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► **To cite this version:**

Janet Battentier, Didier Binder, Sébastien Guillon, Roberto Maggi, Fabio Negrino, et al.. Environment of the last hunters-gatherers and first agro-pastoralists, in the west Mediterranean, between the Rhone and the Northern Apennines (7th - 6th millennium cal. BCE): attractiveness of the landscape units and settlement patterns. *Quaternary Science Reviews*, 2018, 184, pp.167-182. 10.1016/j.quascirev.2017.08.013 . hal-02009522

HAL Id: hal-02009522

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The environment of the last hunters-gatherers and first agro-pastoralists in the western Mediterranean region, between the Rhone and the Northern Apennines (7th - 6th millennium cal. BCE): Attractiveness of the landscape units and settlement patterns

Janet Battentier ^{a,*}, Didier Binder ^a, Sebastien Guillon ^a, Roberto Maggi ^b, Fabio Negrino ^c, Ingrid Sénépart ^a, Carlo Tozzi ^d, Isabelle Théry-Parisot ^a, Claire Delhon ^a

^a Université Côte d'Azur, CNRS, CEPAM, Campus Saint-Jean d'Angély 3, 24 avenue des Diables Bleus, FR-06357 Nice cedex 4, France

^b Istituto internazionale di studi liguri, Via Tigula 40, I-16033 Lavagna, Italy

^c Università di Genova, Dipartimento di Antichità, Filosofia, Storia, Geografia, Via Balbi 2, I-16136 Genova, Italy

^d Università di Pisa, Dipartimento di Civiltà e forme del sapere, Via dei Mille 19, I-56126 Pisa, Italy

ARTICLE INFO

Article history:

Received 8 March 2017

Received in revised form

15 July 2017

Accepted 11 August 2017

Available online xxx

Keywords:

Late mesolithic

Impressed ware

North-western mediterranean

Settlement

Landscape

Abies

ABSTRACT

In the north western Mediterranean, in the area between the Rhone River and the Northern Apennines, the last Mesolithic societies (Castelnovian) and the first Neolithic societies (Impressed Ware or *Impressa*) coexisted during the first half of the 6th millennium cal. BCE (Before Common Era). Linking the two settlement distribution patterns (mainly high lands and low lands for the Castelnovian *versus* Mediterranean coastal areas for the *Impressa*) to their specific environmental backgrounds during that period of coexistence enables us to document the attractiveness of the various available landscape units as a function of the subsistence practices (hunting, fishing and gathering *versus* agro-pastoralism). Pollen and charcoal data from 41 archaeological sites along with contemporaneous natural (off archaeological sites) sequences (hereafter referred to as "off-site sequences") from three windows (Provence/Western Liguria, the middle Rhone valley/Prealps and Southern Alps, Eastern Liguria/Northern Apennines) were examined in order to reconstruct the vegetal landscape in the surroundings of the Mesolithic and Neolithic settlements between 6500 and 5400 cal. BCE. The importance of environmental *versus* cultural factors in the settlement preferences of both groups is discussed in order to document our reflection concerning non-consensual issues, such as the existence of interaction or avoidance behaviours or the sharing (or not) of parts or all of the territory and of its natural resources. The results notably highlight the expansion of fir forests that, based on ecological and accessibility criteria, could be considered as rather inauspicious for settlement and hunting as well as for pastoral activities. This expansion may have influenced the settlement patterns of both cultural complexes, leading populations to locate their settlements principally within landscape units that remained clear of extensive fir forests. It appears that, despite being motivated by the prevailing subsistence activities, the choice of an area of land for settlement is deeply guided by various other cultural factors which are less directly dependent upon natural resources. Thus, in an area providing a large range of possibilities, the landscape in which the groups establish themselves could be considered as just one of many cultural characteristics.

1. Introduction

Before the irreversible disappearance of hunter-gatherer groups

and the development of agro-pastoralism, the Tosco-Liguro-Provençal area, located between the Southern Alps and the Northern Apennines (North-Western Mediterranean, currently astride France and Italy), was occupied by the last Mesolithic populations (Castelnovian) and the first Neolithic ones (Impressed Ware, hereafter referred to as *Impressa*), which coexisted *lato sensu* during the first half of the 6th millennium BCE (all calibrated dates are

* Corresponding author.

E-mail address: janet.battentier@cepam.cnrs.fr (J. Battentier).

given BCE: Before Common Era). Material evidence of direct interaction between both groups is still lacking, but their coexistence at a regional scale, previously controversial, is now supported by a set of reliable radiocarbon dates which demonstrate an obvious overlap between the end of the Castelnovian and the beginning of the *Impressa*. On the one hand, new dates were recently obtained for deposits from the last stage of the Castelnovian at i.e. La Baume de Montclus (Beta-253161, C10B, 6990 ± 40 BP: 5984-5771 cal. BCE (Zó) and Beta-253160, C7, 6660 ± 40 BP: 5646-5512 cal. BCE, Perrin et al., 2009), La Grande Rivoire (Beta-282247, GR08.T17.d28.554.LGM(F), 6490 ± 40 BP: 5527-5367 cal. BCE, Nicod et al., 2012) and Monte Frignone II (LTL-2656A, US2, 6624 ± 45 BP: 5626-5487 cal. BCE, Dini and Fioravanti, 2011). They confirm and strengthen the dating evidence previously obtained at Lama Lite, in the Tosco-Emilian Apennines (Rome-394, US6, 6620 ± 80 BP: 5710-5391 cal. BCE, Dini and Fioravanti, 2011). On the other hand, the earliest *Impressa* is now accurately dated (from *Cerealia* caryopses) in Western Languedoc, Eastern Provence and Western Liguria, where it clearly predates the Castelnovian terminus (e.g. Pont de Roque-Haute: LY-9676, pit F1, 6820 ± 35 BP: 5755-5638 cal. BCE, Guilaine et al., 2007; L'abri Pendimoun: GR-29403, US28889, 6725 ± 45 BP: 5720-5560 cal. BCE, Binder and Sénépart, 2010; Arene Candide: OxA-23072, US10, 6778 ± 39 BP: 5728-5628 cal. BCE; San Sebastiano di Perti: GrA-25715, 6760 ± 45 BP: 5733-5575 cal. BCE, Biagi and Starnini, 2016). This coexistence took place in an area ranging from the Mediterranean coastal low lands to the adjacent mountain ranges, during the period of maturation of the mixed forest that characterizes the Early Atlantic palynozone. In this area, settlements reliably attributed to the Castelnovian and the *Impressa* cultural complexes are scarce and, in spite of recent improvements, are rarely satisfactorily dated (Castelnovian: Perrin, 2013; Perrin and Binder, 2014; Maggi and Negrino, 2016; Marchand and Perrin, 2017; *Impressa*: Binder and Maggi, 2001; Manen and Sabatier, 2003). Although they are partly coeval, remains of the material culture of both groups have so far never been found together on the same site. We, therefore, have to acknowledge that tangible evidence of any syncretism between them is totally lacking for now. Beyond this, on a regional scale, the two groups reveal different settlement distribution patterns: the Castelnovian sites are mainly found in the high lands and low lands rather than at medium altitudes (Binder, 2000; Biagi, 2001; Perrin, 2008; Perrin and Binder, 2014), whereas the known *Impressa* sites are only located on the coastal fringe (Binder and Maggi, 2001; Guilaine and Manen, 2007; Manen, 2014). On the *Impressa* sites, it is occasionally observed that a portion of the lithic resources originate from territories thought to have been “under the Castelnovian control” (Binder et al., 2008 p. 53), because of the absence of nearby coeval Neolithic sites. This suggests either an exchange relationship or the sharing of certain supply territories. Furthermore, the two cultures have different subsistence economies (hunting, fishing, gathering *versus* farming) which we assume implies different environmental managements, spatial organisations and mobility gradients (nomadic *versus* semi-sedentary ways of life respectively). In this area, the coexistence of these two populations, which have very different ways of life, and the scarcity of evidence of a direct relationship between them raises crucial and non-consensual issues about their interactions and the admixture process (Binder and Guilaine, 1999; Perrin, 2013; Perrin and Binder, 2014).

