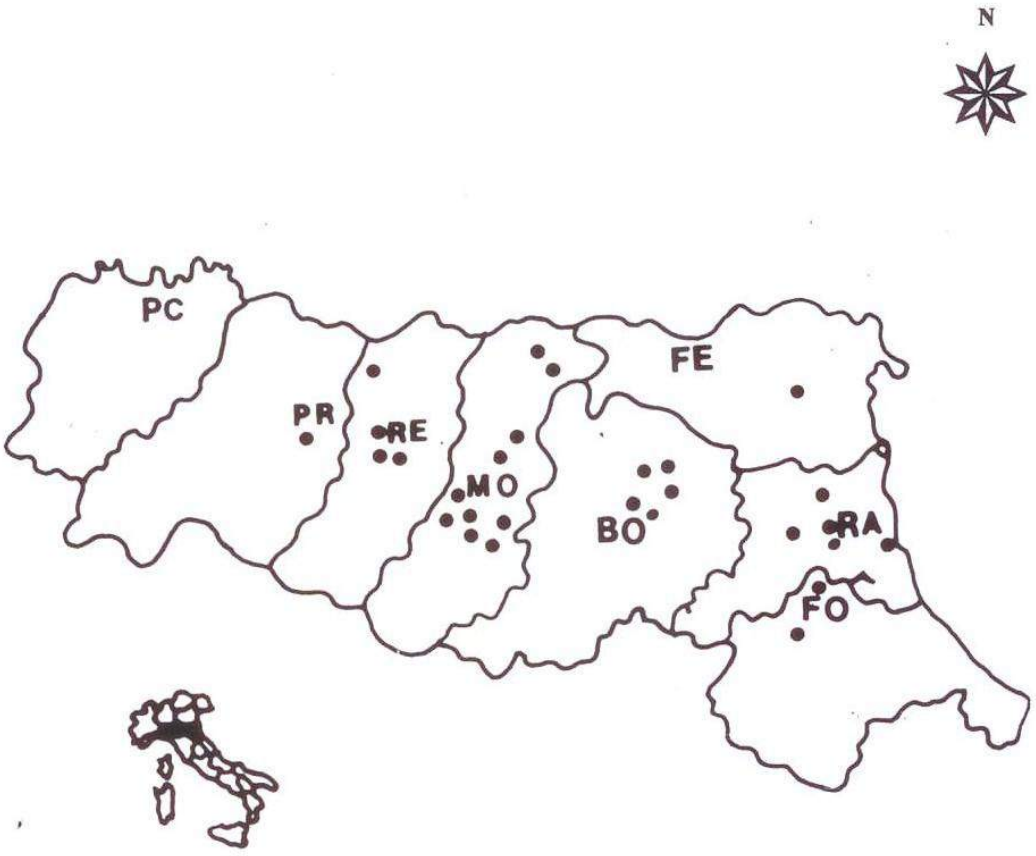

Fig. 1: Map of the distribution of the 28 Po Plain sites considered.

from the Preboreal to the Subatlantic (mainly in the Subboreal - Subatlantic), possibly depending not only on changes in vegetation but also on the increase in the number of sites.

Most of the pollen types belong to woody plants living today in Italy as wild plants. Some of them instead are known today as cultivated plants in the region (*Aesculus*, *Castanea*, *Cupressus*, *Juglans*, *Morus*). As for the *Castanea*, it was already known that *Castanea sativa* is indigenous in Northern Italy (Paganelli & Miola, 1991) while as for the other trees it is still a matter of debate whether they are indigenous or have been introduced.

Tree pollen types were the most frequent and abundant, their cover values ranging in general from 1 to 5; shrubs were less frequently recorded and in low quantity, their cover values normally ranging around "r" and "+".

3.3. Flora/Vegetation picture of the Holocene phases

PREBOREAL (10,000-9,000 BP)

Preboreal pollen rain

The pollen spectra attributed to the Preboreal came from 6 sites: 4 in the area of Modena, 1 Parma and 1 Reggio Emilia. Altogether there were 22 pollen spectra.

Preboreal forest pollen flora is the least various of the Holocene: 18 pollen types were recorded in this phase, 8 per site on average, the lowest observed. Most of the pollen types were trees (14 = 78%), shrubs were represented by 4 taxa (= 22%); the ratio of trees/shrubs being 3.5: 1.

The Characteristic forest pollen combination (CFPC) of the Preboreal consisted of 8 taxa (7 trees + 1 shrub). There were 5 Widespread taxa: *Abies*, *Alnus*, *Betula*, *Corylus*, *Pinus* (in alphabetical order). Among them *Pinus* and *Abies* were Ubiquitous. The other CFPC-taxa (*Quercus*, *Carpinus* and *Salix*) were nevertheless Quite frequent, recorded in 50% of sites, as for *Picea* (outside the CFPC). The pollen outside the CFPC were Frequent or Infrequent.

The 8 CFPC-taxa were in general most abundant besides most frequent; the only exception was *Fagus* (1.2 % = 1a cover, recorded only in 1 site, Pozzo Formigine-Modena, 90 m a.s.l., and therefore not included in the CFPC).

The CFPC-taxa had very different percentages. There were two Leading taxa: *Pinus* and *Abies* but their role was very different. *Pinus* was the Dominant pollen of the Preboreal, having a mean percentage of 80 % and a cover value of "4". It was also Dominant in almost all sites (only exception: at Pozzo Formigine-Modena *Pinus* was not Dominant but Main pollen with cover value = 2). All the other pollen taxa were far lower: *Abies*, the other Leading pollen was 5.3%; *Betula* and *Alnus*, which had the status of Secondary pollen, were 3-4% and *Corylus*, a Companion Widespread pollen was 1.2%. The other CFPC taxa were Minor pollen (*Quercus*, *Carpinus* and *Salix*). All the taxa outside CFPC were Minor pollen taxa except *Fagus* as abovementioned. Among the latter note *Castanea*, recorded in one site.

In brief, the main pollen characteristics of the Preboreal were: a) the Dominant pollen was only *Pinus*; no other taxon even obtained Main pollen status (> 10%); b) in the individual sites again *Pinus* was the only Dominant pollen, but *Abies*, *Alnus* and *Betula* obtained the status of Main pollen and *Fagus* was occasionally a Partner pollen.

Minor pollen represented 66.7 % of the Preboreal Flora and altogether accounted for the 3.3 % of the mean spectrum of the phase.

Preboreal pollen landscape

As for the reconstruction of the forest landscape in the Preboreal it can be said first that the forest was less consistent than presumed, even if it was the most consistent of the Holocene. The AP cover was "4" (64%) on average, and from "4" to "5" in most sites. The only exception was the site of S. Rigo di Rivalta - Reggio Emilia where the AP sum was notably lower (cover = 1d).

In any case, the role of the forest was still quite important in the landscape (in 33% of sites the AP sum was > 80%) and no clear evidence of human clearance appeared in the forest pollen spectra. Moreover, even if in the present paper we only deal with AP pollen, we observe that in the Emilia Romagna plain the Preboreal was marked by slight anthropogenic pollen (Accorsi *et al.*, 1992a): some ruderal pollen; Cerealia pollen in only one site: Pozzo Navicello-Modena. The pollen landscape appeared therefore to be still quite natural.

On the whole deciduous broadleaf trees/shrubs were very low (12%) compared with

conifers (85.5%). Hygrophilous trees were scarce, totaling ca 4%, and Mediterranean evergreens were only testified by a single record of *Laurus* in the Cava S. Antonio site.

The Preboreal forest was shaped by conifers, above all pines, probably mostly *Pinus sylvestris* which were still living on the plain. Although *Abies* was present in all sites it was less significant in the landscape, and *Picea* was even less significant than *Abies*.

Almost all the main deciduous trees/shrubs belonging to today's broadleaf wood of the region were already present but they were scarce. Among them only *Betula* and *Alnus* were widespread and a little more abundant, around 3-4%; the others (e.g. *Quercus, Corylus, Carpinus, Salix*) were more or less frequent with very low values, <2 %, or <1%, and some of them were Minor or Infrequent pollen (e.g. *Fagus, Ostrya, Tilia, Ulmus*, etc.). Among the latter note the record of *Castanea*.

The forest vegetation matches the progressive increase in temperature after the last cold period of the Younger Dryas.

BOREAL (9,000-8,000 BP)

Boreal pollen rain

The pollen spectra attributed to the Boreal came from 6 sites: 5 in the area of Modena and 1 Parma. Altogether there were 10 pollen spectra.

The Boreal pollen flora is a little more various than in the Preboreal: 23 pollen types were recorded in this phase, 11 per site on average. The increase concerned only shrubs. In fact, tree pollen types were the same as in the Preboreal whereas the number of shrubs was more than double. So trees were only slightly more numerous (13 Taxa = 56.5%) than shrubs (10 Taxa = 43.5%) and their ratio decreased to 1.3: 1 a notably lower value than in the Preboreal.

The Characteristic forest pollen combination (CFPC) of the Boreal included a higher number of taxa (11 taxa: 9 trees + 2 shrubs). There were 8 Widespread taxa: the same five as in the Preboreal (*Abies, Alnus, Betula, Corylus, Pinus*, in alphabetical order) plus *Quercus, Tilia, Ulmus*. Only *Pinus* was Ubiquitous. Among the other 3 CFPC-taxa *Carpinus* was Quite frequent, recorded in 50% of sites. The 12 pollen types outside the CFPC were Less frequent or Infrequent.

Also in the Boreal the 11 CFPC-taxa were generally most abundant besides most frequent. The only exception was *Ostrya* (1,3 % = 1a cover, which was not included in the CFPC because it was recorded only in 1 site: Case Nuove-Parma). In the Boreal there was a different relationship among the main taxa. Instead of a Dominant pollen, there was a group of 7 Leading pollen: *Abies, Alnus, Betula, Corylus, Pinus, Quercus, Tilia* (in alphabetical order). Their values were not very different from each other (cover values: 1d, 1c; mean percentage: 6 - 19 %), but 4 of them (*Pinus, Alnus, Quercus, Abies*) were Main pollen (11-19 %).

In the CFPC there were two Secondary pollen types (*Carpinus, Salix*), one Companion pollen (*Ulmus*) and a Minor pollen (*Cornus*). All the other taxa were Minor pollen, except for the Infrequent *Ostrya* (outside the CFPC as mentioned before). Among these Minor pollen types note again *Castanea*, recorded in 1 site as in the Preboreal.

In brief, the main characteristics of the Boreal pollen rain were: a) *Pinus* had lost the status of Dominant pollen and it was replaced by a group of 7 Leading taxa four of which were Main pollen: *Pinus, Alnus, Quercus* and *Abies* (in decreasing order); b) Two broadleaf trees (*Quercus* and *Tilia*) became more abundant and changed from being a

Minor pollen in the Preboreal to a Main or Partner pollen in the spectrum of the Boreal phase; c) Examining the individual sites *Abies* and *Alnus* at one time were Dominant pollen (cover value "3"); some others became Main pollen at least one time (*Betula*, *Carpinus*, *Corylus*, *Pinus*, *Quercus*, *Salix* and *Tilia*); d) Minor pollen represented 52.3 % of the Boreal Flora and altogether accounted for 3.1 % of the mean spectrum of the phase.

Boreal pollen landscape

The first thing that can be noted in the landscape of the Boreal is the scarcity of AP pollen. The mean percentage was 53% and the mean AP cover was "3" (from "4" to "1d" in the individual sites). About 11% of AP belonged to shrubs. This scarcity of AP pollen can be partially explained by the lower broadleaf mixed wood pollen production compared to pine forest. In the recent pollen rain in the Panfilia Forest (Accorsi *et al.*, 1985), one of the few forest remnants in the plain, AP values ranged from 45 % to 60% under the canopy. The global set of Boreal data suggested that the landscape was a patchwork of woody and open areas. The latter were probably either natural, mainly related to river environments, or anthropic. There is more botanical evidence to testify man's presence in the Boreal than in the Preboreal (Accorsi *et al.*, 1992a). This evidence comes from pollen (records of the *Hordeum* group, which suggested farming), firewood and seeds/fruits collected for food. So man could have had a significant role in clearing the forest.

Passing from the Preboreal to the Boreal landscape the relationship between conifer and deciduous broadleaf tree/shrub pollen was inverted. Deciduous broadleaf trees/shrubs prevailed (65%) over conifers (32%), their ratio being around 2:1. Hygrophilous trees totaled ca 21% and Mediterranean evergreens were absent.

Boreal forest mostly consisted of mixed broadleaf wood, in which *Quercus* had a major role, followed by *Corylus*, *Betula*, *Tilia* and then *Carpinus*, *Ulmus*, several shrubs, occasionally *Ostrya*, and hygrophilous woods with *Alnus* and *Salix*. Pines were clearly withdrawing from the plain. *Pinus* in fact drastically evenly declined (the mean percentage fall from 80% to 19% and the cover values of the individual sites mostly from 4-5 to 1-2). On the contrary *Abies* rose (from 5% to 11%) even if the rise concerned only one site (Cava S. Antonio-Modena, 84 m a.s.l.) and in the other sites it was unchanged or absent. In that period *Abies* was spreading in the Tuscan-Emilian Apennines and in some places it may have crept towards the plain, from where its pollen could arrive in large quantities at the Cava S. Antonio, possibly helped by an open environment (Bertolani Marchetti & Lolli, 1983). In this landscape *Fagus* was a Minor and Less Frequent pollen. Its record in the pollen rain of the plain testified it was still scattered at higher altitude.

The spreading of deciduous broadleaf forest followed the increase in temperature in environments where the amount of rain and water in the ground was sufficient.

ATLANTIC (8,000-4,700 BP)

Atlantic pollen rain

The pollen spectra attributed to the Atlantic came from 7 sites: 5 in the area of Modena, 1 Parma and 1 Bologna. Altogether there were 15 pollen spectra.

The pollen flora in the Atlantic was practically as various as it was in the Boreal: 22 pollen types were recorded in this phase, 11 per site on average. The pollen type list

slightly changed. Tree pollen types increased (15 Taxa = 68 %), with the appearance of *Fraxinus* and *Populus*, whereas shrubs decreased (7 Taxa = 32 %) and slightly changed too. The ratio of trees/shrubs increased to 2.1:1.

The Characteristic forest pollen combination (= CFPC) of the Atlantic consisted of 11 taxa (9 trees + 2 shrubs) as in the Boreal. There were 6 Widespread pollen taxa which were already widespread in the Boreal: *Abies, Alnus, Corylus, Pinus, Quercus, Tilia* (in alphabetical order); among them *Abies* and *Pinus* were Ubiquitous. All the other CFPC taxa (*Betula, Carpinus, Picea, Ulmus*) were Quite frequent. The pollen outside the CFPC were mainly Less frequent or Infrequent.

Also in the Atlantic the 11 CFPC-pollen types were generally most abundant besides most frequent. One exception was *Fagus:* higher but less frequent than *Juniperus* (included in the CFPC).

