Available online http://amq.aiqua.it
ISSN (online): 2279-7335

Alpine and Mediterranean Quaternary, Vol. 31 (Quaternary: Past, Present, Future - AIQUA Conference, Florence, 13-14/06/2018), 93 - 97

https://doi.org/10.26382/AIQUA.2018.AIQUAconference

PALAEOENVIRONMENT AND VEGETATION HISTORY IN THE CENTRAL PO PLAIN (N-ITALY) BETWEEN 33-30 KA CAL BP UNDER THE IMPACT OF MILLENNIAL CLIMATE CHANGE

Cesare Ravazzi [1], Lorena Garozzo [1], Massimiliano Deaddis [1,2], Mattia De Amicis [3], Mauro Marchetti [4], Roberta Pini [1], Giovanni Vezzoli [3], Andrea Zanchi [3]

1 Laboratory of Palynology and Palaeoecology, CNR - IDPA, Milano, Italy
2 CFP San Giuseppe Cooperativa Sociale Onlus, Lodi, Italy
3 Dept. of Environmental and Earth Sciences, University of Milano - Bicocca, Milano, Italy
4 Dept. of Education and Humanities, University of Modena and Reggio Emilia, Reggio Emilia, Italy
Corresponding author: C. Ravazzi <cesare.ravazzi@idpa.cnr.it>

ABSTRACT: The Last Glaciation environmental history of the Po Plain (Northern Italy) is still poorly known. Here we present a multiproxy record from a compressed peat dated 33-30 ka cal BP, underlying the Last Glacial Maximum fluvio-glacial belt in the Adda River catchment. Slow river dynamics and subsurface water saturation granted stable surfaces supporting mixed pine-birch forests, including open wetlands - marshes and swamps - and open drylands, with juniper bushes, connected to sandy river bars. Fire phases favoured birch but decreased arboreal pollen, although open lands did not expand. We discuss relationships with millennial climate variability between GI-6 and GS-5.1.

KEYWORDS: Last glaciation, Po plain, boreal forest, alluvial plain, radiocarbon dating, millennial climate variability

1. INTRODUCTION

The Late Pleistocene geological and environmental history of the Central Po Plain in Northern Italy is driven by phases of aggradation by large alluvial bodies, mostly originating at the Pre-Alpine margin from the valley outlets of the two major Alpine rivers (i.e. Adda River, see Fig. 1, and Oglio River). Actually, as far as the Adda and Oglio Glaciers occupied their piedmont end moraine systems, about 27 to 21-18 ka cal BP, several outwash rivers were actively building up a coalescent sandar belt even reaching the axial sector of the Po Plain (Ravazzi et al., 2012), palaeoenvironments being dramatically influenced by fast channel dynamics and persisting high water discharge.

Here we present a high-resolution palaeobotanical research and coupled alluvial stratigraphy carried out in the underlying deposits dated to late MIS 3 and thus shortly preceding the Last Glacial Maximum (LGM) peak aggradation events, depicting a comparatively different environmental framework for the distal Adda plain, with forested stable surfaces, millennial-standing pools and low sedimentation rate, suggesting a low-gradient plain. Thanks to a robust AMS ^{14}C chronology, we examine the effects of the pronounced millennial palaeoclimatic variability which affected Northern Italy in late MIS 3.

2. MATERIAL AND METHODS

A 18 m-thick sediment sequence outcropping at Casaletto Ceredano (Coord. WGS84 - 45°18'49.75"N, 9°37'21.86"E; province of Cremona, 65 m asl, Fig. 1), along the scarp of the entrenched postglacial Adda River valley, shows the depositional history between > 40 and the local end of the LGM aggradation surface. The complete sections are shown in Fig. 2; the study focused on a 40 cm-thick compressed peat and silty peat, sampled through a 50 cm-long metal box. Palynology (27 samples), macroscopic charcoal (48) and geochemistry (81) were analyzed. Pollen and other microbiological particles were extracted by chemical treatments (acid treatments, KOH), microfiltrations and acetolysis, and identified at the optical microscope, reaching a minimum pollen sum of 500 pollen grains. Macrocharcoal fragments between 125 μm - 1 mm and > 1 mm length were wet-sieved and counted under a stereomicroscope. Four samples of wood and charcoal fragments were radiocarbon-dated at the Angstrom Lab., Uppsala University. Calibration was carried out using CALIB version 7.0.4 with the IntCal13 calibration curve (Reimer et al., 2013). An age-depth model was built up with the Bayesian technique in Oxcal package.