Assuming that the distribution patterns of the few dated archaeological sites of both groups are, at least partly, representative of their settlement strategies, the Castelnovian and the *Impressa* populations may have preferred to settle in different and separate territories. This distinctive distribution might be linked either to an avoidance strategy (Binder and Guilaine, 1999; Binder,

2000; Binder and Maggi, 2001) or to their respective technical, economic and cultural characteristics involving the appeal or lack of attractivity of different landscape units. Thus, documenting the environment of both groups enables the possible locations and the modalities of their hitherto hypothetical interactions to be identified. In order to discuss the weight of environmental *versus* cultural factors in the location strategies of both groups, we have reviewed environmental data from archaeological sites along with nearby and contemporaneous natural, off archaeological site, sedimentary sequences (hereafter referred to as “off-site sequences”). Taking account of similarities or discrepancies in the attractiveness of landscape units is a new and challenging way of documenting interaction or avoidance behaviours between the hunter-gatherer and the agro-pastoralist groups.

2. Regional setting

2.1. Environmental framework

The Tosco-Liguro-Provençal area stretches from south to north between c. 43 and 45°, from the Mediterranean Sea to the transition between the Southern and the Northern Alps, and from the west to the east between c. 4 and 10°, from the Rhone valley to the Northern Apennines (the Tosco-Emilian Apennines).

In this area, the Alpine, Apennine and Pyreneo-Provençal ranges converge and plunge into the Mediterranean Sea, resulting in very narrow and discontinuous coastal plains, especially in the area stretching from Eastern Provence to the Northern Apennines. Nowadays, the topography and the climate, mainly Mediterranean (summer drought, heavy seasonal rainfall, wind, frequent fires) but progressively shifting towards a more mountain character (cold winter, snow), favour erosion processes of limestone (widespread) and crystalline (more localised) substrata (Fel, 1962; Gouvernet et al., 1971).

These conditions result in a zonation of the vegetal association which is usually described as being staged in 6 belts, from the thermomediterranean stage, limited to restricted locations on the coast, to the alpine stage, above the treeline. Assuming that the evergreen formations, which are currently characteristic of the mesomediterranean belt, mainly spread after the mid-5th millennium in response to anthropic disturbance, the zonal vegetal associations during the first half of the 6th millennium BCE consisted of deciduous supramediterranean oak forests, mixed oak/beech/conifers (pine, fir) mountain associations, and conifer (spruce, larch, pine, juniper) subalpine formations (Ozenda, 1985; Renault-Miskovsky et al., 1992; Karatsori, 2003; Branch and Morandi, 2015). The alpine treeless formations were probably present in the Southern Alps, which culminate at high altitude (4102 m a.s.l.), but it is likely that scattered trees reached the summits of the Northern Apennines (2165 m a.s.l.).

2.2. Cultural framework

2.2.1. The Castelnovian

The Castelnovian is the latest aspect of the Mesolithic in Southern France and Italy (Marchand and Perrin, 2017). It spread from Southern Italy to Northern Italy and hence to Southern France between c. 6600 and 5600/5400 BCE (Binder, 2013; Binder et al., 2017). It is regarded by several archaeologists as a filiation of the North Africa Upper Capsian (Binder, 2000; Perrin, 2009; Binder et al., 2012) and its subsistence economy was mainly based on the hunting of ibex (*Capra ibex*), chamois (*Rupicapra rupicapra*), red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), boar (*Sus scrofa*), but also smaller prey such as marmot (*Marmota marmota*) and Leporidae (Courtin et al., 1985; Biagi, 2001; Nicod et al., 2012;

Bintz and Millet, 2013). Gathering of European pond turtles (*Emys orbicularis*) and of shellfish is attested, as well as fishing (Courtin et al., 1985; Royer et al., 2011). To date, the gathering and consumption of plants is poorly documented. This subsistence economy suggests the exploitation of a broad altitudinal gradient, ranging from the sea to the mountains, associated with considerable mobility.

2.2.2. Early Neolithic Impressa

The *Impressa* is represented by small pioneering groups of agro-pastoralist settlers who rapidly spread from the Adriatic-Ionian coast and the far South of Italy and Sicily to the north-eastern coasts of the Western Mediterranean between 5900/5800 and 5600/5400 BCE (Guilaine et al., 2007; Binder, 2013; Manen, 2014), probably by sea: seafaring is demonstrated by the transfer of Tyrrhenian obsidian (Briois et al., 2009; Binder et al., 2012). The subsistence economy mainly consists of sheep and cattle herding (Rowley-Conwy et al., 2013), growing of cereal crops (mainly *Triticum dicoccum* and *Hordeum vulgare*), as well as shellfish collection (Binder et al., 1993; Marinval, 2007). The emergence of herding and cultivation implies new modalities of environmental management and of spatial organisation which presuppose reduced mobility compared to the hunter-gatherer groups.

2.2.3. Distribution patterns of the Castelnovian and Impressa sites

Although some exploited areas may have been disconnected from the habitation sites, we assume that the location of the known archaeological sites is at least partly representative of the territories where the main activities were conducted. In this study we focus on the distribution of sites in the Tosco-Liguro-Provençal area, where both Castelnovian and *Impressa* cultural complexes are present (Fig. 1 and Table 1). Moreover, in our assessment of the settlement distribution pattern of both communities we have to rely on those sites that have been preserved, discovered and properly excavated:

clearly such sites only represent a portion of those that originally existed. We are aware that the processes of progradation (Sivan et al., 2010), sea level rise (Guilaine and Manen, 2007; Perrin, 2008), and erosion - sometimes enhanced by climatic events (Berger and Brochier, 2000; Berger, 2005; Berger and Guilaine, 2009) - have impacted on the preservation and the burying of remains. Nevertheless, as the Castelnovian and the *Impressa* communities lived in small groups and were only present for few centuries (Perrin and Binder, 2014; Manen, 2014), their settlements may have been scarce, which at least partly explains the scarcity of the related archaeological sites. Taking all of these potential biases into account, it is still apparent that the distribution pattern of each group, reconstructed from the available archaeological data, is not random and presents its own strong characteristics. For each cultural complex, we have considered the sites that i/are sufficiently well characterized at the archaeological level to be unambiguously attributed to the Castelnovian or to the *Impressa* culture, ii/are well dated and iii/either provide archaeobotanical data or are related to palaeoenvironmental off-site records (mainly pollen sequences). In a few cases, undated or poorly dated sites were included on the basis that their industries were sufficiently characteristic of one or other of the two cultural complexes.