The CFPC in the Atlantic was similar to the Boreal: the number of taxa was quasi equal, the similarity index was quite high (Boreal/Atlantic Sörensen index = 81%), the Leading group (*Abies, Alnus, Corylus, Pinus, Quercus, Tilia*) was the same, apart from the lack of *Betula*, with almost the same values (cover values: 2, 1d, 1c; mean percentage: 9% - 21 %). The same four pollen types: *Pinus, Abies, Alnus, Quercus* (13-21%) obtained the status of Main pollen. Among the other CFPC taxa there were 3 types of Secondary pollen (*Betula, Carpinus, Ulmus*) and 2 Companion pollen types (*Juniperus, Picea*). Also *Fagus* and *Salix* (outside CFPC) were Companion pollen. All the remaining pollen outside the CFPC was Minor, Frequent (eg. *Castanea, Populus*) or Infrequent.

In brief, the main characteristics of the Atlantic pollen rain were: a) a considerable similarity with the Boreal: the number of pollen types, the Leading and Main group composition were almost the same. Also the values of Leading and Secondary pollen remained almost unchanged (the ratios between Atlantic and Boreal values were around 1:1 <1.2:1 - 0.9:1>) for most of them (*Alnus, Carpinus, Corylus, Pinus, Quercus, Tilia, Ulmus*), only *Abies* increased a little, and *Betula* decreased slightly; b) in the individual sites only *Abies* obtained the status of Dominant pollen (cover value "4" in 1 site), but all the other Leading and Secondary taxa (except for *Carpinus*) were Main pollen at least one time; c) Minor pollen represented 41 % of the Atlantic pollen flora and altogether accounted for 2.2 % of the mean spectrum on the phase, the lowest observed.

Despite their similarity, there were some differences between the Atlantic and the Boreal: a) *Betula, Salix* were more spread in the Boreal and *Abies, Picea, Fagus, Castanea* in the Atlantic. Note the latter became both a little more frequent and a little more abundant; b) Oak wood was characterized by slightly more *Ostrya* in the Boreal, whereas in the Atlantic the *Tilia/Carpinus/Ulmus/Fraxinus* group was more spread.

Atlantic pollen landscape

The forest landscape of the Atlantic was quite similar to the Boreal. Deciduous broadleaf trees/shrubs continued to prevail (54%) over conifers (43%); Oak wood again totaled around 25%; Mediterranean evergreens were absent. Nevertheless some differences with the Boreal were: a) the AP sum was significantly lower. In fact, even if the AP sum of the individual sites had the same range of values in the Atlantic as in the Boreal (AP sum cover from "1d" to "4") the mean percentage was 40% versus 53% in the Boreal; b) the ratio of deciduous broadleaf woods to conifers decreased from 2:1 in the Boreal to 1.3: 1. All conifers in fact increased: *Pinus* a little, *Picea* and *Juniperus* more (from cover + or r and Presence class II to cover 1a and Presence class III) but above all *Abies* (from 11% to 19%) keeping the same heterogeneous distribution. *Abies* was

recorded in most sites with significant but moderate values (cover = 1c, 1d) and in one site as Dominant pollen (cover = 4: again at the Cava S. Antonio-MO-90 m a.s.l.); c) hygrophilous trees decreased a little to 15.7%.

Man seems to have been involved in clearing the Atlantic forest. Botanical evidence of human activity increased in the Atlantic: e.g. clearer cereal records consisting of *Hordeum*-group pollen, *Avena-Triticum* group pollen, *Hordeum* caryopses and more abundant anthropogenic weed pollen (Accorsi *et al.*, 1992a). Forest clearance, natural or anthropic, probably enlarged the pollen catchment area, magnifying the representation of conifers (namely *Abies*) in the pollen rain.

Therefore, the vegetal landscape of the plain in the Atlantic was probably shaped by deciduous mesophilous mixed wood, where *Quercus* and *Tilia* shared the leadership followed by *Carpinus*, *Ulmus*, some *Ostrya*, *Fraxinus*; hygrophilous wood with *Alnus* and *Salix* and open areas where man's activity including farming became more evident in the pollen rain. The major role of *Abies* probably reflected its spread in the mountains (Chiarugi, 1950; Bertolani Marchetti *et al.*, 1994).

The Atlantic is known to be the "Optimum Climaticum" of the Holocene (Bertolani Marchetti, 1982; Pinna, 1984). Forest pollen rain in the Emilia Romagna plain appeared to reflect this. Nevertheless human influence began to make it difficult to disentangle climatic from anthropic effects on vegetation. The forest spectra of the Atlantic were anyway the most monotonous (the mean Sörensen index of the sites was around 75%, the highest value observed); the Atlantic forest vegetation in the area seems to have been the most stable of the five phases of the Holocene.

SUBBOREAL (4,700-2,700 BP)

Subboreal pollen rain

The pollen spectra assigned to the Subboreal come from 14 sites: 7 in the area of Modena, 2 Bologna, 2 Forlì, 1 Parma, 1 Ravenna, 1 Reggio Emilia. Altogether there were 30 pollen spectra.

Subboreal pollen flora was more various: there were on average 12 taxa per site. Altogheter 31 taxa, 50% higher than in the Boreal and in the Atlantic, were recorded. Both trees and shrubs increased, mainly the latter (18 trees = 58%, 13 shrubs = 42%). Trees included almost all pollen types from the Preboreal onwards (only *Laurus* and *Ilex* were missing) plus some new pollen: *Acer*, *Juglans*, *Quercus ilex*. There was a higher turnover of shrubs and lianes: *Daphne*, *Hippophae*, *Sorbus*, *Vaccinium*, had disappeared and *Buxus*, *Hedera*, *Humulus*, *Olea*, *Phillyrea*, *Vitis* had appeared. The ratio of trees/shrubs decreased to 1.8: 1, a ratio similar to the Boreal.

The Characteristic forest pollen combination (=CFPC) of the Subboreal consisted of 12 taxa, all trees except *Corylus*. There was less similarity between the Subboreal and the Atlantic compared to the Atlantic and the Boreal (the Subboreal/Atlantic Sörensen index was 78% versus 81% of Atlantic/Boreal). The Widespread taxa were 7: *Abies*, *Alnus*, *Carpinus*, *Corylus*, *Pinus*, *Quercus*, *Ulmus* (in alphabetical order). None of them was Ubiquitous. Among the other 5 CFPC-taxa three were Quite Frequent (*Tilia*, *Salix*, *Castanea*) and two Less Frequent (*Fagus* and *Betula*). It can be noted that *Fagus* and *Castanea* entered the CFPC for the first time. The 19 taxa outside the CFPC were Less Frequent or Infrequent.

In the Subboreal the 12 CFPC-taxa were most abundant besides most frequent without exception. The most abundant taxa and their ratio were similar to the Boreal and Atlantic. The Leading group included 6 pollen types: the usual 5 observed in the Boreal-Atlantic: *Abies, Alnus, Corylus, Pinus, Quercus*, plus *Ulmus*. The latter took the place that *Tilia* had in the Atlantic, and became a Leading pollen for the first and only time in the Holocene. The values of the Leading taxa were similar to the Boreal and Atlantic (cover values 1d, 1c; mean percentage: 7% - 19%); moreover the same 4 (*Alnus, Pinus, Quercus, Abies*) obtained the status of Main pollen (15-19%). Two out of the other six CFPC-taxa were Secondary pollen (*Carpinus* and *Tilia*) and four were Companion pollen (*Fagus, Betula, Castanea, Salix*), more or less frequent. All the remaining 19 taxa outside the CFPC-taxa were Minor pollen except for *Acer* and *Juniperus* only a little higher (1.1%). Among them the record of *Juglans, Vitis* and of some Mediterranean evergreens (*Olea, Phillyrea, Quercus ilex*) can be noted, all being Minor/Infrequent pollen except *Juglans* which was a little more frequent.

In brief the main characteristics of the Subboreal pollen rain were: a) there was a leadership of a group of taxa as in the Boreal and Atlantic; b) the Leading taxa were six. Four of them were Main pollen, the same as in the Boreal and Atlantic: *Alnus, Pinus, Quercus, Abies*; their decreasing order shows *Pinus* was no more head pollen for the first time; c) most Leading/Secondary taxa decreased: *Tilia, Betula* to a higher degree (ratio Subboreal/Atlantic ca 0.4: 1), many others to a lesser degree (ratio ca 0.8-0.9: 1). Only four taxa increased: *Castanea, Ulmus, Alnus, Quercus* (ratio Subboreal/Atlantic ca 2.8-1.2: 1); d) in the individual sites the status of Dominant pollen was obtained only once by *Alnus* (cover value "4"), the other Leading and Secondary taxa became Main pollen at least once with the exception of *Fraxinus, Picea, Juglans, Ostrya, Populus*; e) Minor pollen represented 55% of the flora and altogether accounted for 5.9% of the mean percentage spectrum of the phase.

Subboreal pollen landscape

The main features of the landscape in the Subboreal were similar to the Boreal and/or Atlantic. The consistence of forest was almost the same as in the Atlantic (AP sum = 43% versus 40 %) and deciduous broadleaf trees (65%) still dominated conifers (35%), their ratio being 1.8:1, a middle value between the Boreal and Atlantic. Nevertheless a number of peculiarities can be observed: a) the major role of *Ulmus* in mixed Oak wood where it became second pollen to *Quercus*, taking the place that *Tilia* had in the Atlantic and Boreal; b) the appearance of the Mediterranean evergreens (*Quercus ilex, Olea, Phillyrea*); c) the decrease of large forested areas: the sites with a high AP sum (cover "4" = 60%-80%) were 19%, versus 43% in the Atlantic and 50% in the Boreal; d) the increase of *Castanea, Juglans, Vitis* which are today largely cultivated in the Emilia Romagna region and *Olea*, grown here and there. It is difficult to say whether if it was a long distance transport, which could have been likely for *Castanea* and *Olea* but not for *Vitis* and *Juglans*, or a climatically induced increase in wild plants growing in the pollen catchment area or if these wild plants had been looked after by man to pick walnuts, grapes, in the hills chestnuts and even olives climate permitting. The latter hypothesis matches the general increase in records suggesting human activity in the Subboreal: pollen (*Hordeum* group, *Avena-Triticum* group, weeds) and fruits/seeds (Cereal caryopses e.g. *Triticum, Hordeum, Secale*, Legumes e.g. *Vicia faba* L., *Pisum sativum* L.; some plants for salad etc.) (Accorsi *et al.*, 1992a; Bandini Mazzanti *et al.* in litteris).

Therefore the vegetal landscape of the plain in the Subboreal was possibly a patchwork of closed forest remnant, park-like areas and more open sites. The forest

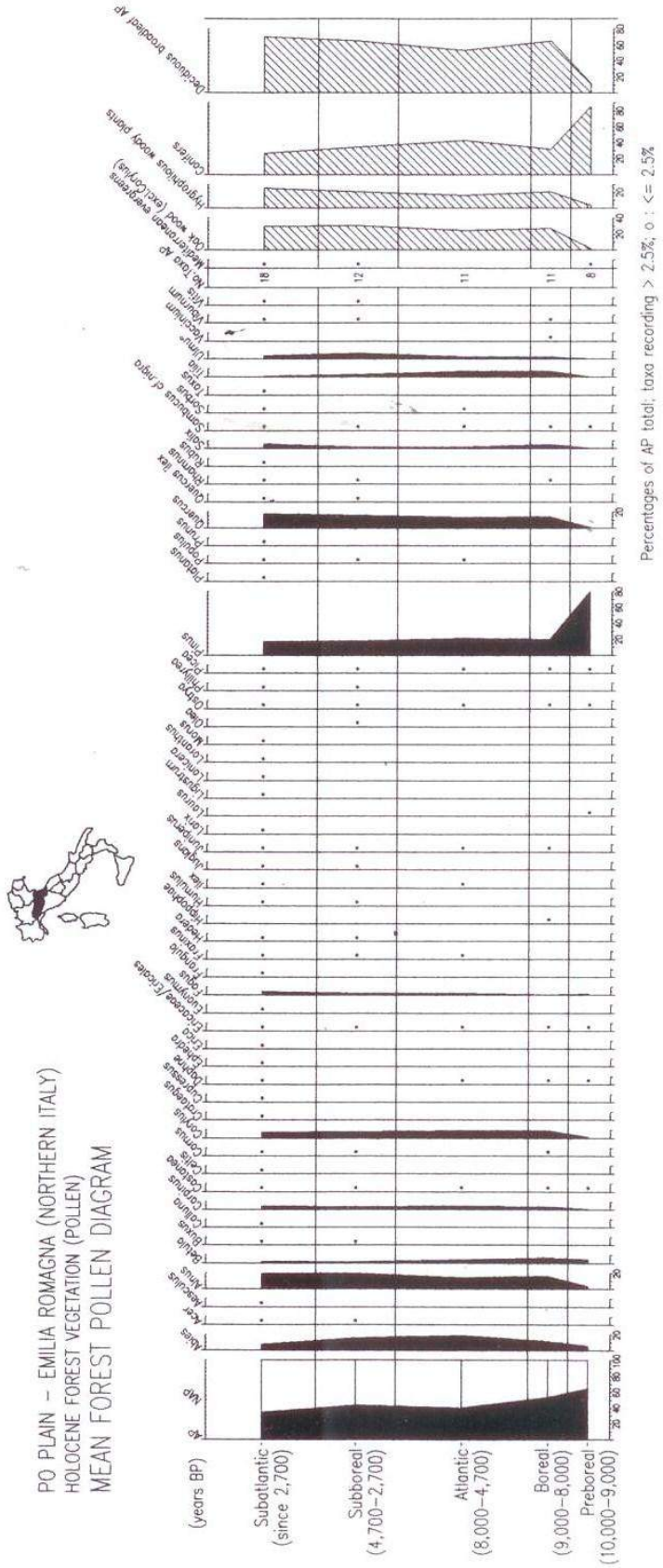

Fig. 3: Holocene mean forest pollen diagram of the Emilia Romagna plain. Methods to obtain percentages are described in the text. Pollen spectra are plotted at the middle of the relevant phase.

continued to be mainly shaped by deciduous mesophilous mixed wood, where *Ulmus* instead of *Tilia* rivaled the leadership of *Quercus*, followed by *Carpinus*, *Fraxinus* and for the first time by *Acer*; and hygrophilous river wood with *Alnus* and *Salix*. On the mountain the relationship between *Abies* and *Fagus* did not change (*Abies/Fagus* ratio = 9:1). The presence of Mediterranean evergreens either indicated small scattered stands of refuge in the area or marked their immigration routes to the Po plain. Man's activity became more evident by the forest pollen rain, confirming what was already shown by herbaceous pollen and other botanical remains. Forest clearance was possibly involved in enlarging the pollen catchment area and magnifying the representation of plants living in higher vegetation belts such as *Abies*, *Fagus* and also pines which must have finally withdrawn from the plain.

Compared to the Atlantic the spectra of the individual Subboreal sites are less monotonous; the mean Sörensen index of the sites was around 70%, whereas in the Atlantic it was 75%; also the cover values of the taxa were more heterogeneous. The forest pollen spectra suggested that climatic and environmental conditions were more variable than in the Atlantic. A warmer and dryer oscillation could have been responsible for the appearance of the Mediterranean evergreens in the pollen rain.

SUBATLANTIC (since 2,700 BP)

Subatlantic pollen rain

The pollen spectra assigned to the Subatlantic came from 20 sites: 8 in the area of Modena, 4 Ravenna, 3 Bologna, 3 Reggio Emilia, 1 Ferrara, 1 Parma. Altogether there were 78 pollen spectra.