3. RESULTS

3.1. Chronology

The dated wood and charcoal originate from two sections exposing the compressed peat stratigraphy which could be visually correlated at cm-detail. The composite section yielded ages spanning a nice sequence (Tab. 1) between 25975 ±450 and 32950 ±1070 ^{14}C a BP (median calibrated ages 30144 - 37150 cal a BP). We selected *in situ* wood and large wood charcoal fragments (unweathered compressed wood from tree stems and cm-thick wood charcoal) in order to minimize the effects of either contamination or rielaboration. The latter

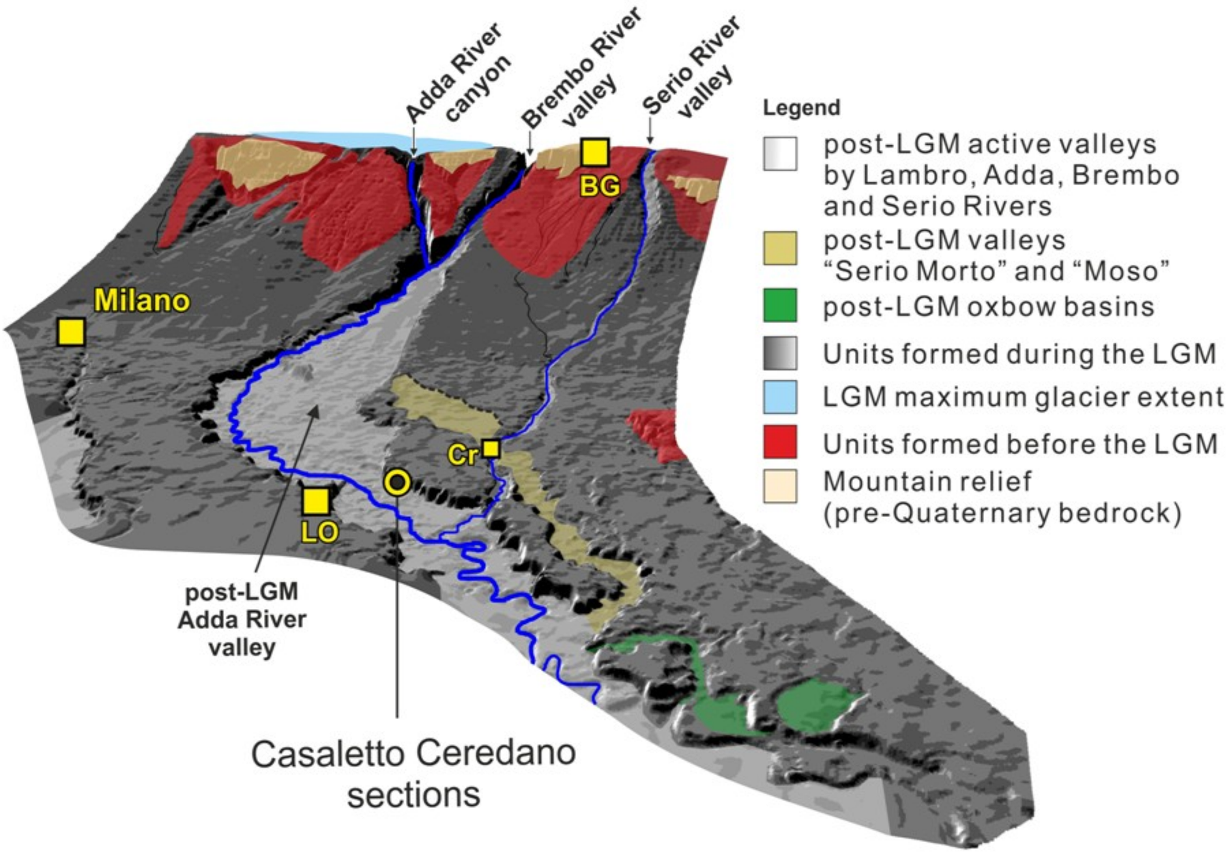


Fig. 1 - Digital Terrain Model of part of the Central Po Plain in Northern Italy showing the valley cut by the Adda River into the alluvial fan system formed during the Last Glacial Maximum (in dark grey). Tributary Rivers Brembo and Serio, as well as inactive post-LGM valleys and ancient oxbow basins are shown. The Casaletto Ceredano sections are outcropping on the eastern scarp delimiting the post-LGM Adda valley. LO = Lodi; BG = Bergamo; Cr = Crema.