2.2.3.1. *Castelnovian*. Within the chosen window, only ten sites present both well-documented Castelnovian industries and reliable dates performed on short-lived remains (vegetal or other). Two further sites (Jausiers-Sagnes; Faravel XVIII) present Castelnovian-like industries and are valuable because they are located in an area where vegetation data is reliable although the sites themselves remain undated. Most of the excavated or potential Castelnovian sites are interpreted as hunting camps (Barker et al., 1990; Biagi, 2003; Walsh et al., 2014) although the context is sometimes unclear (Maggi and Negrino, 2016). They are mainly located in Eastern Liguria/Northern Apennines as well as in a broad area on both sides

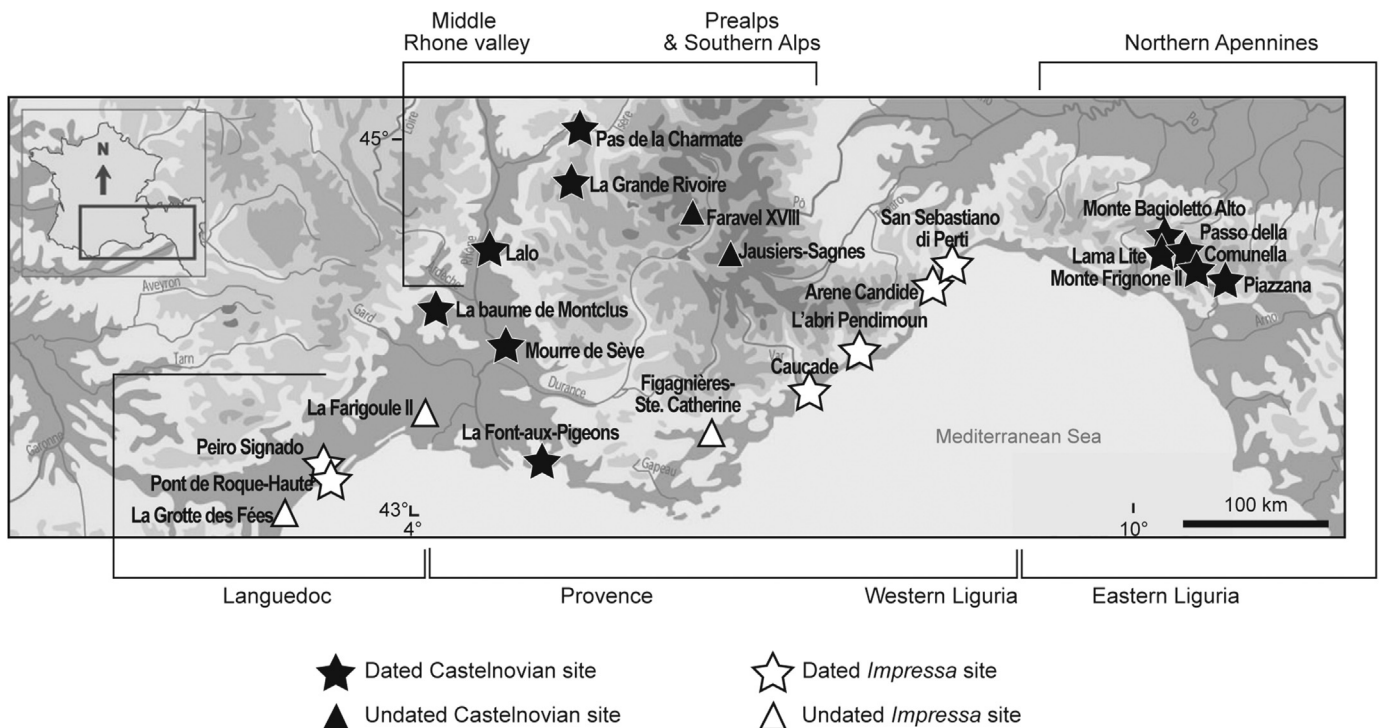


Fig. 1. Locations of the most reliably identified Castelnovian and *Impressa* sites (see Table 1 for details). "Dated sites" refers to sites providing reliable date(s) for the Castelnovian or *Impressa* levels; "undated sites" refers to sites without dates or whose date(s) is (are) considered to be insufficiently reliable.

Table 1
Most reliable Castelnovian and *Impressa* sites in the Tosco-Liguro-Provençal area and in Languedoc, with the corresponding geographical subwindow and altitudinal class. The ^{14}C dates were 2σ calibrated using IntCal 13 and OxCal 4.2.4 software (Reimer et al., 2013).

Site	Cultural Complex	Approximate altitude	Subwindow	Altitudinal classes	Calibrated range of dates (BCE)	References
La Grotte des fées	<i>Impressa</i>	20	Languedoc	Low lands	/	Guilaine, 1985
Pont de Roque-Haute	<i>Impressa</i>	20	Languedoc	Low lands	5877–5527	Manen and Sabatier, 2003; Guilaine et al., 2007
Peiro Signado	<i>Impressa</i>	20	Languedoc	Low lands	5841–5564	Manen and Sabatier, 2003
La Farigoule II	<i>Impressa</i>	50	Languedoc	Low lands	/	Raux, 2015
La Font-aux-Pigeons	Castelnovian	93	Provence & W. Liguria	Low lands	6442–6225	Courtin et al., 1985; Binder et al., 2017
Le Mourre du Sève	Castelnovian	100	Provence & W. Liguria	Low lands	6657–6105	Binder, 2004
La Baume de Montclus	Castelnovian	90	Provence & W. Liguria	Low lands	6210–5512	Perrin et al., 2009; Perrin and Defranould, 2016
Figanières-Ste. Catherine	<i>Impressa</i>	300	Provence & W. Liguria	Low lands	/	Binder and Maggi, 2001
Caucade	<i>Impressa</i>	44	Provence & W. Liguria	Low lands	5978–5491	Binder, 1995; Binder and Sénépart, 2010
L'abri Pendimoun	<i>Impressa</i>	690	Provence & W. Liguria	Middle lands	5741–5475	Binder et al., 1993; Binder and Sénépart, 2010
Arene Candide	<i>Impressa</i>	85	Provence & W. Liguria	Low lands	5790–5639	Maggi, 1997; Binder and Maggi, 2001
San Sebastiano di Perti	<i>Impressa</i>	20	Provence & W. Liguria	Low lands	5733–5575	Capelli et al., 2006
Passo della Comunella	Castelnovian	1617	E. Liguria & N. Apennines	Upper lands	6215–5716	Cremaschi and Castelletti, 1975
Monte Bagioletto Alto	Castelnovian	1700	E. Liguria & N. Apennines	Upper lands	6825–6228	Cremaschi et al., 1984
Lama Lite	Castelnovian	1764	E. Liguria & N. Apennines	Upper lands	5710–5391	Castelletti et al., 1994
Monte Frignone II	Castelnovian	1280	E. Liguria & N. Apennines	High lands	5626–5487	Dini and Notini, 2007; Dini and Fioravanti, 2011
Piazzana	Castelnovian	820	E. Liguria & N. Apennines	High lands	6379–6053	Biagi et al., 1980; Castelletti et al., 1994
Lalo	Castelnovian	120	Middle Rhone valley, Prealps & S. Alps	Low lands	6361–5357	Berger et al., 2002, 2016
La Grande Rivoire	Castelnovian	580	Middle Rhone valley, Prealps & S. Alps	Middle lands	6688–5320	Nicod et al., 2012; Angelin et al., 2016
Pas de la Charmate	Castelnovian	1100	Middle Rhone valley, Prealps & S. Alps	High lands	7291–6466	Bintz et al., 1995
Jausiers-Sagnes	Castelnovian	1900	Middle Rhone valley, Prealps & S. Alps	Upper lands	/	Garcia et al., 2007
Faravel XVIII	Castelnovian	2130	Middle Rhone valley, Prealps & S. Alps	Upper lands	/	Walsh et al., 2014