The Subatlantic pollen flora was the most various in the Holocene: 51 pollen types were recorded, 18 per site, which were the highest observed. It was also less monotonous than the two previous phases (the mean Sörensen Index was around 60% versus 70% in the Subboreal and 75% in the Atlantic). The number of trees increased (25 trees = 49%) and so did the number of shrubs (26 shrubs = 51%) which exceeded trees for the first time. Trees included almost all the pollen types recorded before (only the rare *Laurus* and *Olea* were missing) and several new pollen e.g. *Aesculus*, *Celtis*, *Cupressus*, *Larix*, *Morus*, *Platanus*, *Taxus* etc. It was the same with shrubs: only the rare *Hippophae* and *Vaccinium* were absent and new pollen such as *Euonymus*, *Ligustrum*, *Crataegus* etc. appeared.

Also the Characteristic forest pollen combination (= CFPC) of the Subatlantic was the most various in the Holocene, consisting of 18 taxa (16 trees + 2 shrubs). It included all the CFPC-pollen in the former phases, with the only exception of *Cornus*.

The CFPC of the Subatlantic is more similar to the Subboreal (Subatlantic/Subboreal Sörensen Index = 80%), than to the Atlantic and Boreal (Subatlantic/Atlantic index = 75%; Subatlantic/Boreal = 69%). Nevertheless it is the most peculiar of the Holocene. The Widespread pollen types were 12, more than in the previous phases which had 5-8 Widespread pollen, and included: *Abies*, *Alnus*, *Betula*, *Carpinus*, *Castanea*, *Corylus*, *Fagus*, *Fraxinus*, *Pinus*, *Quercus*, *Salix*, *Ulmus*. *Alnus* and *Pinus* were Ubiquitous. Among the other CFPC-taxa *Juniperus*, *Picea*, *Juglans* were Quite frequent, recorded in 50% of sites. The remaining pollen both in the CFPC and outside the CFPC were Less Frequent or Infrequent. Note *Juglans*, *Platanus*, *Prunus* and *Vitis* recorded in 45-30-40-35 % of sites respectively.

In the Subatlantic the CFPC-taxa were most abundant besides most frequent with little exception: *Populus*, the last CFPC taxon, was lower or equal to *Quercus ilex*, *Platanus* and *Larix*, taxa ouside the CFPC. The most important taxa and their ratio changed a little

compared with the Subboreal. The Leading group included 6 taxa, the usual group of five which had been leading the pollen assemblages since the Boreal (*Abies, Alnus, Corylus, Pinus, Quercus*) plus *Salix*, which was a Leading pollen for the first time. The Leading taxa had similar values to the previous phases (from 5% to 19%; cover values 1d, 1c), but among them only 3 taxa (*Alnus, Quercus, Pinus*) obtained Main pollen status (17-19%), *Abies* dropped out of the group. Moreover there is a higher number of Secondary/Companion pollen in the CFPC: 3 Secondary taxa (*Fagus, Ulmus* and *Carpinus*) and four Companion taxa (*Betula, Fraxinus, Castanea, Picea*), more or less frequent. The remaining 5 CFPC taxa (*Juniperus, Juglans, Tilia, Ostrya, Populus*) and all the 33 taxa outside the CFPC were Minor pollen. Among the minor pollen the record of some Mediterranean evergreens: *Olea, Phillyrea, Quercus ilex*, can be noted.

In brief the main characteristics of the Subatlantic pollen rain were: a) there was the usual leadership of a group of taxa ; b) the Leading taxa were 6, 5 being common to the previous phases (*Alnus, Pinus, Quercus, Corylus, Abies*) and one new, *Salix*; c) only three (*Alnus, Pinus, Quercus*) were Main pollen, *Abies* losing this status; d) the importance of the Leading and Main pollen was slightly decreasing; their sums fell below 80% (74%), and 60% (54%) respectively. These values were always exceeded in the previous phases; e) pollen rain consisted of a higher number of taxa though the Widespread taxa represented a lower percentage of the flora (23% in Subatlantic versus 27- 34% in the other phases); f) half of the Leading and Secondary taxa decreased (*Pinus, Corylus; Abies* and *Ulmus* by up to 50 %) compared with the Subboreal and the other half increased (*Alnus, Quercus; Salix* and *Fagus* were more than double); g) in the individual sites the status of Dominant pollen was obtained only by *Alnus* and *Abies* (cover value "3"), but all the other Leading and Secondary taxa (except for *Ulmus*), became Main pollen at least in one site; h) Minor pollen represented 74.5 % of the Subtlantic Flora and altogether accounted for 8.7 % of the mean spectrum of the phase.

Subatlantic pollen landscape

The landscape of the Subatlantic maintained the same main features of the Subboreal, but underwent a number of significant changes. Some of them appeared more natural than anthropic, induced by climatic/ecological or biological factors: the increase of broadleaf tree dominance (70%) over conifers (27%), their ratio being 2.6: 1; the decrease of *Ulmus* in mixed Oak wood where, with *Carpinus*, it was sharing the status of second pollen to *Quercus* (Figg. 5, 6) and the increase of *Fagus* which doubled and became as widespread as *Abies* for the first time (both recorded in 80% of sites); the *Abies/Fagus* ratio changing (2:1 versus 9:1 in the Atlantic and Boreal) in the plain reflected the spreading of *Fagus* at the expense of *Abies* on the mountains (Chiarugi, 1950; Bertolani *et al.*, 1994; Watson *et al.*, 1994).

Man, on the contrary, appeared to be the responsible for other evident changes which followed a trend from the Preboreal onwards: 1) the consistence of forest decreased significantly: the mean AP sum was 34% versus 43; 40; 54; 64 % going back to the Preboreal, and the sites with a high AP sum (cover "4"/"5" = 60%-100%) decreased to 5% versus 19, 43, 50, 83% going back to the Preboreal; 2) shrubs increased both in number of taxa: 26 versus 13; 7; 10; 4 and in percentage of the flora: 51% versus 42; 32; 43; 22% going back to the Preboreal; 3) the total percentage of trees/ shrubs currently cultivated in the region, for fruits or as ornamental plants, increased to 4.1 versus 3.1; 0.5; 0.8; 0.1 going back to the Preboreal. The relevant taxa were: *Aesculus, Buxus, Castanea, Cupressus, Juglans, Morus, Olea, Prunus, Sorbus, Vitis*.

Therefore the vegetal landscape of the plain in the Subatlantic continued to be a patchwork of park-like and open areas, with shrinking forest remnants. The forest continued to be mainly shaped by deciduous mesophilous mixed wood, consistintig mainly of *Quercus*, followed by *Ulmus* and *Carpinus, Fraxinus, Acer* and a number of shrubs and lianes such as *Corylus, Viburnum, Rhamnus, Humulus, Lonicera* etc. Hygrophilous wood with *Alnus* and *Salix* occupied larger areas. Small stands of Mediterranean evergreens continued to be scattered in the area. Man's activity became more evident in the Subatlantic forest pollen rain than it was in the Subboreal, confirming the evidence shown by the herbaceous pollen, seeds/fruits and wood remains testifying or suggesting a higher relationship between plants and man than in the Subboreal (gathering for food, firewood, drugs; farming, use of plants as ornaments; careful choice of wood for artifacts etc. - Accorsi *et al.*, 1992a; Bandini Mazzanti *et al., in litteris*).

In the Subatlantic it is very difficult to disentangle natural from anthropic changes in vegetation. The spread of *Fagus* and the decrease of *Abies*, an event which occurred on the Apennines and the increase of *Salix* and *Fraxinus* on the plain could be indicators of a change in climate which became wetter and cooler on the whole.

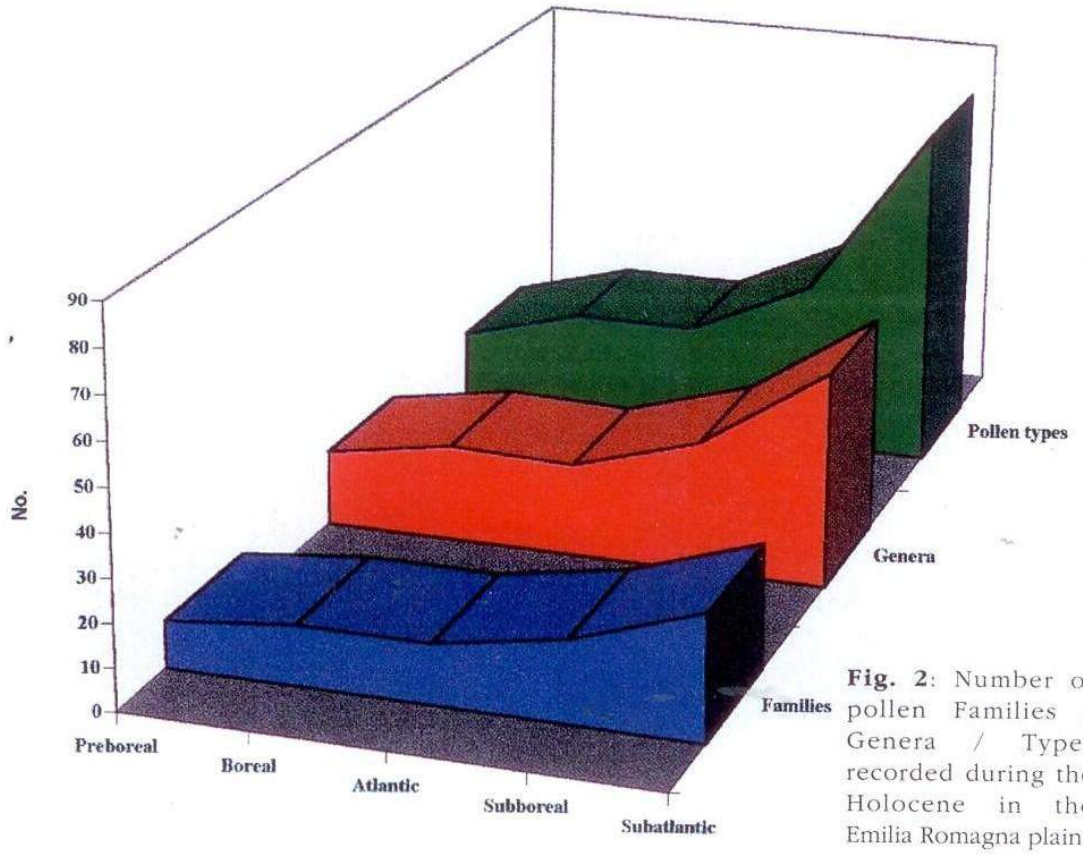

Fig. 2: Number of pollen Families / Genera / Types recorded during the Holocene in the Emilia Romagna plain.

4. CONCLUSIONS

The final picture of the set of mean data looked reliable. There were some weak points (e.g. some difference in pollen analysis methods; the scarcity of ^{14}C datings) but these faded in the framework of pollen spectra which had been produced for various

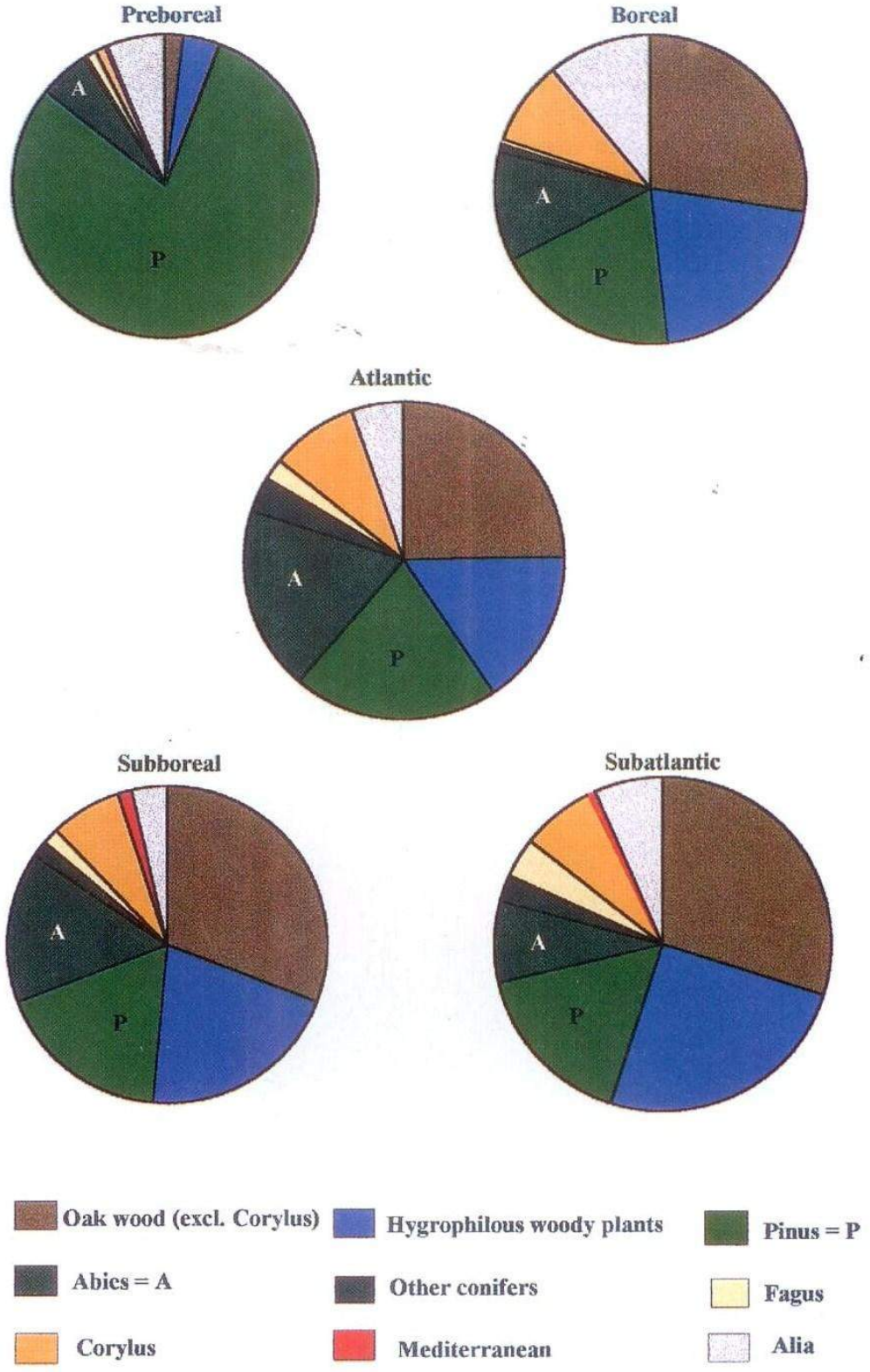

Fig. 4: Synthetic mean forest pollen spectra of the Holocene phases in the Emilia Romagna plain.