taphonomic process is a cause of age bias in drift peat imbedded in alluvial and glacial deposits. The availability of datable wood tissue from tree stems obviously depends on tree occurrence in contemporary vegetation, a circumstance which favourably compares with the forest persistence in N-Italy throughout the last glaciation. A posterior analysis of a bayesian age/depth model designed in software Oxcal also supports the reliability of the obtained age sequence between top and base of the compressed peat layer, spanning about three millennia between (29172 -2σ range) 30144 and 33427 (34791 -2σ range) cal a BP.

3.2. Pollen, charcoal stratigraphy and vegetation history

We obtained a pollen and charcoal record with an average sample resolution (133 and 65 years respectively) suitable to detect centennial-scale secondary ecological successions as well as the effects of millennial climate events which characterized the late MIS 3, although our detail is still not appropriate to check fire frequency.

The vegetation history is clustered in the following pollen % phases (Fig. 3, upper panel):

CC01 (91-93 cm) - Before the onset of organic deposition, sandy sediments are characterized by moderate values of pine pollen (*Pinus sylvestris/mugo)* accompanied by several herbs. Low xerophytes (*Artemisia, Ephedra, Hippophaë,* Chenopodiaceae) mark open environments, such as sandy riverbeds.

CC02 (93-97 cm) - An organic soil rich in charcoal particles developed, recording higher pine pollen percentages (75-88%). The abundance of charcoal, along with cm-size fragments, suggests local fires affecting pine woodlands. Indicators of local wetlands are still scanty.

CC03 (97-101 cm) - A sharp decrease in pine pollen abundance is coupled with increasing values of *Betula* (birch) and the expansion of wetland and herb vegetation (Cyperaceae, Gramineae). The *in situ* development of a *Carex* (sedge) fen is shown by the abundance of sedge roots. We infer a withdrawal of pine forests that had previously been affected by fires, while pioneer birches and terrestrial wetlands expanded, favored by increasing water table.

CC04 (101-111 cm) - Pine pollen increases again (values around 70%), *Juniperus* and other xerophytes expand. We reconstruct a rather open pine forest, including sporadic spruce, with open land occupied by *Juniperus* and herbs. A sedge marsh persists locally, its