of the middle Rhone valley, Prealps and Southern Alps (Picavet et al., 2014): they are absent from Western Liguria/Eastern Provence (Fig. 1). Moreover, they seem to be mainly distributed below 200 m a.s.l and above 800 m a.s.l (Table 1), whereas they are much rarer at medium altitude (Biagi, 2001; Perrin, 2008; Franco, 2011). The highest settlements are assumed to be hunting camps which were frequented during the warmer months (Biagi et al., 1980; Castelletti et al., 1994; Franco, 2011; Walsh et al., 2014). Despite the lack of evidence, it seems reasonable to assume that lower settlements were occupied during the coldest months (Biagi, 2001, 2003; Franco, 2011), notwithstanding that they may have been used at various seasons considering the low level of climatic constraint. The settlements also seem to be preferentially located where aquatic resources are available (Biagi et al., 1980; Binder, 2000; Franco, 2011), with a particular preference for freshwater. The attraction of flint resources has also been suggested (Binder, 2000; Binder and Maggi, 2001; Perrin, 2008), as the known sites tend to concentrate in areas where flint and/or other lithic resources, such as jasper, are abundant and of good quality.

2.2.3.2. *Impressa*. The very few confirmed *Impressa* settlements are located on the littoral (Fig. 1 and Table 1), mainly at low altitude, on the coast of Eastern Provence/Western Liguria (Guilaine and Manen, 2007; Binder et al., 2008; Perrin, 2008; Manen, 2014). At least two important *Impressa* sites are known in Languedoc, which occupies the western part of the French Mediterranean coast. Nevertheless, due to the lack of environmental data linked to these

occupations, we have chosen to restrict the study to the Tosco-Liguro-Provençal zone. In the study area, documented settlements mainly take the form of rock-shelters or caves (Barker et al., 1990; Maggi and Negrino, 2016) and it is difficult to assess their representativeness for the whole territory (Binder and Maggi, 2001). It is also difficult to determine their length of occupation although the growing of cereals crops generally implies reduced mobility, at least for part of the group, over several months. Finally, while proximity to the coast appears to have influenced the settlement of *Impressa* populations, their distribution pattern also appears, in the present state of the knowledge, to have been restricted to areas that seem free of any Castelnovian occupation (Fig. 1 and Table 1). This situation has been interpreted as being linked either to the organisation of each socio-economic model *per se* (need for abundant, good quality mineral raw materials particularly available in the hinterland vs. strong connection to the sea) or as an avoidance strategy between both populations (Binder and Guilaine, 1999; Binder, 2000; Binder and Maggi, 2001). In the Tosco-Liguro-Provençal area, the site distribution patterns, if they are representative of the real settlement patterns, might suggest that the Castelnovians were an obstacle to the spread of Neolithic cultural features (Binder and Guilaine, 1999; Binder, 2000; Binder and Maggi, 2001). This echoes the “dual model” described in the Iberian Peninsula (Juan-Cabanilles, 1990; García-Puchol et al., 2009) where the neolithisation of the hunters-gatherers occurred after a period of persistence of the Mesolithic tradition.

3. Material and methods

In order to reconstruct the landscape of each Castelnovian and *Impressa* site, we reviewed the available pollen and charcoal data in the study area for the period concerned. The data taken into account was obtained not only directly from the archaeological sites, but also from off-site sequences from the same area that include levels accurately dated to between 6500 and 5400 BCE (Fig. 2, Tables 2 and 3). Archaeological sites mainly provided charcoal data and occasionally pollen data. We selected only those sites with accurate radiocarbon dates, carried on layers well documented and culturally characterized (Fig. 2 and Table 2). Off-site sequences (Fig. 2 and Table 3) provided pollen and, occasionally, charcoal data (Les Brassières). In order to maintain an operating scale, the data from archaeological sites and those from off-site sequences were considered in geographical clusters. Three zones were defined which provided sufficient data and which were considered sufficiently coherent from a biogeographical point of view: these zones stretch from the low lands to the high lands. Within each zone, the data were classified according to four altitudinal classes. From west to east, the geographical subwindows are as follows: middle Rhone valley/Prealps and Southern Alps; Provence/Western Liguria; Eastern Liguria/Northern Apennines (Fig. 2). From the sea to the mountains, the four altitudinal classes are: low, middle, high and upper lands (Table 4).

A number of challenges and difficulties are encountered in the reconstruction of landscape using different proxies from different kinds of records. Charcoal analysis only provides information about woody plants whereas palynology also records herbaceous plants.

Moreover, the accuracy of the taxonomical determinations may vary depending on the taxa and on the nature of the studied remains (Table 5). Charcoal and pollen assemblages have different catchment sizes since pollen accumulates partly through airborne transportation, sometimes over long distances, whereas charcoal fragments primarily document the nearby environment. Otherwise, the mechanism by which the assemblages form, through natural processes or through human gathering of plants, also influences the exhaustiveness and the spatial scale of the record. Finally, the conditions required for the preservation of the signal may skew the reconstruction of the vegetal associations at a regional level, as pollen sampling mainly concerns wet areas (marsh and swamp areas in the lower Rhone valley, lakes in the mountains) and thus may overestimate the part played by hygrophilic and mesophilic taxa that thrive in such conditions (Delhon et al., 2010). As a consequence of these processes but also of the targets favoured by the researchers in each area, the altitudinal distribution of the data is very disparate. Provence/Western Liguria is documented mainly by low altitude pollen sequences and charcoal analyses, while a broad gradient of altitude is covered by accurately dated pollen sequences in the Northern Apennines (Tables 2 and 3). However, in the same area, charcoal analyses from Castelnovian settlements are based on small and/or hand-picked samples thereby only providing qualitative results (e.g. Piazzana, Monte Bagioletto Alto, Lama Lite). In the middle Rhone valley/Prealps and Southern Alps, the archaeological sites provide accurate data, but a sedimentary hiatus, potentially due to the 8200 cal. BP event (c. 6200 BCE), is frequently encountered in the off-site sequences (Berger, 2005; Berger and Guilaine, 2009) (Fig. 4,