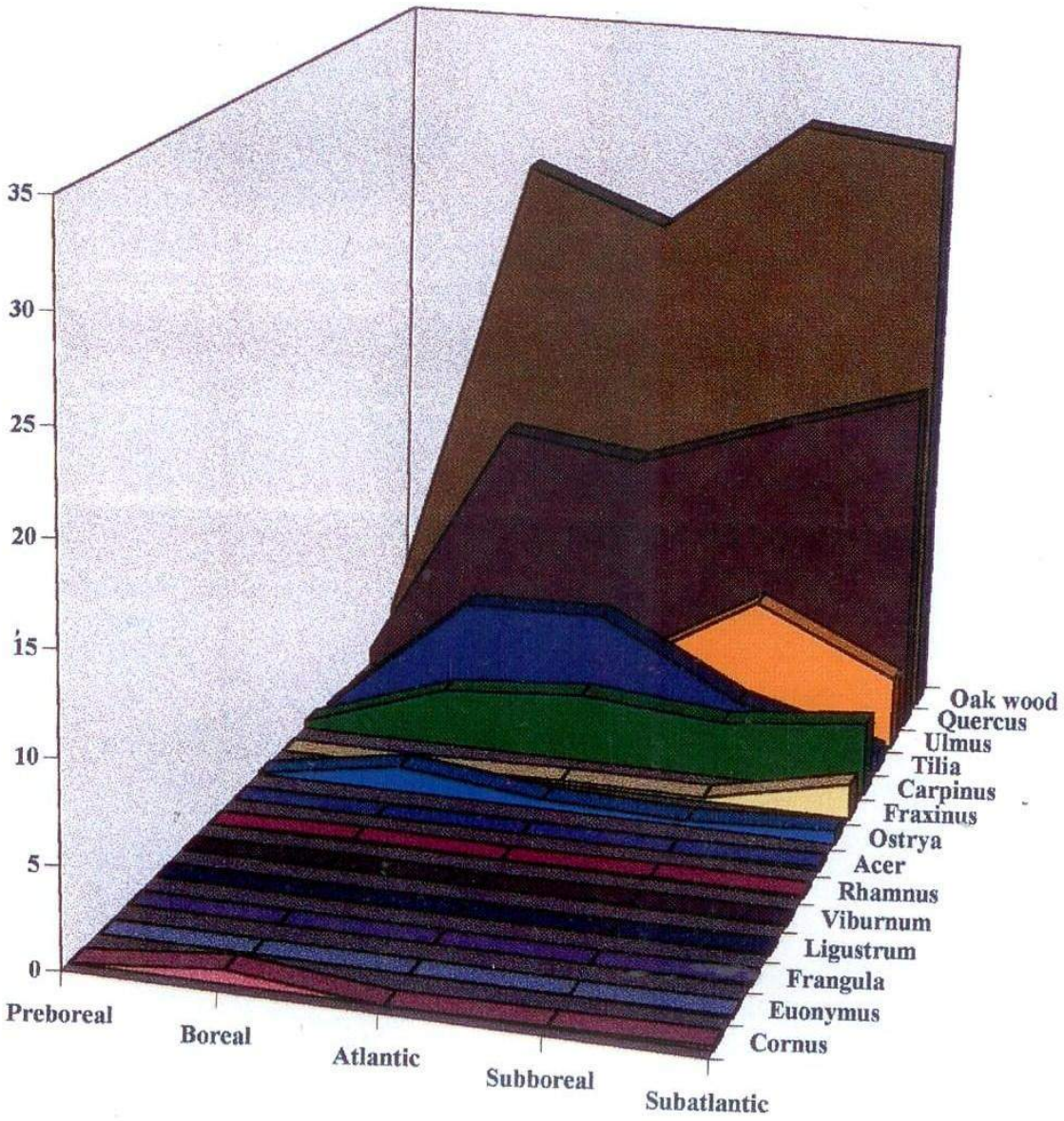

Fig. 5: Mean pollen Oak wood composition during the Holocene in the Emilia Romagna plain.

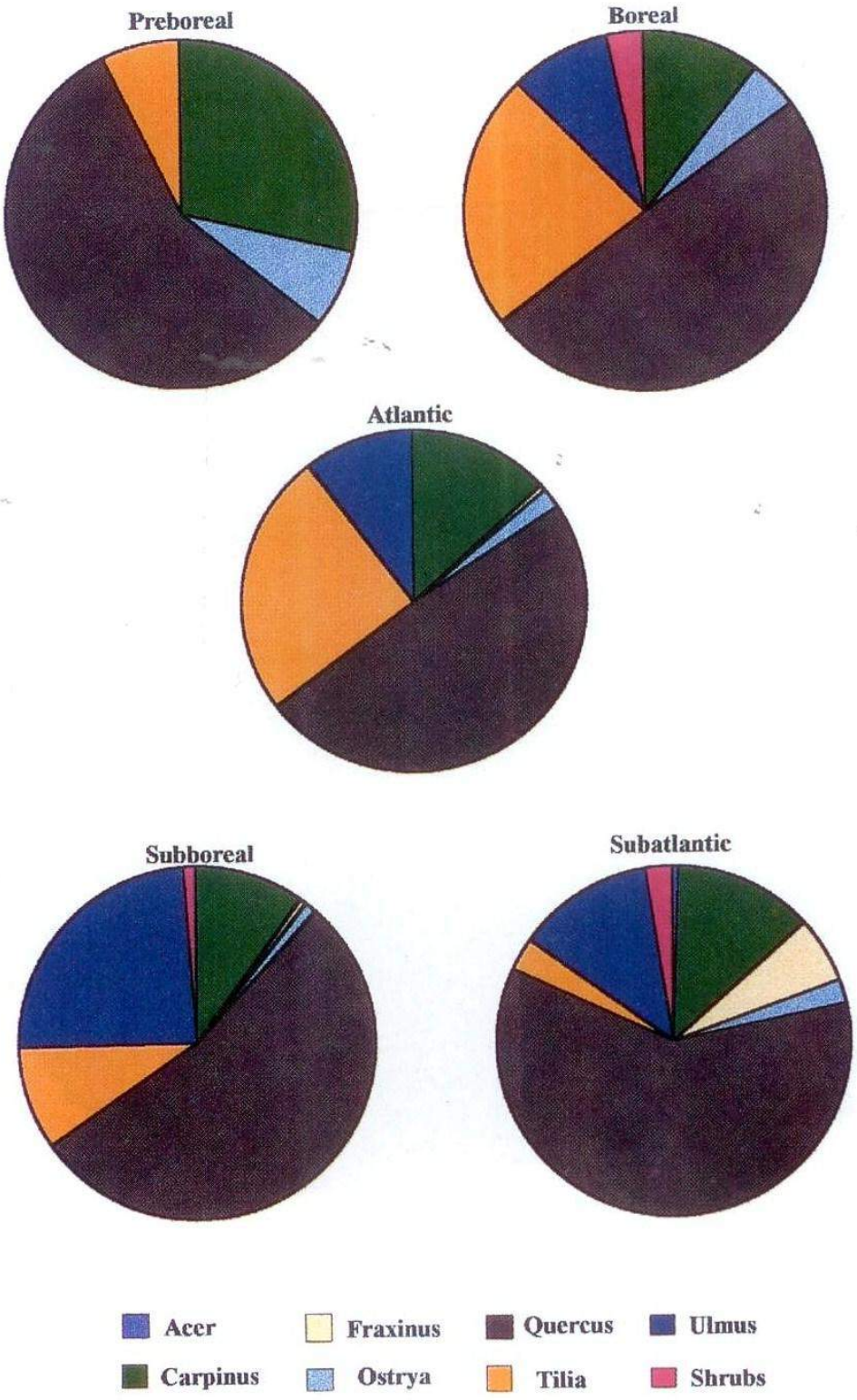

Fig 6: Mean pollen Oak wood composition of the Holocene phases in the Emilia Romagna plain. (Oak wood pollen = 100%)

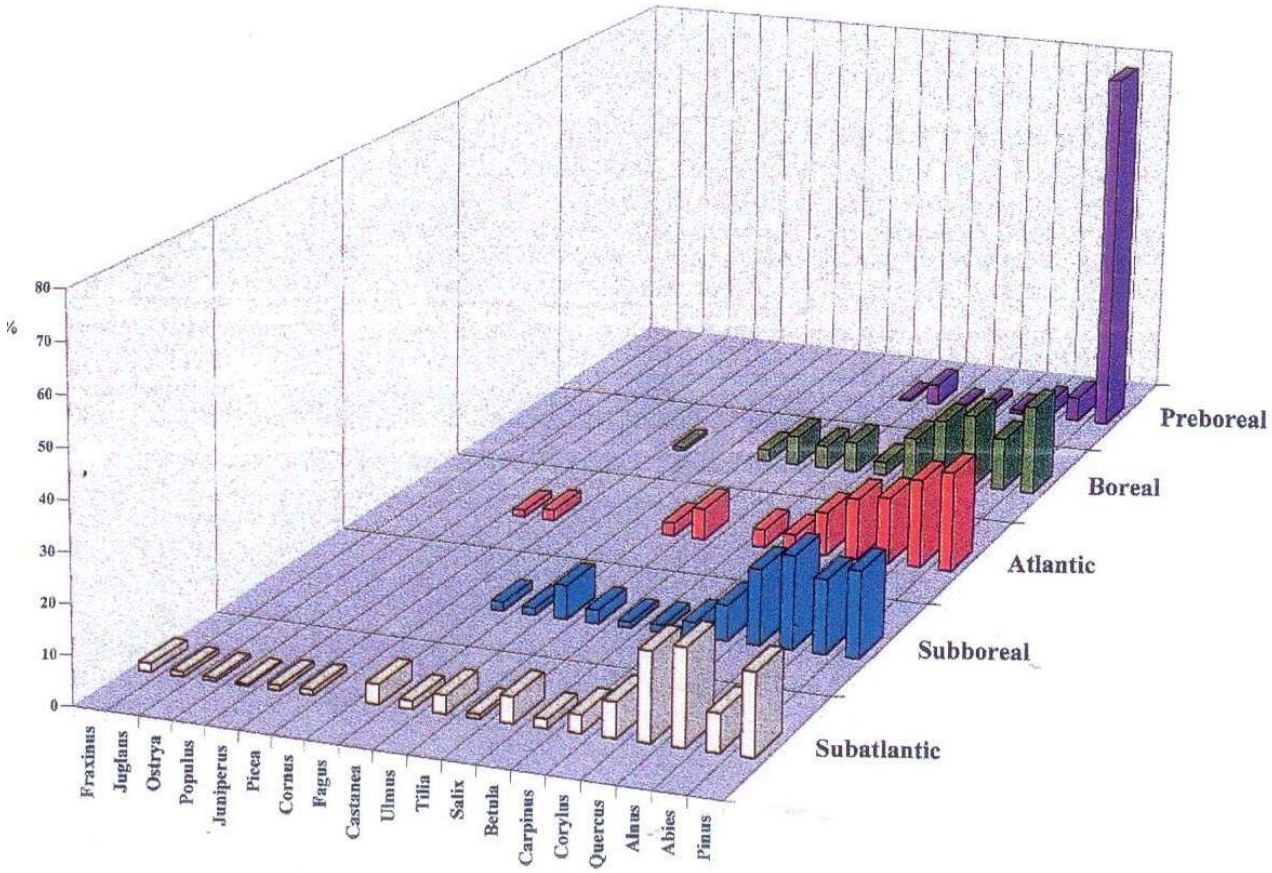

Fig. 7: Holocene forest pollen vegetation: Characteristic Forest Pollen Combination (CFPC) of the five Holocene phases.

goals and concerned therefore quite randomly sampled environments, natural or anthropic, wet or dry, woody or open.

According to AP pollen data the forest of the Emilia Romagna plain in the Holocene was less consistent than we had expected (AP sum from Preboreal to Subatlantic= 80, 64, 40, 43, 34%) suggesting, expecially from the Boreal onwards, a human influence on the vegetal landscape. Forest pollen spectra suggested man cleared the forest and then, from the Subboreal, first looked after wild local plants such as *Juglans* and *Vitis*, to collect fruits, and later grew them and other trees/shrubs (*Platanus, Prunus, Morus* etc.). Both climate and Subboreal/Subatlantic man seem responsible for the increase in the number of taxa in the pollen rain (from the Preboreal onwards the number of taxa in the Characteristic forest pollen combination rose: 8; 11; 11; 12; 18), and the weakening leadership of the Main taxa (80; 69; 66; 67; 54% of the flora in the various phases). Maybe man was the most responsible for the increase in Minor pollen (which represented 67; 52; 41; 55; 74.5% of the flora and accounted for 3; 3; 2; 6; 9 % of the mean spectra from the Preboreal onwards).

In the Preboreal the landscape was a pine kingdom with some fir, but deciduous broadleaf trees were always in the plain, possibly more spread than the pollen rain showed, concealed by the large pollen production of pines.

From the Boreal, eight thousand years ago, to medieval times (the most recent time involved in the data) forest composition did not change much. The forested areas mainly consisted of riverside wood with *Alnus* (*A. glutinosa, A. incana*) and *Salix*, and mesophilous mixed woods in which the leadership of *Quercus* (*Q. pedunculata*) was initially shared with *Tilia* in the Boreal and Atlantic, then with *Ulmus*, and more recently with *Ulmus* and *Carpinus* (Subatlantic) when also *Acer* appeared. In the meantime pines, and also *Abies*, withdrew from the plain; from the Subboreal some Mediterranean evergreens appeared in the pollen rain (*Quercus ilex, Olea, Phillyrea*).

From forest pollen spectra the Atlantic vegetation appeared to have been the most stable in the Holocene; pollen spectra of the individual sites were more similar to each other than in the other phases, as Sörensen indexes showed: 70%; 67%; 75%; 71%; 61% from the Preboreal onwards. The most variable phase appeared to be the last, the Subatlantic.

Some palinologists indicated that current vegetal associations could have been the main parent coenoses of some pollen assemblages recorded from the Boreal onwards. In particular the *Querceto-Carpinetum boeritalicum* (Pignatti 1952-53) was indicated as the palaeoclimax of the Po plain from the Boreo-Atlantic by Bertolani Marchetti (1969/70). They were ambitious suggestions, as pollen is not identified at the species level, even if they could be exact, especially for the Subboreal/Subatlantic. So it could be more warily inferred by the pollen data that the vegetation of the Emilia Romagna plain has belonged to the medioeuropean vegetation belt as definited by Pignatti (1979) since the Boreal.

To conclude we would like to point out that collecting pollen values was busy work, for numeric values were rarely available and it was often very difficult to get pollen percentages from pollen diagrams. The habit of phytosociologists, who anyway publish their big sheets of data should be picked-up. When facing synthesis work everyone appreciates the availability of numerical pollen spectra, which can be easily rearranged and reinterpreted.