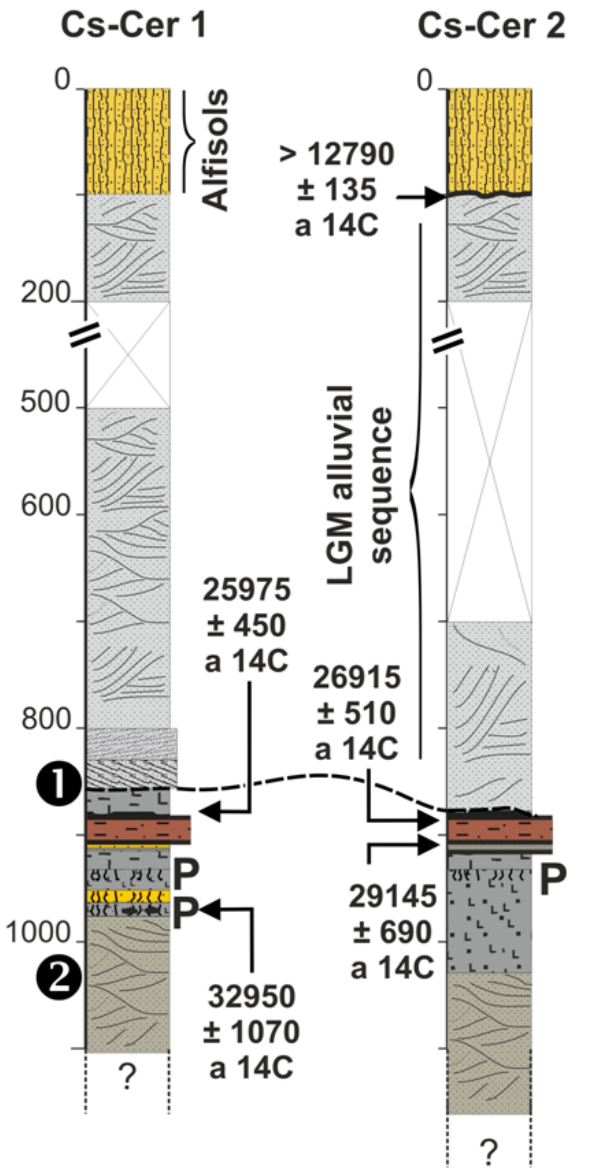


Fig. 2 - Summary logs of sections exposed along the eastern scarp of the Adda River valley at Casaletto Ceredano. Compressed peat layer in dark brown. P = root casts marking exposed surfaces in sand layers. Labels 1 and 2 show the position of petrographic samples for sediment provenance analysis.

fluctuations depending on detrital supply.

CC05 (111-117 cm) - Pine stillstand (70%), xerophytes, open vegetation and sedge fen developed (sedges roots are abundant in sediments). The local environment was more drained and partially oxygenated, favoring the activity of some fungi (*Glomus*).

Last phase (117-119 cm) - Pine pollen declines and birch expands, as a consequence of a renewed phase of fires. The find of tree birch stems in these peat layers suggests that those trees settled *in situ* together with sedges (birch swamp).