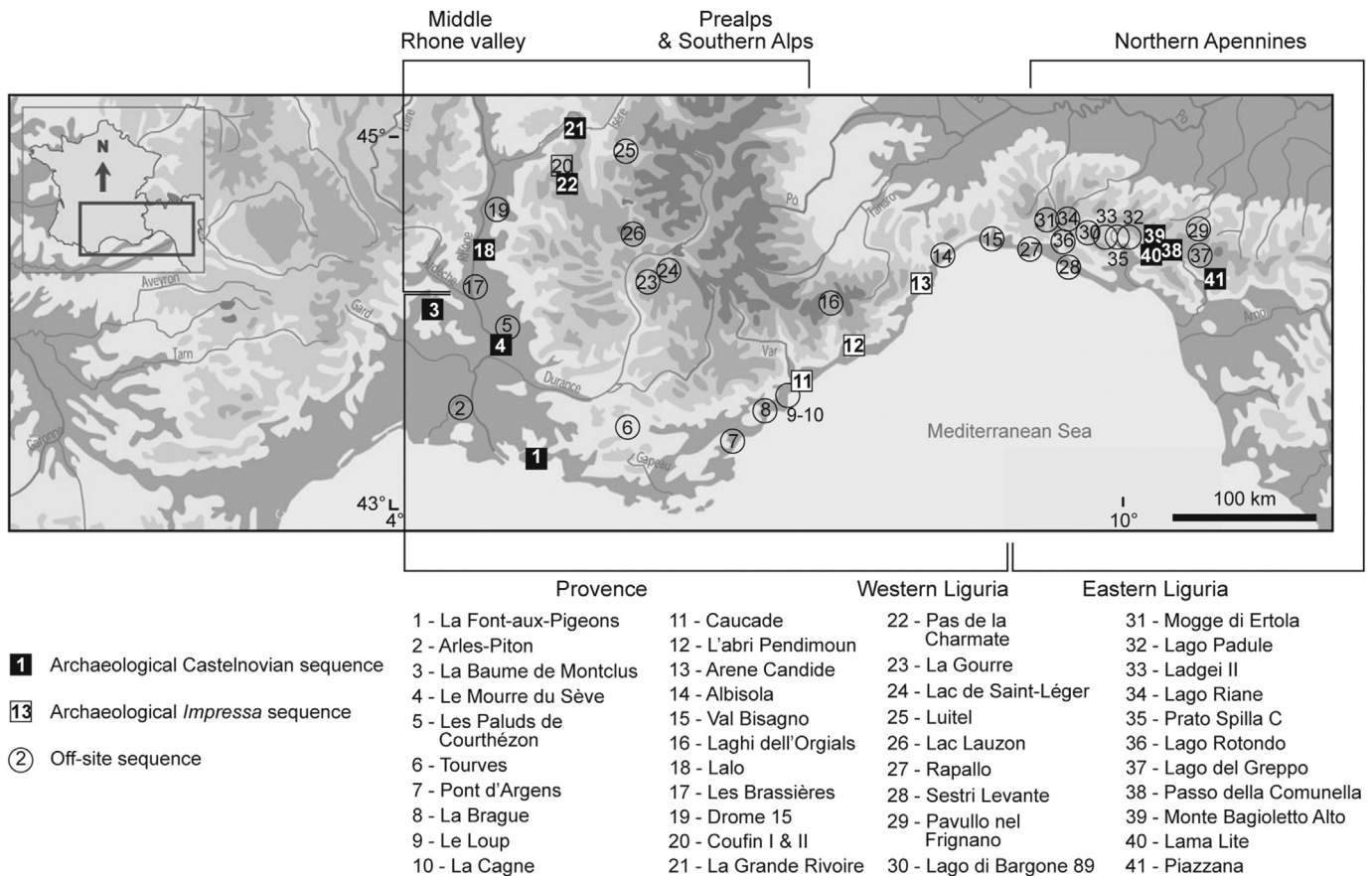


Fig. 2. Sources of pollen and charcoal data used in the study. Squares: archaeological sequences (see Table 2 for details), dots: off archaeological site sedimentary sequences referred as off-site sequences (see Table 3 for details).

Table 2
Charcoal and pollen data from archaeological sequences, with the corresponding geographical subwindow and altitudinal class. The ^{14}C dates were 2σ calibrated using IntCal 13 and OxCal 4.2.4 software (Reimer et al., 2013).

ID	Site	Sequence	Data	Approximate altitude	Subwindow	Altitudinal classes	Calibrated range of dates (BCE)	References
1	La Font-aux-Pigeons	Archaeological	Charcoal	93	Provence & W. Liguria	Low lands	6442–6225	Vernet, 1971; Bazile-Robert, 1984; Thiébaud, 1999
3	La Baume de Montclus	Archaeological	Charcoal	90	Provence & W. Liguria	Low lands	6210–5512	Bazile-Robert, 1983
4	Le Mourre du Sève	Archaeological	Charcoal	100	Provence & W. Liguria	Low lands	6657–6105	Thiébaud, 1999
11	Caucade	Archaeological	Charcoal	44	Provence & W. Liguria	Low lands	5978–5491	Thiébaud, 1999
12	L'abri Pendimoun	Archaeological	Charcoal	690	Provence & W. Liguria	Middle lands	5741–5475	Thiébaud, 1995, 1999; Battentier et al., 2015
13	Arene Candide	Archaeological	Charcoal	85	Provence & W. Liguria	Low lands	5790–5639	Fancelli Galletti, 1972; Nisbet, 1997, 2008
18	Lalo	Archaeological	Charcoal	120	Middle Rhone valley, Prealps & S. Alps	Low lands	6361–5357	Berger et al., 2002, 2016
20	Coufin I & II	Archaeological	Pollen + Charcoal	550–580	Middle Rhone valley, Prealps & S. Alps	Middle lands	7542–4616	Bui Thi Maï et al., 1987; Thiébaud, 1991, 1999
21	La Grande Rivoire	Archaeological	Charcoal	580	Middle Rhone valley, Prealps & S. Alps	Middle lands	6688–5320	Thiébaud, 1999
22	Pas de la Charmate	Archaeological	Charcoal	1100	Middle Rhone valley, Prealps & S. Alps	High lands	7291–6466	Thiébaud, 1991, 1999
38	Passo della Comunella	Archaeological	Charcoal	1617	E. Liguria & N. Apennines	Upper lands	6215–5716	Cremašchi and Castelletti, 1975; Castelletti et al., 1976, 1994
39	Monte Bagioletto Alto	Archaeological	Pollen + Charcoal	1700	E. Liguria & N. Apennines	Upper lands	6825–6228	Panizza et al., 1982; Cremašchi et al., 1984; Castelletti et al., 1994
40	Lama Lite	Archaeological	Charcoal	1764	E. Liguria & N. Apennines	Upper lands	5710–5391	Castelletti et al., 1976, 1994
41	Piazzana	Archaeological	Charcoal	820	E. Liguria & N. Apennines	High lands	6379–6053	Castelletti, 1984; Castelletti et al., 1994

Tables 2 and 3). Moreover, the high land sequences from the Alps (Lac de Saint-Léger, La Gourre) provide very condensed sediment accumulation which hinders the understanding of the vegetation dynamics.

In order to compare them, charcoal and pollen data were summarized and homogenised and the assemblages were considered in terms of large vegetal associations: “larch open formations”, which refers to clear forests or woody meadows where larch is the most frequent tree; “fir forest”, which refers to rather dense forests dominated by fir; “juniper steppe”, which refers to open steppe formations with juniper (presumably mostly *Juniperus communis*); “open formation”, which refers to open landscapes with clumps of ash, alder and willow in humid areas; “mixed deciduous oak forests”, which refers to mixed deciduous forests where deciduous oak is significant and to the related more open or more humid associations; “evergreen association”, which refers to more or less open Mediterranean evergreen formations (matorral, holm oak forests) characterized by sclerophyllous trees and shrubs (Table 5). Due to the fact that pine produces large quantities of pollen that diffuses over wide areas, its presence and abundance were only considered on the basis of charcoal data.

Once converted into vegetal associations, the data were sorted chronologically (on the basis of the available ^{14}C dates) and geographically. Within each of the three subwindows (Figs. 3–5), the data were considered in relation to their altitudinal classification.