PO PLAIN - EMILIA ROMAGNA (NORTHERN ITALY)						
HOLOCENE FOREST VEGETATION (POLLEN)						
List of sites						
No.	Province	Town	Site name	Abbreviation name	Holocene Phases	References
1	Bologna	Bologna	Cava Due Madonne	BO4	A	1,14,20
2	Bologna	Bologna	Convento San Domenico	BO5	Sb-Sa	4,5
3	Bologna	Budrio	Budrio	BO1	Sa	3,2
4	Bologna	Castenaso	Capanna A - Castenaso	BO2	Sb	14,20,24
5	Bologna	Castenaso	Via Cà dell'Orbo	BO3	Sa	3,2
6	Ferrara	Argenta	Argenta	FE1	Sa	33
7	Forlì	Forlì	Pianta di Forlì	FO2	Sb	37
8	Forlì	Forlì	Villafranca di Forlì	FO1	Sb	32,37
9	Modena	Formigine	Cava Sant'Antonio	MO1	P-B-A-Sb-Sa	15,16,25,26
10	Modena	Formigine	Fornaci di Formigine	MO2	Sa	10,11
11	Modena	Formigine	Pozzo Formigine	MO3	P-B-A-Sb-Sa	13,15,16,35
12	Modena	Magreta	Tabina di Magreta	MO4	Sb-Sa	17,18,19,23
13	Modena	Mirandola	Arginone di Mirandola	MO5	Sa	9
14	Modena	Mirandola	Miseria Vecchia di Mirandola	MO6	Sa	8
15	Modena	Modena	Pozzo Navicello	MO8	P-B-A-Sb-Sa	17,18,19,27,28, 29,36
16	Modena	San Cesario sul Panaro	San Cesario sul Panaro	MO10	B-A-Sb	2,18,20
17	Modena	Sant'Agnese/ San Damaso	Collegio Universitario	MO7	P-B-A-Sb-Sa	12,19,20,21,22, 27,28,29
18	Modena	Spilamberto	Necropoli di Spilamberto	MO9	Sb	2,18,20
19	Parma	Parma	Case Nuove	PR1	P-B-A-Sb-Sa	30
20	Ravenna	Alfonsine	Alfonsine	RA1	Sa	37
21	Ravenna	Classe	Litorale di Classe	RA2	Sa	37
22	Ravenna	Lugo	Villa di Lugo	RA3	Sa	32,37
23	Ravenna	Ravenna	Ravenna	RA4	Sb	37
24	Ravenna	Ravenna	Ravenna-Periferia	RA5	Sa	31,32,37
25	Reggio Emilia	Poviglio	Terramara di Santa Rosa	RE2	Sb-Sa	34
26	Reggio Emilia	Reggio Emilia	San Claudio	RE1	Sa	7
27	Reggio Emilia	Rivalta	Casale di Rivalta	RE3	Sa	6
28	Reggio Emilia	Rivalta	San Rigo di Rivalta	RE4	P	13,35

Tab. I: List of sites considered. The relevant reference numbers can be traced in the reference section of the paper, at the end of the entry.

PO PLAIN - EMILIA ROMAGNA (NORTHERN ITALY)
HOLOCENE FOREST VEGETATION (POLLEN)
Sites: geographical location and main information
PREBOREAL (10,000-9,000 BP)

Province	Town	Site name	Abbreviation name	m a.s.l.	Latitude and longitude	Archaeological site	Base of chronology	No. of samples	Pollen concentration	Pollen photos	Table of pollen spectra	Pollen diagram	Other vegetal remains	Main reference
Modena	Modena	Pozzo Navicello	MO8	28	44°40' N 11°00' E	N	pollen	2	N	Y	Y	Y	N	Vecchi (1982/83)
Modena	Sant'Agnese/ San Damaso	Collegio Universitario	MO7	34	44°40' N 10° 56' E	N	pollen; stratigraphy	2	N	N	Y	Y	N	Bertolani Marchetti & Cupisti (1970)
Parma	Parma	Case Nuove	PR1	57	44°48' N 10°20' E	N	pollen	1	N	N	Y	Y	N	Dall'Olio (1987/88)
Modena	Formigine	Cava Sant'Antonio	MO1	83	44°33' N 10°51' E	N	pollen	3	N	N	Y	Y	N	Bertolani Marchetti & Lolli (1983)
Modena	Formigine	Pozzo Formigine	MO3	90	44°33' N 10°51' E	N	pollen	11	N	N	N	Y	N	Bertolani Marchetti (1980b)
Reggio Emilia	Rivalta	San Rigo di Rivalta	RE4	90	44°39' N 10°35' E	N	pollen	3	N	N	N	Y	N	Bertolani Marchetti (1980b)

Tab. II: Preboreal: Geographical location and main information concerning the sites. (Y = yes; N = no)

PO PLAIN - EMILIA ROMAGNA (NORTHERN ITALY)
HOLOCENE FOREST VEGETATION (POLLEN)
Sites: geographical location and main information
BOREAL (9,000-8,000 BP)

Province	Town	Site name	Abbreviation name	m a.s.l.	Latitude and longitude	Archaeological site	Base of chronology	No. of samples	Pollen concentration	Pollen photos	Table of pollen spectra	Pollen diagram	Other vegetal remains	Main reference
Modena	Modena	Pozzo Navicello	MO8	28	44°40' N 11°00' E	N	pollen	4	N	Y	Y	Y	N	Vecchi (1982/83)
Modena	Sant'Agnese/ San Damaso	Collegio Universitario	MO7	34	44°40' N 10° 56' E	N	pollen; stratigraphy	1	N	N	Y	Y	N	Bertolani Marchetti & Cupisti (1970)
Modena	San Cesario sul Panaro	San Cesario sul Panaro	MO10	54	44°31' N 11°02' E	Y	archaeology; pollen	2	Y	Y	Y	Y	N	Accorsi et al. (1981)
Parma	Parma	Case Nuove	PR1	57	44°48' N 10°20' E	N	pollen	1	N	N	Y	Y	N	Dall'Olio (1987/88)
Modena	Formigine	Cava Sant'Antonio	MO1	83	44°33' N 10°51' E	N	pollen	1	N	N	Y	Y	N	Bertolani Marchetti & Lolli (1983)
Modena	Formigine	Pozzo Formigine	MO3	90	44°33' N 10°51' E	N	pollen	1	N	N	N	Y	N	Bertolani Marchetti (1980b)

Tab. III: Boreal: Geographical location and main information concerning the sites. (Y = yes; N = no)

PO PLAIN - EMILIA ROMAGNA (NORTHERN ITALY)
HOLOCENE FOREST VEGETATION (POLLEN)
Sites: geographical location and main information
ATLANTIC (8,000-4,700 BP)

Province	Town	Site name	Abbreviation name	m a.s.l.	Latitude and longitude	Archaeological site	Base of chronology	No. of samples	Pollen concentration	Pollen photos	Table of pollen spectra	Pollen diagram	Other vegetal remains	Main reference
Modena	Modena	**Pozzo Navicello**	MO8	28	44°40' N 11°00' E	N	pollen	2	N	Y	Y	Y	N	Vecchi (1982/83)
Modena	Sant'Agnese/ San Damaso	**Collegio Universitario**	MO7	34	44°40' N 10° 56' E	N	pollen; stratigraphy	1	N	N	Y	Y	N	Bertolani Marchetti & Cupisti (1970)
Bologna	Bologna	**Cava Due Madonne**	BO4	50	44°29' N 11°20' E	Y	^{14}C; pollen	2	Y	N	Y	Y	wood at 3.8-3.6m over 42ky old	Accorsi & Bandini (1980)
Modena	San Cesario sul Panaro	**San Cesario sul Panaro**	MO10	54	44°31' N 11°02' E	Y	^{14}C; pollen	2	Y	Y	Y	Y	N	Accorsi et al. (1981)
Parma	Parma	**Case Nuove**	PR1	57	44°48' N 10°20' E	N	pollen	3	N	N	Y	Y	N	Dall'Olio (1987/88)
Modena	Formigine	**Cava Sant'Antonio**	MO1	83	44°33' N 10°51' E	N	pollen	3	N	N	Y	Y	N	Bertolani Marchetti & Lolli (1983)
Modena	Formigine	**Pozzo Formigine**	MO3	90	44°33' N 10°51' E	N	pollen	2	N	N	N	Y	N	Bertolani Marchetti (1980b)

Tab. IV: Atlantic: Geographical location and main information concerning the sites. (Y = yes; N = no)

PO PLAIN - EMILIA ROMAGNA (NORTHERN ITALY) HOLOCENE FOREST VEGETATION (POLLEN) Sites: geographical location and main information SUBBOREAL (4,700-2,700 BP)														
Province	Town	Site name	Abbreviation name	m a.s.l.	Latitude and longitude	Archaeological site	Base of chronology	No. of samples	Pollen concentration	Pollen photos	Table of pollen spectra	Pollen diagram	Other vegetal remains	Main reference
Ravenna	Ravenna	Ravenna	RA4	4	44°25' N 12°12' E	N	pollen	1	N	N	N	N	N	Zangheri (1966)
Modena	Modena	Pozzo Navicello	MO8	28	44°40' N 11°00' E	N	pollen	4	N	Y	Y	Y	N	Vecchi (1982/83)
Reggio Emilia	Poviglio	Terramara di Santa Rosa	RE2	29	44°51' N 10°32'E	Y	archaeology; pollen	7	Y	N	N	Y	N	Ravazzi et al. (1992)
Forlì	Forlì	Pianta di Forlì	FO2	34	44°18' N 12°01' E	N	pollen	1	N	N	N	N	N	Zangheri (1966)
Forlì	Forlì	Villafranca di Forlì	FO1	34	44°18' N 12°01' E	N	pollen	1	N	N	Y	N	N	Dubois & Zangheri (1957b)
Modena	Sant'Agnese/ San Damaso	Collegio Universitario	MO7	34	44°40' N 10° 56' E	N	pollen; stratigraphy	3	N	N	Y	Y	N	Bertolani Marchetti & Cupisti (1970)
Bologna	Castenaso	Capanna A-Castenaso	BO3	41	44°30' N 11°28' E	Y	archaeology; pollen	1	N	N	Y	N	N	Bertolani Marchetti (1980c)
Modena	Spilamberto	Necropoli di Spilamberto	MO9	49	44°31' N 11°02' E	Y	^{14}C; archaeology; pollen	2	Y	Y	Y	Y	N	Accorsi et al. (1981)
Modena	San Cesario sul Panaro	San Cesario sul Panaro	MO10	54	44°31' N 11°02' E	Y	archaeology; pollen	2	Y	Y	Y	Y	N	Accorsi et al. (1981)
Parma	Parma	Case Nuove	PR1	57	44°48' N 10°20' E	N	pollen	2	N	N	Y	Y	N	Dall'Olio (1987/88)
Modena	Magreta	Tabina di Magreta	MO4	59	44°35' N 10°48' E	Y	archaeology; pollen	2	N	Y	N	Y	fruits/seeds in Bandini et al. (1988)	Bertolani Marchetti et al. (1988)
Bologna	Bologna	Convento San Domenico	BO5	69	44°29' N 11°20' E	Y	archaeology; pollen	1	Y	N	N	Y	N	Accorsi et al. (1987)
Modena	Formigine	Cava Sant'Antonio	MO1	83	44°33' N 10°51' E	N	pollen	2	N	N	Y	Y	N	Bertolani Marchetti & Lolli (1983)
Modena	Formigine	Pozzo Formigine	MO3	90	44°33' N 10°51' E	N	pollen	1	N	N	N	Y	N	Bertolani Marchetti (1980b)

Tab. V: Subboreal: Geographical location and main information concerning the sites.
(Y = yes; N = no)

PO PLAIN - EMILIA ROMAGNA (NORTHERN ITALY)														
HOLOCENE FOREST VEGETATION (POLLEN)														
Sites: geographical location and main information														
SUBATLANTIC (since 2,700 BP)														
Province	Town	Site name	Abbreviation name	m a.s.l.	Latitude and longitude	Archaeological site	Base of chronology	No. of samples	Pollen concentration	Pollen photos	Table of pollen spectra	Pollen diagram	Other vegetal remains	Main reference
Ravenna	Classe	Litorale di Classe	RA2	0	44°21' N 12° 17' E	N	pollen	1	N	N	N	N	N	Zangheri (1966)
Ferrara	Argenta	Argenta	FE2	4	44°37' N 11° 50' E	N	pollen	1	Y	N	Y	N	N	Forlani (1994)
Ravenna	Ravenna	Ravenna-Periferia	RA5	4	44°25' N 12°12' E	N	pollen	1	N	N	N	N	N	Dubois & Zangheri (1957a,b)
Ravenna	Alfonsine	Alfonsine	RA1	6	44°30' N 12°03' E	N	pollen	1	N	N	N	N	N	Zangheri (1966)
Modena	Mirandola	Arginone di Mirandola	MO5	10	44°53' N 11° 04' E	Y	archaeology; pollen	7	Y	N	Y	Y	N	Accorsi et al. (1992c)
Modena	Mirandola	Miseria Vecchia di Mirandola	MO6	10	44°53' N 11°04' E	Y	archaeology; pollen	3	Y	N	Y	N	charred/un. charred wood	Accorsi et al. (1992b)
Ravenna	Lugo	Villa di Lugo	RA3	14	44°25' N 11°54' E	N	pollen	1	N	N	N	N	N	Dubois & Zangheri (1957b)
Bologna	Budrio	Budrio	BO1	25	44°32 N 11°32' E	Y	archaeology; pollen	10	Y	Y	Y	Y	N	Accorsi et al. (1982)
Modena	Modena	Pozzo Navicello	MO8	28	44°40' N 11°00' E	N	pollen	5	N	Y	Y	Y	N	Vecchi (1982/83)
Reggio Emilia	Poviglio	Terramara di Santa Rosa	RE2	29	44°51' N 10°32' E	Y	archaeology; pollen	3	Y	N	N	Y	N	Ravazzi et al. (1992)
Modena	Sant'Agnese/ San Damaso	Collegio Universitario	MO7	34	44°40' N 10° 56' E	N	pollen; stratigraphy	3	N	N	Y	Y	N	Bertolani Marchetti & Cupisti (1970)
Bologna	Castenaso	Via Cà dell'Orbo	BO3	41	44°30' N 11°28' E	Y	archaeology; pollen	2	Y	Y	Y	Y	N	Accorsi et al. (1982)
Parma	Parma	Case Nuove	PR1	57	44°48' N 10°20' E	N	pollen	2	N	N	Y	Y	N	Dall'Olio (1987/88)
Reggio Emilia	Reggio Emilia	San Claudio	RE1	60	44°43' N 10°36' E	Y	archaeology; pollen	3	Y	N	N	Y	N	Accorsi et al. (1990d)
Bologna	Bologna	Convento San Domenico	BO5	69	44°29' N 11°20' E	Y	archaeology; pollen	10	Y	N	N	Y	N	Accorsi et al. (1987)
Modena	Magreta	Tabina di Magreta	MO4	78	44°35' N 10°48' E	Y	archaeology; pollen	3	N	Y	N	Y	fruits/seeds in Bandini et al. (1988)	Bertolani Marchetti et al. (1988)
Modena	Formigine	Cava Sant'Antonio	MO1	83	44°33' N 10°51' E	N	pollen	1	N	N	Y	Y	N	Bertolani Marchetti & Lolli (1983)
Modena	Formigine	Fornaci di Formigine	MO2	90	44°33' N 10°51' E	Y	archaeology; pollen	16	Y	N	Y	Y	N	Bertolani et al. (1992)
Modena	Formigine	Pozzo Formigine	MO3	90	44°33' N 10°51' E	N	pollen	3	N	N	N	Y	N	Bertolani Marchetti (1980b)
Reggio Emilia	Rivalta	Casale di Rivalta	RE3	90	44°25' N 10°26' E	Y	archaeology; pollen	2	Y	N	N	Y	charcoals	Accorsi et al. (1990b)

Tab. VI: Subatlantic: Geographical location and main information concerning the sites. (Y = yes; N = no)