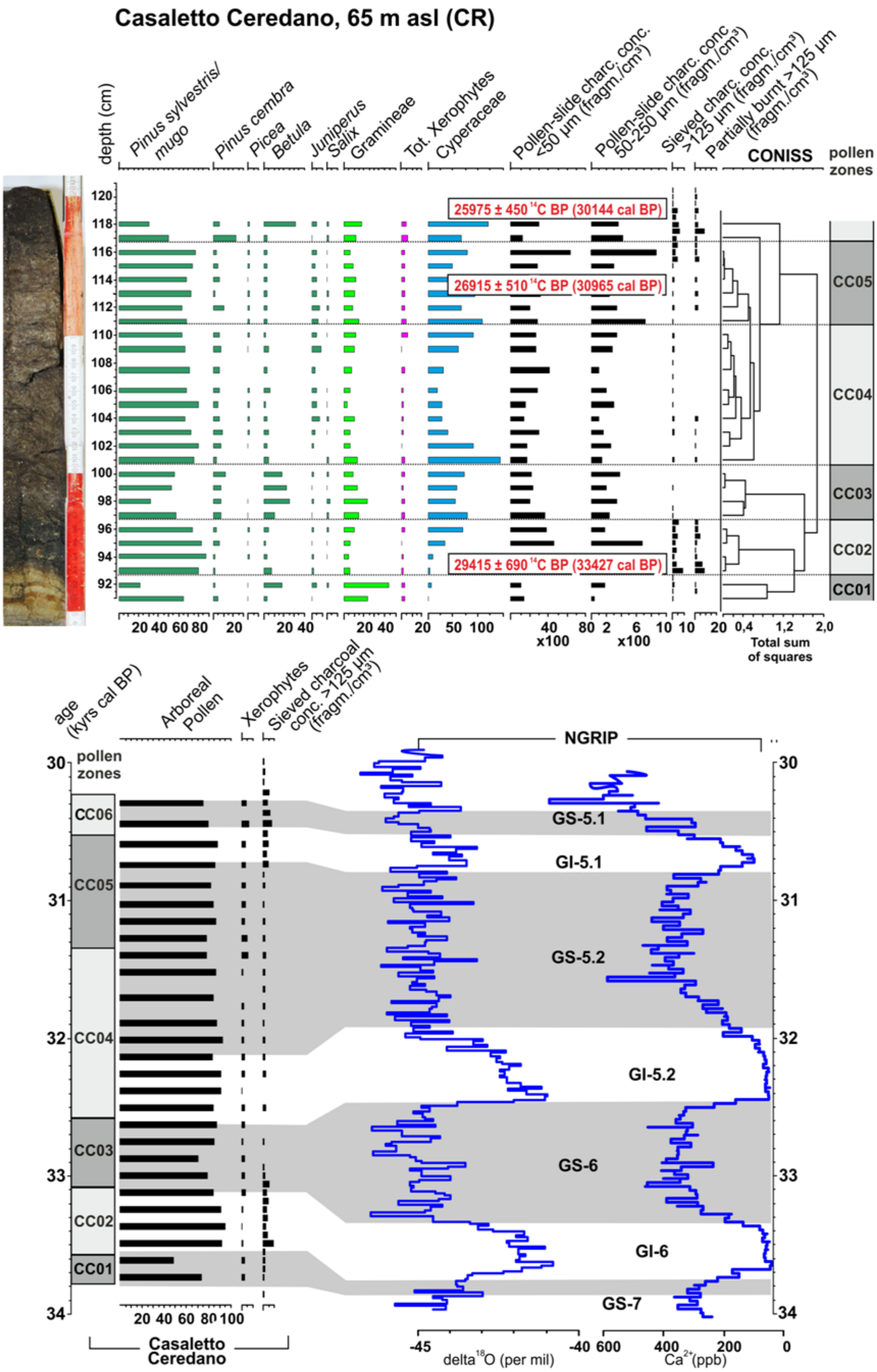
4. DISCUSSION AND CONCLUSION

The compressed peat deposit at Casaletto Ceredano formed in a long-lasting wetland occupied by a terrestrial marsh and finally by a swamp forest, subtly fed by silt from the Adda River catchment. The radiocarbon sequence robustly points to the persistence of this regime for about three millennia. This requires an overall subsurface water saturation, favoured by a thin-grained texture (silty sands), and excludes fast river dynamics and aggradation processes in the area, which would have implied an immediate wetland burial by an actively growing minerogenic plain surface. Accordingly, sediment accumulation rate for the underlying minerogenic deposits (0.16 mm/a between 37.1 and 33.4 cal ka BP) is low compared to estimated LGM fluvio-glacial rates. Compressed peat layers are common in the lower Adda valley alluvial record (Casaletto Ceredano unit, see Ravazzi et al., 2012), but so far dated to > 40 cal ka BP, thus accumulation rates could not be measured yet. An impressive amount of Late Pleistocene mammal remains, including one Neanderthal frontal bone, have been rielaborated, mostly from the Casaletto Ceredano unit and heteropic units formed in adjacent river catchments, and accumulated downstream in secondary deposition (Persico et al., 2015). Recent downcutting provides field evidence of post-depositional deformation in these peat seams, suggesting that Late Pleistocene deformational events may be of importance for the paludification history of the area, e.g. through the development of microrelief and channel diversions.

Palaeobotanical analysis established that pine and birch forests persisted across the late MIS 3 on stable surfaces in the lower Adda Valley, regardless to intervening millennial climate variability. Edaphic and topographic factors and ecological disturbance changes are believed to have modulated the extent of open habitats (open drylands on sandy river channels and bars, tree-

Section	Material	Laboratory code	^{14}C a BP	Calibrated 2σ Range	Calibrated age median value	^{13}C ‰
Cs-Cer1	wood fragment from the outer rings of a tree stem	Ua-33261	25975 ± 450	29172 - 30987	30144	
Cs-Cer2	wood fragment from the outer rings of a tree stem	Ua-34537	26915 ± 510	27834 - 29857	30965	-27
Cs-Cer2	cm-sized wood charcoal	Ua-34536	29415 ± 690	31724 - 34791	33427	-25,5
Cs-Cer1	cm-sized wood charcoal	Ua-33262	32950 ± 1070	34180 - 39533	37153	

Tab. 1 - Radiocarbon ages obtained on terrestrial plant remains from the Casaletto Ceredano sections.


Casaletto Ceredano, 65 m asl (CR)
depth (cm)
Pinus sylvestris/ mugo
Pinus cembra
Picea
Betula
Juniperus
Salix
Gramineae
Tot. Xerophytes
Cyperaceae
Pollen-slide charc. conc. >250 µm (fragm./cm³)
Pollen-slide charc. conc 50-250 µm (fragm./cm³)
Sieved charc. conc. >125 µm (fragm./cm³)
Partially burnt >125 µm (fragm./cm³)
CONISS
pollen zones
25975 ± 450 ¹⁴C BP (30144 cal BP)
26915 ± 510 ¹⁴C BP (30965 cal BP)
29415 ± 690 ¹⁴C BP (33427 cal BP)
CC05
CC04
CC03
CC02
CC01
x100
x100
Total sum of squares
age (kyrs cal BP)
Arboreal Pollen
Xerophytes
Sieved charcoal conc. >125 µm (fragm./cm³)
NGRIP
pollen zones
CC06
GS-5.1
GI-5.1
GS-5.2
GI-5.2
GS-6
GI-6
GS-7
Casaletto Ceredano
delta¹⁸O (per mil)
Ca²⁺(ppb)