4. Vegetal landscapes surrounding the Castelnovian and *Impressa* settlements

4.1. Provence and Western Liguria (Fig. 3)

Pollen analyses from this coastal region are characterized by short-term variations in the riparian formation resulting from

eustatic, geomorphologic and hydrologic evolution (Guillon, 2014a and b). Besides these frequent local changes adjacent to the water courses, a more long-term regional vegetal dynamic is recorded. Before c. 6000 BCE, at low altitude, the windy, dry slopes of Western Provence sometimes support a pioneer or post-pioneer juniper steppe-like formation consisting of sparse, light-demanding, hardy shrubs or small trees, such as juniper, and evergreen broadleaved species such as buckthorn or phillyrea (cf. La Font-aux-Pigeons) and hazel in more humid areas (cf. La Baume de Montclus). After c. 6000 BCE, these formations almost disappear from the record. At higher altitude, open stands mainly consisting of larch seem to prevail in the environs of Laghi dell’Orgials (2240 m a.s.l.), above denser fir forests (Ortu et al., 2005). As its pollen dispersion is weak (Mazier et al., 2008) and its pollen production is rather low (Geburek et al., 2012), fir abundance suggests that forest stands with closed canopy were present at a relatively short distance from the sampling site. As fir forests require sufficient soil and air moisture, at times they may have shared the same space with deciduous oak forests in the Ligurian low lands (Val Bisagno) (Montanari et al., 1998). In the Provence low and middle lands (L’abri Pendimoun, Tourves, Les Paluds de Courthézon and Le Mourre du Sève) mixed forests, principally consisting of deciduous oak, lime and elm associated with fringe taxa, prevailed. At low and middle altitudes, evergreen formations, which are more adapted to drought, discreetly rise from the second half of the 7th millennium BCE but maintain a reduced presence in the landscape. The first anthropogenic pollen indicators, consisting of cereal pollen including *Hordeum* sp., accompanied by the rise of grasses and forbs to the detriment of the alluvial forest, appear to date to between 6071 and 5916 BCE and 5882–5719 BCE in the lower valley of the river Loup (Guillon, 2014a and b). So far, these indications of cereal cultivation are not directly linked to any material remains of early Neolithic occupation, but they are synchronous with - and probably even somewhat earlier than - the *Impressa* settlements at L’abri

Table 3

Charcoal and pollen data from off-site sequences, with the corresponding geographical subwindow and altitudinal class. The ^{14}C dates were 2σ calibrated using IntCal 13 and OxCal 4.2.4 software (Reimer et al., 2013).

ID Site	Sequence Data	Approximate altitude	Subwindow	Altitudinal classes	Calibrated range of dates (BCE)	References
2 Arles-Piton	Off-site Pollen	10	Provence & W. Liguria	Low lands	6205–5531	Arnaud-Fassetta et al., 2005
5 Les Paluds de Courthézon	Off-site Pollen	32	Provence & W. Liguria	Low lands	6563–5893	Triat-Laval, 1978
6 Tourves	Off-site Pollen	298	Provence & W. Liguria	Low lands	6209–2794	Nicol-Pichard, 1987
7 Pont D'Argens	Off-site Pollen	12	Provence & W. Liguria	Low lands	6454–5797	Dubar et al., 2004, 2011
8 La Brague	Off-site Pollen	6	Provence & W. Liguria	Low lands	7547–7085	Nicol-Pichard and Dubar, 1998; Dubar et al., 2011
9 Le Loup	Off-site Pollen	10	Provence & W. Liguria	Low lands	6654–6237	Guillon, 2014a and b
10 La Cagne	Off-site Pollen	10	Provence & W. Liguria	Low lands	6425–5005	Guillon et al., 2010; Guillon, 2014a and b
14 Albisola	Off-site Pollen	6	Provence & W. Liguria	Low lands	6216–5931	Arobba et al., 2001
15 Val Bisagno	Off-site Pollen	50	Provence & W. Liguria	Low lands	6078–5026	Montanari et al., 1998
16 Laghi dell'Orgials	Off-site Pollen	2240	Provence & W. Liguria	Upper lands	6774–3366	Ortu et al., 2005
17 Les Brassières	Off-site Charcoal	40	Middle Rhone valley, Prealps & S. Alps	Low lands	6382–6067	Delhon, 2007
19 Drôme 15	Off-site Pollen	96	Middle Rhone valley, Prealps & S. Alps	Low lands	5886–3702	Argant, 1990
23 La Gourre	Off-site Pollen	992	Middle Rhone valley, Prealps & S. Alps	High lands	8219–4464	Muller et al., 2012
24 Lac de Saint-Léger	Off-site Pollen	1308	Middle Rhone valley, Prealps & S. Alps	High lands	6361–5675	Beaulieu, 1977; Digerfeldt et al., 1997
25 Luitel	Off-site Pollen	1325	Middle Rhone valley, Prealps & S. Alps	High lands	6473–5659	Guiter et al., 2015
26 Lac Lauzon	Off-site Pollen	1980	Middle Rhone valley, Prealps & S. Alps	Upper lands	6212–3360	Argant et al., 2006
27 Rapallo	Off-site Pollen	10	E. Liguria & N. Apennines	Low lands	6202–3097	Bellini et al., 2009
28 Sestri Levante	Off-site Pollen	10	E. Liguria & N. Apennines	Low lands	6222–5990	Bellini et al., 2009
29 Pavullo nel Frignano	Off-site Pollen	670	E. Liguria & N. Apennines	Middle lands	6642–4715	Vescovi et al., 2010a
30 Lago di Bargone	Off-site Pollen	831	E. Liguria & N. Apennines	High lands	6372–4843	Cruise et al., 2009
31 Mogge di Ertola	Off-site Pollen	1115	E. Liguria & N. Apennines	High lands	7312–5931	Guido et al., 2013
32 Lago Padule	Off-site Pollen	1187	E. Liguria & N. Apennines	High lands	7040–4345	Watson, 1996; Branch and Marini, 2014
33 Lagdei II	Off-site Pollen	1254	E. Liguria & N. Apennines	High lands	7451–5629	Bertoldi et al., 2007
34 Lago Riane	Off-site Pollen	1279	E. Liguria & N. Apennines	High lands	7239–3962	Branch, 2004, 2013; Branch and Marini, 2014
35 Prato Spilla C	Off-site Pollen	1350	E. Liguria & N. Apennines	High lands	7675–6076	Lowe, 1992; Lowe and Watson, 1993; Lowe et al., 1994a
36 Lago Rotondo	Off-site Pollen	1331	E. Liguria & N. Apennines	High lands	6203–5232	Vescovi et al., 2010a; Branch and Marini, 2014
37 Lago del Greppo	Off-site Pollen	1442	E. Liguria & N. Apennines	High lands	7024–5771	Vescovi et al., 2010b

Pendimoun, Caucade, Arene Candide and San Sebastiano di Perti (Binder, 2013; Guillon, 2014a), within the same region. They may indicate that the first Neolithic communities took advantage of the expansion of the coastal plain, which started c. 6050 BCE and which was driven by the progradation of the delta, to cultivate cereals on the newly formed alluvial soils. A comparable and probably contemporaneous agricultural use of the soils located around the coastal lagoon-marshes of Eastern Liguria is documented in the off-site sequence from Sestri Levante (Bellini et al., 2009).