PO PLAIN - EMILIA ROMAGNA (NORTHERN ITALY)								
HOLOCENE FOREST VEGETATION (POLLEN)								
Mean Forest Pollen Spectra								
PREBOREAL (10,000-9,000 BP)								
SITES Total = 6	POZZO NAVICELLO	COLLEGIO UNIVERSITARIO	CASE NUOVE	CAVA SANT'ANTONIO	POZZO FORMIGINE	SAN RIGO DI RIVALTA		
Abbreviation name	MO8	MO7	PR1	MO1	MO3	RE4		
m a.s.l.	28	34	57	83	90	90		
Main Reference	Vecchi (1982-83)	Bertolani Marchetti & Cupisti (1970)	Dall'Olio (1987-88)	Bertolani Marchetti & Lolli (1983)	Bertolani Marchetti (1980b)	Bertolani Marchetti (1980b)	Mean% spectrum	Mean cover spectrum
Number of samples Total = 22	2	2	1	3	11	3		
Depth (m)	21.8/21.5	12.5-15.5/11-12.5	16.05	10.1/9.5/7.5	52-42	23/22.5/22		
Trees+shrubs								
Abies	+	1b	1b	1c	1d	+	5.3	1c
Alnus		1a	(1b)		1d	1b	3.4	1b
Betula	r	1c			1d	1b	4.4	1b
Carpinus	+		1a	r			0.4	r
Castanea			r				0.1	r
Corylus	+	1a	1b	+			1.2	1a
Daphne				1a			0.3	r
Ericales					1a	+	0.4	r
Fagus					1c		1.2	1a
Laurus				r			0.1	r
Ostrya				r			0.1	r
Picea		+		+	r		0.2	r
Pinus	5	5	5	5	2	5	80	4
Quercus		r	1b	+			0.8	+
Salix			1a	r	r		0.4	r
Sambucus cf. nigra			1a				0.3	r
Tilia		r		r			0.1	r
Ulmus				r			0.1	r
Mediocratics					1c		1.2	1a
Oak wood (excl.Corylus)	+	r	1c	1b			2.0	1a
Hygrophilous woody plants		1a	1a	r	2	1b	3.8	1b
Conifers	5	5	5	5	3	5	85.5	5
Deciduous broadleaf AP	1a	1c	1d	1b	3	1b	12.3	1d
Mediterranean evergreens				r			0.1	r
AP Sum	4	4	5	5	4	1d	64	4
No.TAXA AP Total = 18	*5*	*8*	*9*	*12*	*?*	*5*	*mean = 8*	

Tab. VII: Preboreal : Mean forest pollen cover spectrum of each site and Mean spectra of the phase (Mean percentage forest pollen spectrum and Mean forest pollen cover spectrum).— Pollen cover classes : 5 = 81-100 %; 4 = 61- 80 %; 3 = 41-60 %; 2 = 21-40 %; 1d =11-20%; 1c = 5.1-10 %; 1b = 2.6 - 5 %; 1a = 1.1- 2.5 %; + = 0.5 - 1 %; r = < 0.5 %. — ( ) = Pollen sum excluding *Alnus* — "?" = not computable number of taxa.

PO PLAIN - EMILIA ROMAGNA (NORTHERN ITALY)								
HOLOCENE FOREST VEGETATION (POLLEN)								
Mean Forest Pollen Spectra								
BOREAL (9,000-8,000 BP)								
SITES Total = 6	POZZO NAVICELLO	COLLEGIO UNIVERSITARIO	SAN CESARIO SUL PANARO	CASE NUOVE	CAVA SANT'ANTONIO	POZZO FORMIGINE		
Abbreviation name	MO8	MO7	MO10	PR1	MO1	MO3		
m a.s.l.	28	34	54	57	83	90		
Main Reference	Vecchi (1982-83)	Bertolani Marchetti & Cupisti (1970)	Accorsi et al. (1981)	Dall'Olio (1987-88)	Bertolani Marchetti & Lolli (1983)	Bertolani Marchetti (1980b)	**Mean % spectrum**	**Mean cover spectrum**
Number of samples Total = 10	4	1	2	1	1	1		
Depth (m)	20.75/20.1/ 19.8/19.6	10/11	90/70	15.5	5.9	41		
Trees+shrubs								
Abies	1d	1a			3	1a	11.4	1d
Alnus	1c	3	1c	(1c)		2	15.8	1d
Betula	1b	1b			1a	2	6.6	1c
Carpinus	1a	+		1d			2.9	1b
Castanea	+						0.1	r
Cornus	r		1b				0.7	+
Corylus	1d	1c	1d	1d	1a		9.1	1c
Daphne					1a		0.3	r
Ericales/Ericaceae	r		1a				0.3	r
Fagus	r	1a					0.3	r
Hippophae	r						0.1	r
Juniperus	r				1a		0.3	r
Ostrya				1c			1.3	1a
Picea	1a				1a		0.6	+
Pinus	1d	1b	2	1c	2	2	19.4	1d
Quercus	2	1c	2	1d			13.8	1d
Rhamnus	r						0.1	r
Salix		1d		1d			5.0	1b
Sambucus cf.nigra				r			0.1	r
Tilia	1b	+		2	1b		6.4	1c
Ulmus	1c	1b		1a	1a		2.5	1a
Vaccinium	r						0.1	r
Viburnum	r						0.1	r
Mediocratics						1d	2.5	1a
Oak wood (excl.Corylus)	3	1d	2	4	1c		27.4	2
Hygrophilous woody plants	1c	4	1c	1d		2	20.8	2
Conifers	2	1c	2	1c	5	2	31.7	2
Deciduous broadleaf AP	4	5	3	5	1c	4	64.9	4
Mediterranean evergreens								
AP Sum	2	4	1d	3	4	4	53	3
No.TAXA AP Total = 23	*19*	*11*	*6*	*10*	*9*	*?*	*mean=11*	

Tab. VIII: Boreal : Mean forest pollen cover spectrum of each site and Mean spectra of the phase (Mean percentage forest pollen spectrum and Mean forest pollen cover spectrum).— Pollen cover classes : 5 = 81-100 %; 4 = 61- 80 %; 3 = 41-60 %; 2 = 21-40 %; 1d =11-20%; 1c = 5.1-10 %; 1b = 2.6 - 5 %; 1a = 1.1- 2.5 %; + = 0.5 - 1 %; r = < 0.5 %. — ( ) = Pollen sum excluding *Alnus* — "?" = not computable number of taxa.

PO PLAIN - EMILIA ROMAGNA (NORTHERN ITALY)									
HOLOCENE FOREST VEGETATION (POLLEN)									
Mean Forest Pollen Spectra									
ATLANTIC (8,000-4,700 BP)									
SITES Total = 7	POZZO MAVICELLO	COLLEGIO UNIVERSITARIO	SAN CESARIO SUL PANARO	CAVA DUE MADONNE	CASE NUOVE	CAVA SANT'ANTONIO	POZZO FORMIGINE		
Abbreviation name	MO8	MO7	MO10	BO4	PR1	MO1	MO3		
m a.s.l.	28	34	54	55	57	83	90		
Main Reference	Vecchi (1982-83)	Bertolani Marchetti & Cupisti (1970)	Accorsi et al. (1981)	Accorsi & Bandini (1980)	Dall'Olio (1987-88)	Bertolani Marchetti & Lolli (1983)	Bertolani Marchetti (1980b)	**Mean % spectrum**	**Mean cover spectrum**
Number of samples Total = 15	2	1	2	2	3	3	2		
Depth (m)	18.93/18.85	9/10	35/50	2.8/1.6	15/14.9/14.8	4.9/4.6/4.5	30/28		
Trees+shrubs									
Abies	1c	1c	1c	1d	1c	4	1d	18.5	1d
Alnus	1d	1c	2	2	(2)		1d	13.9	1d
Betula	1b	1c				r	1d	3.8	1b
Carpinus	+	1c		1c	1a			3.5	1b
Castanea			1a	1a		r		0.5	r
Corylus	1d	1c	2		1c	1b		9.1	1c
Daphne						r		0.1	r
Ericales/Ericaceae				+			r	0.1	r
Fagus				1c	r		1c	2.1	1a
Fraxinus				1a				0.2	r
Ilex	r							0.1	r
Juniperus	r		1c		1a	+		1.4	1a
Ostrya					1b			0.5	r
Picea	+	1d				+		2.3	1a
Pinus	1b	2	1c	2	2	2	1d	20.9	2
Populus			1a	1a	r			0.5	r
Quercus	2	1c	1c	2	1d	r		12.9	1d
Salix	1a				1c			1.3	1a
Sambucus cf. nigra					r			0.1	r
Sorbus						r		0.1	r
Tilia	1c	1c	1d		1d	1a		6.6	1c
Ulmus	1d	1b			r			2.7	1b
Mediocratics							2	4.3	1b
Oak wood (excl.Corylus)	3	2	2	2	2	1a		24.8	2
Hygrophilous woody plants	1d	1c	2	1d	1c		1d	15.7	1d
Conifers	1d	3	2	3	2	5	2	43.1	3
Deciduous broadleaf AP	5	3	5	3	3	1c	4	53.5	3
Mediterranean evergreens									
AP Sum	2	1d	1d	1d	4	4	4	40	2
***No.TAXA AP Total* = 22**	*13*	*10*	*9*	*10*	*14*	*11*	*?*	*mean =11*	

Tab. IX: Atlantic : Mean forest pollen cover spectrum of each site and Mean spectra of the phase (Mean percentage forest pollen spectrum and Mean forest pollen cover spectrum).— Pollen cover classes : 5 = 81-100 %; 4 = 61- 80 %; 3 = 41-60 %; 2 = 21-40 %; 1d =11-20%; 1c = 5.1-10 %; 1b = 2.6 - 5 %; 1a = 1.1- 2.5 %; + = 0.5 - 1 %; r = < 0.5 %. — ( ) = Pollen sum excluding *Alnus* — "?" = not computable number of taxa.

PO PLAIN - EMILIA ROMAGNA (NORTHERN ITALY)																
HOLOCENE FOREST VEGETATION (POLLEN)																
Mean Forest Pollen Spectra																
SUBBOREAL (4,700 - 2,700 BP)																
SITES Total = 14	RAVENNA	POZZO NAVICELLO	TERRAMARA DI SANTA ROSA	PIANTA DI FORLI'	VILLAFRANCA DI FORLI'	COLLEGIO UNIVERSITARIO	CAPANNA A-CASTENASO	NECROPOLI DI SPILAMBERTO	SAN CESARIO SUL PANARO	CASE NUOVE	TABINA DI MAGRETA	CONVENTO SAN DOMENICO	CAVA SANT'ANTONIO	POZZO FORMIGINE		
Abbreviation name	RA4	MO6	RE2	F02	FO1	MO7	BO2	MO9	MO10	PR1	MO4	BO5	MO1	MO3		
m a.s.l.	4	28	29	34	34	34	41	49	54	57	59	69	83	90		
Main Reference	Zangheri (1966)	Vecchi (1982-83)	Ravazzi et al. (1992)	Zangheri (1966)	Dubois & Zangheri (1957b)	Bertolani Marchetti & Cupisti (1970)	Bertolani Marchetti (1960c)	Accorsi et al. (1981)	Accorsi et al. (1981)	Dall'Olio (1987-88)	Bertolani Marchetti et al. (1988)	Accorsi et al. (1987)	Bertolani Marchetti & Loli (1983)	Bertolani Marchetti (1960b)	**Mean % spectrum**	**Mean cover spectrum**
Number of samples Total = 30	1	4	7	1	1	3	1	2	2	2	2	1	2	1		
Depth (m) or SSUU	90	18.6/18.4/18.0/17.7	SU3-SU3b-SU4-SU5-SU6-SU7	50	14	8-9/7-8/6-7		0.75/ 0.25	25/10	14.2/13	SU2	0.85	3/ 3.1	6		
Trees+shrubs+lianes																
Abies	§	2	2	1d	2	1a	2	1a	r	1d		1c	2	1c	15.2	1d
Acer		r	1c	1a				1a				1b			1.1	1a
Alnus		1c	2	1d	1a	3		3	2	(2)	1d	1d	1b	2	19.1	1d
Betula					1a	1c			r				+	1d	1.4	1a
Buxus											r				0.1	r
Carpinus		+	1a	1a		1b		1a	1a	1d	1b	1b	1b		2.9	1b
Castanea			r					1a	r		1c	1c	+		1.4	1a
Cornus								r							0.1	r
Corylus		1d	1c	1b	1a	1b		1d	1d	1d	1b	1d			7.3	1c
Ericales/Ericaceae						r		+							0.1	r
Fagus		r			1b	+						1b		1d	1.8	1a
Fraxinus		+	r	1a											0.2	r
Hedera				1a											0.1	r
Humulus				1c				r							0.6	+
Juglans		+		1a							1a	1c			0.9	+
Juniperus											1d				1.1	1a
Olea				1a											0.1	r
Ostrya		r							r		1b				0.3	r
Phillyrea				1b			1b								0.6	+
Picea			r	1a							1b		+		0.5	r
Pinus	§	1c	2	1d		1c	2	1c	1d	2	1a	1c	3	2	17.8	1d
Populus		+	1a					1a	+	+					0.4	r
Quercus		2	1b	1c	4	1c	1c	1d	1d	1d	1d	1d			15.5	1d
Quercus Ilex							1c								0.6	+
Rhamnus			r						r						0.1	r
Salix		1a			1a	+			r	1a		1c		1a	1.2	1a
Sambucus cf. nigra			1b							1b					0.5	r
Tilia	§	1c	r			+			1a	1d		1c	1b		2.8	1b
Ulmus		1d		1b	+	1c	1d	1b	1c		2	1c	+		7.0	1c
Viburnum									r						0.1	r
Vitis				1c											0.6	+
Mediocratics														1c	0.6	+
Oak wood (excl.Corylus)		3	1d	2	4	1d	2	2	2	3	3	2	1c		30.7	2
Hygrophilous woody plants		1c	2	1d	1b	3		3	2	1a	1d	2	1b	2	20.7	2
Conifers		2	4	2	2	1c	3	1a	1d	3	2	1d	5	2	34.6	2
Deciduous broadleaf AP		4	3	3	5	5	2	5	4	4	5	5	1d	4	65.3	4
Mediterranean evergreens				1c			1d								1,3	1a
AP Sum		3	2	?	?	4	3	1d	2	3	2	2	4	3	43	3
No.TAXA AP Total = 31	*?*	*15*	*14*	*16*	*8*	*12*	*6*	*13*	*15*	*10*	*12*	*13*	*9*	*?*	*mean=12*	

Tab.X: Subboreal : Mean forest pollen cover spectrum of each site and Mean spectra of the phase (Mean percentage forest pollen spectrum and Mean forest pollen cover spectrum).— Pollen cover classes : 5 = 81-100 %; 4 = 61- 80 %; 3 = 41-60 %; 2 = 21-40 %; 1d =11-20%; 1c = 5,1-10 %; 1b = 2.6 - 5 %; 1a = 1.1- 2.5 %; + = 0.5 - 1 %; r = < 0.5 %. — ( ) = Pollen sum excluding *Alnus* — "?" = not computable number of taxa.