less wetlands depending on subsurface water saturation, fire avoiding wetland areas). Still, climate variability may have acted as the ultimate factor driving the alluvial geo-ecological system. In Fig. 3 (lower panel) we compare isotope and dust proxies from the NGRIP core depicting stadial-interstadial sequence between 30 and 34 cal ka BP (Rasmussen et al., 2014) with the arboreal pollen and xerophyte pollen % from Casaletto Ceredano, plotted against their own age-depth model, and propose a tentative correlation. Notice that, in our record, fire phases marks enhanced forest phases (GI-6 and GI-5.2). Birch expansion occurred at the end of fire phases, mirroring the typical succession of modern boreal forests (Sannikov and Goldammer, 1996), and also lead to a slight arboreal pollen decrease, although open land did not expand henceforth. Stadial phases GS-6 and GS-5.2 might correlate to phases of higher water table, triggered by increased fluvio-glacial discharge. Overall, during late MIS 3 the central Po Plain remained under a cold temperate regional climate of middle boreal type (Moen, 1999), with T_{july} < 15°C, but well within the climatic woodland limits. Quantitative climate reconstructions are planned as next research step.

REFERENCES

Moen A. (1999) - National Atlas of Norway - Vegetation. Norwegian Mapping Authority, Honefoss, N., Persico D., Billia E.M.E., Ravara S., Sala B. (2015) - The skull of *Stephanorhinus kirchbergensis* (Jäger, 1839) (Mammalia, Rhinocerontidae) from Spinadesco (Cremona, Lombardia, Northern Italy): morphological analyses and taxonomical remarks - an opportunity for revising the three other skulls from the Po Valley. Quaternary Science Reviews, 109, 28-37.

Rasmussen S.O., Bigler M., Blockley S.P., Blunier T., Buchardt S.L., Clausen H.B., Cvijanovic I., Dahl-Jensen D., Johnsen S.J., Fischer H. et al. (2014) - A stratigraphic framework for abrupt climatic changes during the Last Glacial period based on three synchronized Greenland ice-core records: refining and extending the INTIMATE event stratigraphy. Quaternary Science Reviews, 106, 14-28.

Ravazzi C., Deaddis M., De Amicis M., Marchetti M., Vezzoli G., Zanchi A. (2012) - The last 40 ka evolution of the Central Po Plain between the Adda and Serio Rivers. Géomorphologie: relief, processus, environment, 2, 131-154.

Reimer P.J, Bard E., Bayliss A., Beck J. W., Blackwell P.G., Bronk Ramsey C., Buck C.E., Cheng H., Lawrence Edwards R., Friedrich M., Grootes P.M. et al. (2013) - IntCal13 and Marine13 Radiocarbon Age Calibration Curves 0–50,000 Years cal BP. Radiocarbon, 55 (4), 1869-1887.

Sannikov S.N., Goldammer J.G. (1996) - Fire Ecology of Pine Forests of Northern Eurasia. In (Goldammer J.G. & Furyaev V.V. , eds.) Fire in Ecosystems of Boreal Eurasia. Forestry Science, 48, 151-167. Kluwer Academic Publishers, Dordrecht.

Ms. received: May 4, 2018
Final text received: May 16, 2018

<< <<< ------- -------

Fig. 3 - (**upper panel**) - Palaeobotanical proxies, pollen zonation and radiocarbon ages obtained from the compressed peat layer at Casaletto Ceredano, lower Adda River valley, central Po Plain, plotted against stratigraphy. (**lower panel**) - Summary palaeobotanical proxies (Arboreal pollen; sum of xerophytes - i.e. *Artemisia, Ephedra,* Chenopodiaceae*, Hippophaë*; sieved charcoal) plotted against chronology and compared with isotope and dust proxies from the NGRIP core.