4.2. Middle Rhone valley/Prealps and Southern Alps

Mixed deciduous forest, mainly consisting of deciduous oak, elm, lime, beech, and related fringe taxa, seems to have been present at a particularly early date in the low and the middle lands of the middle Rhone valley/Prealps and Southern Alps, which probably explains why it was already well spread by the mid-8th millennium BCE (Fig. 4: Les Brassières; Lalo; Coufin I and II; La Gourre; Pas de la Charmate; Lac de Saint-Léger). At middle altitude, fir forests - which had been expanding since the second half of the 7th millennium BCE at least (Terhürne-Berson et al., 2004; Muller et al., 2006, 2007; Walsh et al., 2014) - seem to co-dominate with the deciduous oak forest, as evidenced at La Gourre and in the Castelnovian layer of La Grande Rivoire. In the high lands, and up to the upper lands (Lac Lauzon, 1980 m a.s.l.), fir is dominant in the pollen

spectra since at least c. 6000 BCE, and represents c. 30% to c. 60% of the pollen counts. On the basis of the scarcity of tree macroremains in the Lac Lauzon sequence, it appears that the timberline was located below the altitude of this lake (1980 a.s.l.) at this time. In contrast, fir needles are abundant in the sediment of the lake and peat of Luitel (1325 m a.s.l.), proving the *in situ* presence of a very dense fir forest (Guiter et al., 2015). Up to the timberline, the high lands were thus probably covered by dense fir forests, as shown by various pollen records (Beaulieu, 1977; Digerfeldt et al., 1997; Argant et al., 2006; Muller et al., 2007; Guiter et al., 2015). Nevertheless, it is surprising that the Castelnovian sites, including those situated at an elevation where (based on regional pollen data) fir would be expected to be abundant (La Grande Rivoire, Pas de la Charmate), never yield anthracological evidence for this vegetal association in the vicinity. As daily fuel is known to be gathered in the near environs of settlements (Chabal, 1997), it seems that all the studied settlements, even those located in the vegetation belt then characterized by fir forests, were located in areas where these forests were not prevalent.

At lower altitude, evergreen taxa (evergreen oak, box, buckhorn/phillyrea) have been identified only occasionally, in particular in the Castelnovian layers of Lalo, where they are interpreted as a possible “occasional and local Mesolithic impact on the vegetation” (Berger et al., 2016, p.76). In the upper lands, the first evidence for anthropogenic pollen indicators appears c. 5500 BCE with the

Table 4
Altitudinal classes.

Altitude a.s.l.	Altitudinal classes
over 1600 m	upper lands
800-1600 m	high lands
400-800 m	middle lands
0-400 m	low lands

Table 5
Taxa quoted in the text: charcoal taxa, pollen taxa, corresponding scientific taxa (Latin name) and vernacular denomination used in the text and main related vegetal associations during the Early/Mid-Holocene. The discrepancies between charcoal and pollen taxa are related to the identification levels reached by each kind of analysis. Pollen and charcoal taxa may vary depending on the preservation state of the remains, only the most frequent ones are listed.

Determined taxa	Real taxa	Main related vegetal associations during early/mid-Holocene		
Charcoal taxa	Pollen taxa	Latin name	Vernacular name used in the text	
<i>Abies</i> sp.	<i>Abies</i> sp.	<i>Abies alba</i>	fir	fir forest/mixed deciduous oak forest
<i>Acer</i> sp. (or various species groups depending on the authors)	<i>Acer</i> sp.	<i>Acer</i> spp.	maples	mixed deciduous oak forest
<i>Alnus</i> sp.	<i>Alnus</i> sp.	<i>Alnus</i> spp.	alder	mixed deciduous oak forest (early successional stage/humid)/open formations
<i>Arbutus unedo</i>	Ericaceae	<i>Arbutus unedo</i>	arbutus	evergreen formations
<i>Betula</i> sp.	<i>Betula</i> sp.	<i>Betula</i> spp.	birch	larch open formation/mixed deciduous oak forest (early successional stage/humid)
<i>Buxus sempervirens</i>	<i>Buxus sempervirens</i>	<i>Buxus sempervirens</i>	box	evergreen formations
<i>Corylus</i> sp.	<i>Corylus</i> sp.	<i>Corylus avellana</i>	hazel	mixed deciduous oak forest
deciduous <i>Quercus</i>	deciduous <i>Quercus</i>	<i>Quercus</i> sp., <i>Q. deciduous</i>	deciduous oak, mostly pubescent oak	mixed deciduous oak forest
<i>Erica</i> sp., <i>Erica</i> cf. <i>arborea</i>	Ericaceae, <i>Erica</i> type, <i>Erica arborea</i>	mostly <i>Erica arborea</i>	mostly great heathers, including tree heather	evergreen formations
evergreen <i>Quercus</i>	<i>Quercus</i> type <i>ilex</i>	mostly <i>Quercus ilex</i>	Evergreen oak, mostly holm oak	evergreen formations
<i>Fagus sylvatica</i>	<i>Fagus</i> sp.	<i>Fagus sylvatica</i>	beech	mixed deciduous oak forest
<i>Fraxinus</i> sp.	<i>Fraxinus</i> sp., <i>Fraxinus excelsior</i>	mostly <i>Fraxinus excelsior</i>	ash	mixed deciduous oak forest/open formations
<i>Juniperus</i> sp.	Cupressaceae, <i>Juniperus</i> sp.	mostly <i>Juniperus communis</i> or <i>J. oxycedrus</i>	juniper	juniper steppe/evergreen formations
<i>Laburnum</i>	–	<i>Laburnum</i>	laburnum	open formations
<i>Larix</i> sp., <i>Larix</i> sp./	<i>Larix</i> sp.	<i>Larix decidua</i>	larch	larch open formations
<i>Picea</i> sp.	<i>Picea</i> sp.	<i>Picea abies</i>	spruce	fir forest
<i>Olea europea</i>	<i>Olea europea</i>	<i>Olea europea</i>	wild olive	evergreen formations
<i>Ostrya carpinifolia</i>	<i>Ostrya carpinifolia</i>	<i>Ostrya carpinifolia</i>	hop hornbeam	mixed deciduous oak forest
<i>Phillyrea</i> sp./ <i>Rhamnus alaternus</i>	<i>Rhamnus</i> <i>Phillyrea media</i> , <i>Phillyrea angustifolia</i>	<i>Rhamnus alaternus</i> <i>Phillyrea</i>	buckthorn or phillyrea	evergreen formations
<i>Pinus cembra</i>	<i>Pinus</i> (not taken into account in this work)	<i>Pinus cembra</i>	arolla pine	larch open formations
<i>Pinus</i> sp. mediterranean type, <i>P. halepensis/pinaster/pinea</i>	<i>Pinus</i> (not considered in this work)	mostly <i>Pinus halepensis</i>	Aleppo pine	evergreen formations
<i>Pinus</i> sp., <i>Pinus sylvestris/mugo</i> ,	<i>Pinus</i> (not taken into account in this work)	<i>Pinus Sylvestris</i> sub-section	pine	–
<i>Pistacia</i> sp.	<i>Pistacia</i> sp.	<i>Pistacia lentiscus</i> or <i>P. terebinthus</i>	mastic or terebinth pistachios	evergreen formations
Rosaceae, Maloideae, Prunoideae (or various species groups depending on the authors)	<i>Prunus</i> or <i>Sorbus</i>	woody Rosaceae	Rosaceae	mixed deciduous oak forest
<i>Salix</i> sp.	<i>Salix</i> sp.	<i>Salix</i> spp.	willow	mixed deciduous oak forest (early successional stage/humid)/open formations
<i>Tilia</i> sp.	<i>Tilia</i> sp., <i>Tilia cordata</i>	<i>Tilia cordata</i> or <i>T. platyphyllos</i>	lime	mixed deciduous oak forest
<i>Ulmus</i> sp.	<i>Ulmus</i> sp.	<i>Ulmus minor</i>	elm	mixed deciduous oak forest

presence of synanthropic taxa, which are interpreted as indicators of isolated forest clearance (Argant et al., 2006; Walsh et al., 2014).