PO PLAIN - EMILIA ROMAGNA (NORTHERN ITALY)

HOLOCENE FOREST VEGETATION (POLLEN)

Mean Forest Pollen Spectra

SUBATLANTIC (since 2,700 BP)

SITES Total = 20	LITORALE DI CLASSE	ARGENTA	RAVENNA-PERIFERIA	ALFONSINE	ARGINONE DI MIRANDOLA	MISERIA VECCHIA DI MIRANDOLA	VILLA DI LUGO	BUDRIO	POZZO NAVICELLO	FERRARESE DI SANTAGOSA	COLLEGIO UNIVERSITARIO	VIA CA' DELL'ORDO	CASE NUOVE	SAN CLAUDIO	CONVENTO SAN DOMENICO	TARINA DI MAGRETA	CAVA SANT'ANTONIO	FORNACI DI FORMIGINE	POZZO FORMIGINE	CASALE DI RIVALTA		
Abbreviation name	RA2	FE1	RA5	RA1	MO5	MO6	RA3	BO1	MO8	RE2	MO7	BO3	PR1	RE1	BO6	MO4	MO1	MO2	MO3	RE3		
m a.s.l.	0	4	4	6	10	10	14	25	28	29	34	41	57	60	69	78	80	90	90	90		
Main Reference	Zangheri (1966)	Forlani (1964)	Dubois & Zangheri (1957a,b)	Zangheri (1966)	Accorsi et al. (1992c)	Accorsi et al. (1992b)	Dubois & Zangheri (1957b)	Accorsi et al. (1982)	Vecchi (1982-83)	Ravazzi et al. (1992)	Bertolani Marchetti & Cupisti (1979)	Accorsi et al. (1982)	Dall'Olio (1987-88)	Accorsi et al. (1990d)	Accorsi et al. (1987)	Bertolani Marchetti et al. (1988)	Bertolani Marchetti & Lolli (1983)	Bertolani et al (1992)	Bertolani Marchetti (1990b)	Accorsi et al. (1990b)	Mean % spectrum	Mean cover spectrum
Number of samples Total = 78	1	1	1	1	7	3	1	10	5	3	3	2	2	3	10	3	1	16	3	2		
Depth (m) or SSUU	5-6	4	6	8	1/0.95/0.9; 1/0.85/0.80	1.1/ 0.7/ 0.8	2	1.1 / 1 / 0.8 / 0.7 / 0.6	14.5 / 13.3 / 5.3 / 3.5 / 2.5	SU8-SU9-SU10	6-5/5-4/4-3	1.1/0.7	11.3/ 8.3	SU2-SU4-SU5	1.5 / 1.5 / 1.2 / 0.9 / 0.7 / 0.5 / 0.4 / 0.3 / 0.1	SU105-SU106	0.8	SSUU 45/35/2/100/ 103/67/94/95	3/2/1	A / B		
Trees+shrubs+lianes																						
Abies			1b		1a	1b	1c	1c	1d	1c	1c	1a	1c	1c	1a	1c	3	1d	1c		7.7	1c
Acer					r			r	r	+		1a			+			r			0.2	r
Aesculus															r						0.1	r
Alnus	2	1c	1d	1d	1d	2	3	1d	2	3	2	2	(>5)	1c	1d	2	1a	1a	1c	1c	19.4	1d
Betula	1b		+	1a	1a	1a			+	r	1c	+	+	+	+			+	1d	1a	1.9	1a
Buxus					r			r						r	r	r		r			0.1	r
Calluna																		r			0.1	r
Carpinus		1a		1a	1a	1a		1c	+	1c	1b	1a	+	1d	1c	1b		1b		1c	3.7	1b
Castanea		1a		+	1a	+		1c	1b	r		1b		1a	1c	1a		1a		1a	1.7	1a
Celtis					+																0.1	r
Cornus					r	1a			r			r		r	r			+		r	0.2	r
Corylus	1c		1d	1c	1c	1c		1b	1c	r	1d	1c	1d	1c	1d	1c	1b	1c		1c	7.1	1c
Crataegus																				r	0.1	r
Cupressus								1a													0.1	r
Daphne																	r	r			0.1	r
Ephedra				+		1a		r								r					0.1	r
Erica																		r			0.1	r
Ericales/Ericaceae		1a						r	r		r	r			r						0.1	r
Euonymus														r							0.1	r
Fagus	1b	+	2	1d	1a	1a		1a	r	r		1a		1b	+		1a	+	1d	1a	4.0	1b
Frangula		+																			0.1	r
Fraxinus	1b	1b			1b	1a		1a	r	r		+	1c	1c	1a			+		1a	1.8	1a
Hedera					r																0.1	r
Humulus					r			r				r				r					0.1	r
Ilex		-						r	r			r						r			0.1	r
Juglans		1a		+	+	r		1b	1b			1b			1b			+			1.0	+
Juniperus				+	1c	1c		r	r			r		r	r	r		1b		r	1.0	+
Larix							1b							1a				1a			0.4	r
Ligustrum								r													0.1	r
Lonicera															r						0.1	r
Loranthus					r																0.1	r
Morus																		r			0.1	r
Ostrya	1b							r						1a	+	1a		1a		1b	0.7	+
Phillyrea				1a																	0.1	r
Picea	1b		1b		1a			r	+			1a			+		1c	+	r		1.1	1a
Pinus	1b	1d	1b	1b	1d	1d	1b	2	1d	2	1d	1c	2	1d	2	1c	2	1d	1d	2	16.5	1d
Platanus					+	+		1b				1a			r					1a	0.4	r
Populus		1b			r	r		1a	r				+		r			r			0.4	r
Prunus		+			r	r		+						r	r			r		r	0.1	r
Quercus	2	2	1d	2	1d	2	2	1d	1d	1b	1d	1c	1d	1d	1d	1d		2		2	17.8	1d
Quercus Ilex					r	+								1a	r					1c	0.5	r
Rhamnus					r			r	r						r			r			0.1	r
Rubus					r			r												r	0.1	r
Salix		2	1a	1c	1b	+	1c	1b	1b			1a	1d	1c	1c	1b		+		1b	5.3	1c
Sambucus cf. nigra					r	+							r					r			0.1	r
Sorbus														r						r	0.1	r
Taxus					r			+					r								0.1	r
Tilia					r				1b	r	1a		1c		1a		1a	r			0.9	+
Ulmus	1b	1b	1b	1c	1b	1b		1a	1c	r	r	1c		1c	1b	1c		1b		1c	3.7	1b
Viburnum										1a				r	r						0.1	r
Vitis	1b			1a		r		r				r			r					r	0.3	r
Mediocratica																			2		1.5	a
Oak wood (excl.Corylus)	2	2	1d	2	2	2	2	1d	2	1c	1d	1d	2	2	2	2	1a	2		3	29.9	2
Hygrophilous woody plants	2	3	1d	2	1d	2	3	2	2	3	2	3	1c	1d	2	2	1a	1b	1c	1d	28.1	2
Conifers	1c	1d	1d	1b	2	2	1d	2	2	2	2	1d	2	2	2	1d	5	2	2	2	26.6	2
Deciduous broadleaf AP	5	5	5	5	3	5	5	4	4	3	4	5	3	3	4	4	1c	3	4	4	70.6	4
Mediterranean evergreens				1a	r	+								1a	r					1c	0.6	+
AP Sum	?	2	?	?	2	2	?	1d	3	2	2	2	3	2	1d	2	4	3	3	2	34	2
No.TAXA AP Total =51	11	14	10	15	30	23	6	30	22	14	11	24	11	22	30	14	8	30	?	21	mean=18	

Tab. XI: Subatlantic : Mean forest pollen cover spectrum of each site and Mean spectra of the phase (Mean percentage forest pollen spectrum and Mean forest pollen cover spectrum).— Pollen cover classes : 5 = 81-100 %; 4 = 61- 80 %; 3 = 41-60 %; 2 = 21-40 %; 1d =11-20%; 1c = 5.1-10 %; 1b = 2.6 - 5 %; 1a = 1.1- 2.5 %; + = 0.5 - 1 %; r = < 0.5 %. — ( ) = Pollen sum excluding *Alnus* — "?" = not computable number of taxa.

PO PLAIN - EMILIA ROMAGNA (NORTHERN ITALY)			
HOLOCENE FOREST VEGETATION (POLLEN)			
Pollen types and Characteristic pollen combination PREBOREAL (10,000-9,000 BP)			
No. of Sites = 6			
TREES/SHRUBS	**Presence class**	**Mean % spectrum**	**Mean cover spectrum**
Characteristic forest pollen combination (mean number of taxa per site = 8)			
Pinus	V	80.0	4
Abies	V	5.3	1c
Betula	IV	4.4	1b
Alnus	IV	3.4	1b
Corylus	IV	1.2	1a
Quercus	III	0.8	+
Carpinus	III	0.4	r
Salix	III	0.4	r
Other taxa			
Picea	III	0.2	r
Ericales	II	0.4	r
Tilia	II	0.1	r
Fagus	I	1.2	1a
Daphne	I	0.3	r
Sambucus cf. nigra	I	0.3	r
Castanea	I	0.1	r
Laurus	I	0.1	r
Ostrya	I	0.1	r
Ulmus	I	0.1	r

Tab. XII: Preboreal : Recorded tree/shrub taxa in order of presence class. The characteristic forest pollen combination includes the most frequent taxa found overall, which is equal in number to the mean number of taxa per site. The other taxa recorded are listed below. — Pollen presence classes : I = taxa recorded in 1- 20% of sites; II = 21-40% of sites; III = 41-60% of sites ; IV = 61- 80% of sites; V = 81- 100% of sites. Pollen cover classes : 5 = 81-100 %; 4 = 61- 80 %; 3 = 41-60 %; 2 = 21-40 %; 1d =11-20%; 1c = 5.1-10 %; 1b = 2.6 - 5 %; 1a = 1.1- 2.5 %; + = 0.5 - 1 %; r = < 0.5 %.

PO PLAIN - EMILIA ROMAGNA (NORTHERN ITALY)			
HOLOCENE FOREST VEGETATION (POLLEN)			
Pollen types and Characteristic pollen combination BOREAL (9,000-8,000 BP)			
No. Sites = 6			
TREES/SHRUBS	Presence class	Mean % spectrum	Mean cover spectrum
Characteristic forest pollen combination (mean number of taxa per site = 11)			
Pinus	V	19.4	1d
Alnus	V	15.8	1d
Corylus	V	9.1	1c
Quercus	IV	13.8	1d
Abies	IV	11.4	1d
Betula	IV	6.6	1c
Tilia	IV	6.4	1c
Ulmus	IV	2.5	1a
Carpinus	III	2.9	1b
Salix	II	5.0	1b
Cornus	II	0.7	+
Other taxa			
Picea	II	0.6	+
Ericales/Ericaceae	II	0.3	r
Fagus	II	0.3	r
Juniperus	II	0.3	r
Ostrya	I	1.3	1a
Daphne	I	0.3	r
Castanea	I	0.1	r
Hippophae	I	0.1	r
Rhamnus	I	0.1	r
Sambucus cf. nigra	I	0.1	r
Vaccinium	I	0.1	r
Viburnum	I	0.1	r

Tab. XIII: Boreal : Recorded tree/shrub taxa in order of presence class. The characteristic forest pollen combination includes the most frequent taxa found overall, which is equal in number to the mean number of taxa per site. The other taxa recorded are listed below. — Pollen presence classes : I = taxa recorded in 1- 20% of sites; II = 21-40% of sites; III = 41-60% of sites ; IV = 61- 80% of sites; V = 81- 100% of sites. Pollen cover classes : 5 = 81-100 %; 4 = 61- 80 %; 3 = 41-60 %; 2 = 21-40 %; 1d =11-20%; 1c = 5.1-10 %; 1b = 2.6 - 5 %; 1a = 1.1- 2.5 %; + = 0.5 - 1 %; r = < 0.5 %.

PO PLAIN - EMILIA ROMAGNA (NORTHERN ITALY)			
HOLOCENE FOREST VEGETATION (POLLEN)			
Pollen types and Characteristic pollen combination ATLANTIC (8,000-4,700 BP)			
No. Sites = 7			
TREES/SHRUBS	**Presence class**	**Mean % spectrum**	**Mean cover spectrum**
Characteristic forest pollen combination (mean number of taxa per site = 11)			
Pinus	V	20.9	2
Abies	V	18.5	1.d
Alnus	V	13.9	1.d
Quercus	V	12.9	1d
Corylus	IV	9.1	1.c
Tilia	IV	6.6	1.c
Betula	III	3.8	1.b
Carpinus	III	3.5	1.b
Juniperus	III	1.4	1.a
Ulmus	III	2.7	1.b
Picea	III	2.3	1.a
Other taxa			
Fagus	III	2.1	1.a
Castanea	III	0.5	r
Populus	III	0.5	r
Salix	II	1.3	1.a
Ericales/Ericaceae	II	0.1	r
Ostrya	I	0.5	r
Fraxinus	I	0.2	r
Daphne	I	0.1	r
Ilex	I	0.1	r
Sambucus cf. nigra	I	0.1	r
Sorbus	I	0.1	r

Tab. XIV: Atlantic : Recorded tree/shrub taxa in order of presence class. The characteristic forest pollen combination includes the most frequent taxa found overall, which is equal in number to the mean number of taxa per site. The other taxa recorded are listed below. — Pollen presence classes : I = taxa recorded in 1- 20% of sites; II = 21-40% of sites; III = 41-60% of sites ; IV = 61- 80% of sites; V = 81- 100% of sites. Pollen cover classes : 5 = 81-100 %; 4 = 61- 80 %; 3 = 41-60 %; 2 = 21-40 %; 1d =11-20%; 1c = 5.1-10 %; 1b = 2.6 - 5 %; 1a = 1.1- 2.5 %; + = 0.5 - 1 %; r = < 0.5 %.

PO PLAIN - EMILIA ROMAGNA (NORTHERN ITALY)			
HOLOCENE FOREST VEGETATION (POLLEN)			
Pollen types and Characteristic pollen combination SUBBOREAL (4,700-2,700 BP)			
No. Sites =13			
TREES/SHRUBS/LIANES	Presence class	Mean % spectrum	Mean cover spectrum
Characteristic forest pollen combination (mean number of taxa per site = 12)			
Pinus	V	17.8	1d
Abies	V	15.2	1d
Alnus	V	19.1	1d
Quercus	V	15.5	1d
Corylus	IV	7.3	1c
Ulmus	IV	7.0	1c
Carpinus	IV	2.9	1b
Tilia	III	2.8	1b
Salix	III	1.2	1a
Castanea	III	1.4	1a
Fagus	II	1.8	1a
Betula	II	1.4	1a
Other taxa			
Acer	II	1.1	1a
Populus	II	0.4	r
Juglans	II	0.9	+
Picea	II	0.5	r
Ostrya	II	0.3	r
Fraxinus	II	0.2	r
Humulus	I	0.6	+
Phillyrea	I	0.6	+
Sambucus cf. nigra	I	0.5	r
Ericales/Ericaceae	I	0.1	r
Rhamnus	I	0.1	r
Juniperus	I	1.1	1a
Quercus ilex	I	0.6	+
Vitis	I	0.6	+
Buxus	I	0.1	r
Cornus	I	0.1	r
Hedera	I	0.1	r
Olea	I	0.1	r
Viburnum	I	0.1	r

Tab. XV: Subboreal : Recorded tree/shrub/liane taxa in order of presence class. The characteristic forest pollen combination includes the most frequent taxa found overall, which is equal in number to the mean number of taxa per site. The other taxa recorded are listed below. — Pollen presence classes : I = taxa recorded in 1- 20% of sites; II = 21-40% of sites; III = 41-60% of sites ; IV = 61-80% of sites; V = 81- 100% of sites. Pollen cover classes : 5 = 81-100 %; 4 = 61- 80 %; 3 = 41-60 %; 2 = 21-40 %; 1d =11-20%; 1c = 5.1-10 %; 1b = 2.6 - 5 %; 1a = 1.1- 2.5 %; + = 0.5 - 1 %; r = < 0.5 %.

PO PLAIN - EMILIA ROMAGNA (NORTHERN ITALY)			
HOLOCENE FOREST VEGETATION (POLLEN)			
Pollen types and Characteristic pollen combination			
SUBATLANTIC (since 2,700 BP)			
No. Sites = 20			
TREES/SHRUBS/LIANES	Presence class	Mean % spectrum	Mean cover spectrum
Characteristic forest pollen combination (mean number of taxa per site = 18)			
Alnus	V	19.4	1d
Pinus	V	16.5	1d
Quercus	V	17.8	1d
Corylus	V	7.1	1c
Abies	IV	7.7	1c
Salix	IV	5.3	1c
Fagus	IV	4.0	1b
Ulmus	IV	3.7	1b
Carpinus	IV	3.7	1b
Betula	IV	1.9	1a
Fraxinus	IV	1.8	1a
Castanea	IV	1.7	1a
Juniperus	III	1.0	+
Picea	III	1.1	1a
Juglans	III	1.0	+
Tilia	II	0.9	+
Ostrya	II	0.7	+
Populus	II	0.4	r
Other taxa			
Cornus	II	0.2	r
Prunus	II	0.1	r
Vitis	II	0.3	r
Acer	II	0.2	r
Platanus	II	0.4	r
Buxus	II	0.1	r
Ericales/Ericaceae	II	0.1	r
Quercus ilex	II	0.5	r
Rhamnus	II	0.1	r
Ephedra	I	0.1	r
Humulus	I	0.1	r
Ilex	I	0.1	r
Sambucus cf. nigra	I	0.1	r
Larix	I	0.4	r
Rubus	I	0.1	r
Taxus	I	0.1	r
Viburnum	I	0.1	r
Daphne	I	0.1	r
Sorbus	I	0.1	r
Aesculus	I	0.1	r
Calluna	I	0.1	r
Celtis	I	0.1	r
Crataegus	I	0.1	r
Cupressus	I	0.1	r
Erica	I	0.1	r
Euonymus	I	0.1	r
Frangula	I	0.1	r
Hedera	I	0.1	r
Ligustrum	I	0.1	r
Lonicera	I	0.1	r
Loranthus	I	0.1	r
Morus	I	0.1	r
Phillyrea	I	0.1	r

Tab. XVI: Subatlantic : Recorded tree shrub liane taxa in order of presence class. The characteristic forest pollen combination includes the most frequent taxa found overall, which is equal in number to the mean number of taxa per site. The other taxa recorded are listed below. — Pollen presence classes : I = taxa recorded in 1- 20% of sites; II = 21-40% of sites; III = 41-60% of sites ; IV = 61-80% of sites; V = 81- 100% of sites. Pollen cover classes : 5 = 81-100 %; 4 = 61- 80 %; 3 = 41-60 %; 2 = 21-40 %; 1d =11-20%; 1c = 5.1-10 %; 1b = 2.6 - 5 %; 1a = 1.1- 2.5 %; + = 0.5 - 1 %; r = < 0.5 %.

PO PLAIN - Emilia Romagna (Northern Italy)

Holocene forest vegetation (Pollen)

Forest pollen flora and mean pollen cover spectra

CHRONOLOGY (^{14}C y BP)		10,000-9,000	9,000-8,000	8,000-4,700	4,700-2,700	since 2,700
HOLOCENE PHASES		PREBOREAL	BOREAL	ATLANTIC	SUBBOREAL	SUBATLANTIC
Trees+shrubs+lianes						
ACERACEAE					**1a**	**r**
Acer	DO/DB				1a	r
AQUIFOLIACEAE				**r**		**r**
Ilex				r		r
ARALIACEAE					**r**	**r**
Hedera					r	r
BETULACEAE		**1c**	**2**	**1d**	**2**	**2**
Alnus	HW/DB	1b	1d	1d	1d	1d
A. cf. glutinosa/A. glutinosa (L.) Gaertner	HW/DB				p	p
A. incana (L.) Moench	HW/DB					p
Betula	DB	1b	1c	1b	1a	1a
BUXACEAE					**r**	**r**
Buxus					r	r
CANNABACEAE					**+**	**r**
Humulus					+	r
Humulus/Cannabis					p	
CAPRIFOLIACEAE		**r**	**r**	**r**	**+**	**r**
Lonicera						r
Sambucus nigra L./S. cf. nigra	DB	r	r	r	r	r
Viburnum	DO/DB		r		r	r
CELASTRACEAE						**r**
Euonymus	DO/DB					r
Euonymus europaeus L.	DO/DB					p
CORNACEAE			**+**		**r**	**r**
Cornus	DO/DB		+		r	r
Cornus mas L.	DO/DB				p	p
CORYLACEAE		**1a**	**1d**	**1d**	**1d**	**1d**
Corylus	DB	1a	1c	1c	1c	1c
Corylus avellana L.	DB					p
Carpinus	DO/DB	r	1b	1b	1b	1b
Carpinus betulus L.	DO/DB				p	p
Ostrya	DO/DB	r	1a	r	r	+
Ostrya carpinifolia Scop.	DO/DB					p
CUPRESSACEAE			**r**	**1a**	**1a**	**1a**
Cupressus	CF					r
Juniperus	CF		r	1a	1a	+
Juniperus tipo	CF					p
Juniperus communis L.	CF					p
ELEAGNACEAE			**r**			
Hippophae			r			
EPHEDRACEAE						**r**
Ephedra						r
ERICALES/ERICACEAE		**r**	**r**	**r**	**r**	**r**
Ericales/Ericaceae		r	r	r	r	r
Calluna						r
Erica						r
Vaccinium			r			

CHRONOLOGY (^{14}C y B.P.)		10,000-9,000	9,000-8,000	8,000-4,700	4,700-2,700	since 2,700
HOLOCENE PHASES		PREBOREAL	BOREAL	ATLANTIC	SUBBOREAL	SUBATLANTIC
FAGACEAE		**1a**	**1d**	**1d**	**1d**	**2**
Castanea	DB	r	r	r	1a	1a
Castanea sativa Miller	DB				p	p
Fagus	DB	1a	r	1a	1a	1b
Fagus sylvatica L.	DB				p	p
Quercus caducif. indiff.	DO/DB	+	1d	1d	1d	1d
Q. cerris L.	DO/DB		p	p		p
Q. ilex L.	ME				+	r
Q. pubescens Willd.	DO/DB		p	p	p	p
Q. robur L. s.s./Q. cf. robur s.s.	DO/DB		p	p	p	p
HIPPOCASTANACEAE						**r**
Aesculus	DB					r
JUGLANDACEAE					**+**	**+**
Juglans	DB				+	+
Juglans regia L.	DB					p
LAURACEAE		**r**				
Laurus	ME	r				
LORANTHACEAE						**r**
Loranthus						r
MORACEAE						**r**
Morus						r
OLEACEAE				**r**	**+**	**1a**
Fraxinus	DO/DB			r	r	1a
F. excelsior tipo	DO/DB					p
F. excelsior L.	DO/DB					p
F. ornus tipo	DO/DB					p
Ligustrum	DO/DB					r
Ligustrum vulgare tipo	DO/DB					p
Olea cf.	ME				r	
Phillyrea	ME				+	r
PINACEAE		**5**	**2**	**3**	**2**	**2**
Abies	CF	1c	1d	1d	1d	1c
Abies alba Miller	CF				p	p
Larix	CF					r
Picea	CF	r	+	1a	r	1a
Picea excelsa (Lam.) Link	CF					p
Pinus	CF	4	1d	2	1d	1d
Pinus cembra L.	CF					p
Pinus pinea L.	CF			p		p
Pinus sylvestris L.	CF	p	p	p	p	p
PLATANACEAE						**r**
Platanus	DB					r
Platanus orientalis L.	DB					p
RHAMNACEAE			**r**		**r**	**r**
Frangula	DO/DB					r
Frangula alnus Miller	DO/DB					p
Rhamnus	DO/DB		r		r	r
ROSACEAE				**r**		**r**
Crataegus	DB					r
Prunus	DB					r
Rubus						r
Sorbus	DB			r		r
SALICACEAE		**r**	**1b**	**1a**	**1a**	**1c**
Populus	HW/DB			r	r	r
Populus cf. alba	HW/DB					p
Salix	HW/DB	r	1b	1a	1a	1c
TAXACEAE						**r**
Taxus	CF					r

CHRONOLOGY (^{14}C y B.P.)		10,000-9,000	9,000-8,000	8,000-4,700	4,700-2,700	since 2,700
HOLOCENE PHASES		PREBOREAL	BOREAL	ATLANTIC	SUBBOREAL	SUBATLANTIC
THYMELEACEAE		r	r	r		r
Daphne		r	r	r		r
TILIACEAE		r	1c	1c	1b	+
Tilia	DO/DB	r	1c	1c	1b	+
Tilia cordata Miller	DO/DB					p
Tilia platyphyllos Scop.	DO/DB					p
ULMACEAE		r	1a	1b	1c	1b
Celtis	DB					r
Celtis australis L.	DB					p
Ulmus	DO/DB	r	1a	1b	1c	1b
Ulmus minor Miller/Ulmus cf. minor	DO/DB					p
VITACEAE					+	r
Vitis					+	r
Vitis vinifera L.						p
Oak wood (excl.Corylus)	DO	1a	2	1d	2	2
Hygrophilous woody plants	HW	1b	2	1d	2	2
Conifers	CF	5	2	3	2	2
Deciduous broadleaf AP	DB	1d	4	3	4	4
Mediterranean evergreens	ME				1a	+
AP Sum		4/2	3/3	2/3	3/3	2/4
No. Families (Total = 31)		11	14	14	19	29
No. Genera (Total = 53)		18	23	22	31	51
No. Pollen types (Total = 88)		19	27	27	41	83

Tab. XVII: Holocene forest pollen flora and Mean pollen cover spectra. Cover values are shown for pollen families and genera. As for pollen types and species only the presence is shown (= p). Pollen cover classes : 5 = 81-100 %; 4 = 61- 80 %; 3 = 41-60 %; 2 = 21-40 %; 1d =11-20%; 1c = 5.1-10 %; 1b = 2.6 - 5 %; 1a = 1.1- 2.5 %; + = 0.5 - 1 %; r = < 0.5 %.

PO PLAIN - EMILIA ROMAGNA (NORTHERN ITALY)										
HOLOCENE FOREST VEGETATION (POLLEN)										
Mean Forest Pollen Spectra (Percentage Spectra and Cover Spectra)										
HOLOCENE										
	PREBOREAL (10,000-9,000 BP)		BOREAL (9,000-8,000 BP)		ATLANTIC (8,000-4,700 BP)		SUBBOREAL (4,700-2,700 BP)		SUBATLANTIC (since 2,700 BP)	
No. SITES Total = 28	6		6		7		14		20	
Number of samples Total = 155	22		10		15		30		78	
Trees+shrubs+lianes	Mean % spectrum	Mean cover spectrum	Mean % spectrum	Mean cover spectrum	Mean % spectrum	Mean cover spectrum	Mean % spectrum	Mean cover spectrum	Mean % spectrum	Mean cover spectrum
Abies	5.3	1c	11.4	1d	18.5	1d	15.2	1d	7.7	1c
Acer							1.1	1a	0.2	r
Aesculus									0.1	r
Alnus	3.4	1b	15.8	1d	13.9	1d	19.1	1d	19.4	1d
Betula	4.4	1b	6.6	1c	3.8	1b	1.4	1a	1.9	1a
Buxus							0.1	r	0.1	r
Calluna									0.1	r
Carpinus	0.4	r	2.9	1b	3.5	1b	2.9	1b	3.7	1b
Castanea	0.1	r	0.1	r	0.5	r	1.4	1a	1.7	1a
Celtis									0.1	r
Cornus			0.7	+			0.1	r	0.2	r
Corylus	1.2	1a	9.1	1c	9.1	1c	7.3	1c	7.1	1c
Crataegus									0.1	r
Cupressus									0.1	r
Daphne	0.3	r	0.3	r	0.1	r			0.1	r
Ephedra									0.1	r
Erica									0.1	r
Ericales/Ericaceae	0.4	r	0.3	r	0.1	r	0.1	r	0.1	r
Euonymus									0.1	r
Fagus	1.2	1a	0.3	r	2.1	1a	1.8	1a	4.0	1b
Frangula									0.1	r
Fraxinus					0.2	r	0.2	r	1.8	1a
Hedera							0.1	r	0.1	r
Hippophae			0.1	r						
Humulus							0.6	+	0.1	r
Ilex					0.1	r			0.1	r
Juglans							0.9	+	1.0	+
Juniperus			0.3	r	1.4	1a	1.1	1a	1.0	+
Larix									0.4	r
Laurus	0.1	r								
Ligustrum									0.1	r
Lonicera									0.1	r
Loranthus									0.1	r
Morus									0.1	r
Olea							0.1	r		
Ostrya	0.1	r	1.3	1a	0.5	r	0.3	r	0.7	+
Phillyrea							0.6	+	0.1	r
Picea	0.2	r	0.6	+	2.3	1a	0.5	r	1.1	1a
Pinus	80	4	19.4	1d	20.9	2	17.8	1d	16.5	1d
Platanus									0.4	r
Populus					0.5	r	0.4	r	0.4	r
Prunus									0.1	r
Quercus	0.8	+	13.8	1d	12.9	1d	15.5	1d	17.8	1d
Quercus ilex							0.6	+	0.5	r
Rhamnus			0.1	r			0.1	r	0.1	r
Rubus									0.1	r
Salix	0.4	r	5.0	1b	1.3	1a	1.2	1a	5.3	1c
Sambucus cf. nigra	0.3	r	0.1	r	0.1	r	0.5	r	0.1	r
Sorbus					0.1	r			0.1	r
Taxus									0.1	r
Tilia	0.1	r	6.4	1c	6.6	1c	2.8	1b	0.9	+
Ulmus	0.1	r	2.5	1a	2.7	1b	7	1c	3.7	1b
Vaccinium			0.1	r						
Viburnum			0.1	r			0.1	r	0.1	r
Vitis							0.6	+	0.3	r
Oak wood (excl.Corylus)	2.0	1a	27.4	2	24.8	2	30.7	2	29.9	2
Hygrophilous woody plants	3.8	1b	20.8	2	15.7	1d	20.7	2	25.1	2
Conifers	85.5	5	31.7	2	43.1	3	34.6	2	26.6	2
Deciduous broadleaf AP	12.3	1d	64.9	4	53.5	3	65.3	4	70.6	4
Mediterranean evergreens	0.1	r					1.3	1a	0.6	+
AP Sum	64	4	53	3	40	2	43	3	34	2
No.TAXA AP (Total)	*18*		*23*		*22*		*31*		*51*	
No.TAXA AP (Mean)	*8*		*11*		*11*		*12*		*18*	

Tab. XVIII: Holocene forest pollen vegetation: Mean percentage forest pollen spectra and Mean cover forest pollen spectra of the five Holocene phases. Pollen cover classes : 5 = 81-100 %; 4 = 61-80 %; 3 = 41-60 %; 2 = 21-40 %; 1d =11-20%; 1c = 5.1-10 %; 1b = 2.6 - 5 %; 1a = 1.1- 2.5 %; + = 0.5 - 1 %; r = < 0.5 %.

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