4.3. Eastern Liguria and the Northern Apennines

In Eastern Liguria and the Northern Apennines, for the period between 6500 and 5400 BCE and for an area stretching from the low lands to the high lands, arboreal pollen generally accounts for

more than 90% of the pollen sum and fir pollen for c. 40%–80% of the pollen sum (Magri et al., 2015). Fir macroremains are reported in off-site sequences from the shoreline at Sestri-Levante to Lago del Greppo at 1442 m a.s.l. (Fig. 5), showing that fir forests developed over a broad altitudinal range. Deciduous mixed forests, consisting of deciduous oak, lime, elm, hop hornbeam, beech and sparse related fringe- or more hydrophilic formations (birch, hazel, maple and ash) seem to co-dominate with fir formations at lower

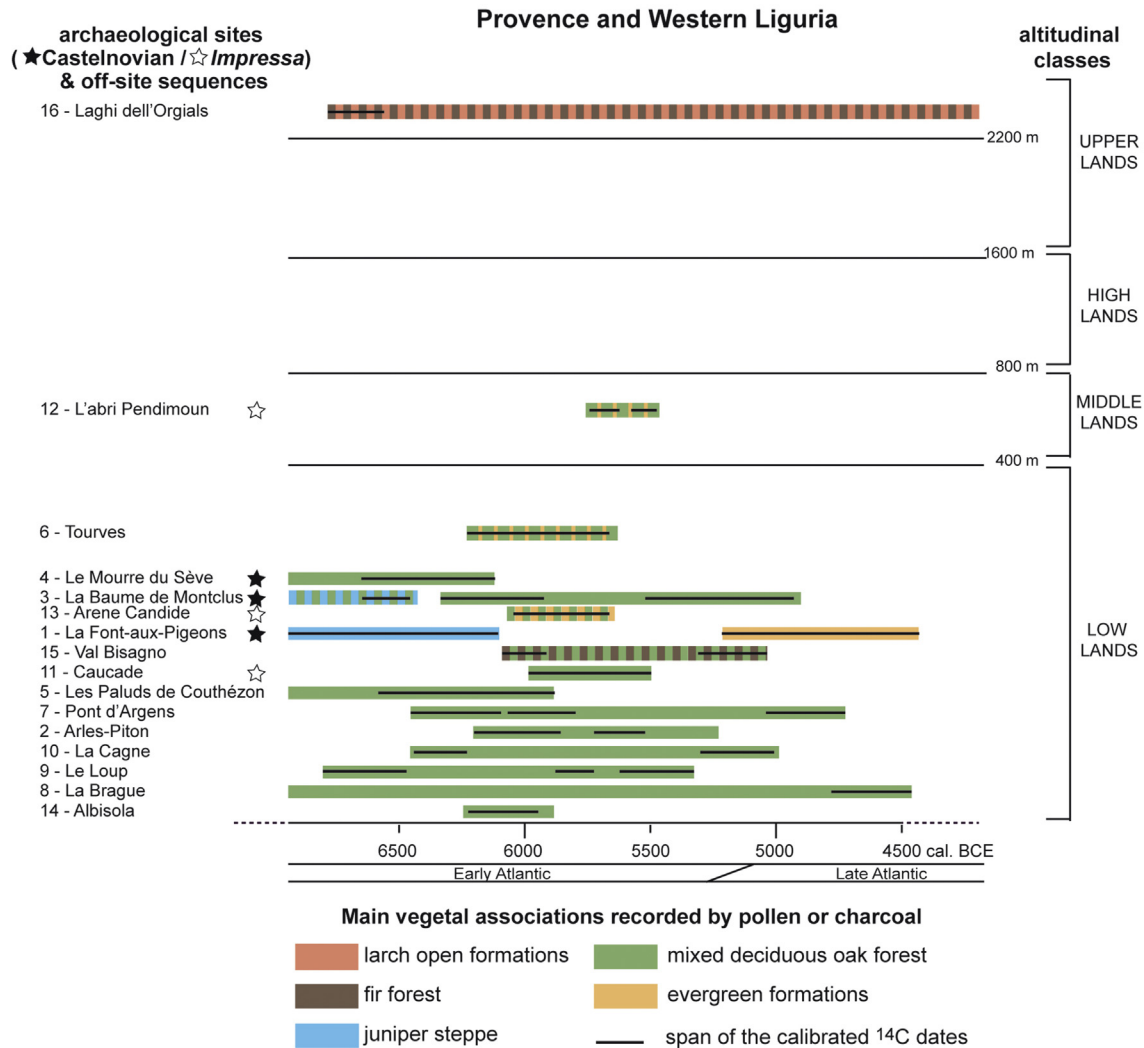


Fig. 3. Main vegetal associations reconstructed using pollen and charcoal from ¹⁴C dated archaeological and off-site sequences in Provence and Western Liguria. The data are classified according to their altitude. Castelnovian archaeological sites are marked by a black star, *Impressa* archaeological sites by a white star. The spans of the ¹⁴C calibrated dates are given by the black lines (IntCal 13 OxCal 4.2.4, Reimer et al., 2013). When several vegetal associations are present, they are represented by alternating strips; the importance of each vegetal association is indicated by the length of the strips. For the meaning of the vegetal associations, see Table 5.

elevations, and/or on more freely draining, well exposed, rich soils (Lowe and Watson, 1993; Watson et al., 1994; Mariotti Lippi et al., 2007; Vescovi et al., 2010a; Guido et al., 2013). In the upper lands, light-demanding pioneer taxa (ash, alder, willow and maple) make up the charcoal assemblages of the Castelnovian settlements at Passo della Comunella, Monte Bagioletto Alto and Lama Lite, located at relatively high altitudes. A Leguminosae identified as *Laburnum* sp. is also well represented in these charcoal assemblages. However, confusion may occur between this taxon and elm, which has a very similar anatomy (Castelletti et al., 1976; Cremaschi et al., 1984). Both are light-demanding taxa. The low amount of arboreal pollen on the site of Monte Bagioletto Alto suggests that trees were scarce around the site (Panizza et al., 1982; Castelletti, 1984; Cremaschi et al., 1984). More specifically, fir is either marginal or absent in the available data from the upper lands of the Northern Apennines. The reliability of the data is somewhat insufficient: they rely on hand-picked charcoal fragments, which are not accurate for representing the entire surrounding vegetation, and on archaeo-palynological samples, whose preservation and palaeoenvironmental representativeness is often criticised due to

differential pollen preservation (Coles et al., 1989; Lebreton et al., 2010). Nevertheless, they are congruent with settlement locations at the upper edge of the forests.

On the coast (Sestri-Levante, Rapallo), the presence of evergreen oak and great heathers (including tree heather) are evidence of the existence of more open vegetal formations, since at least the end of the 7th millennium BCE, probably located on dry, sandy soils (Bellini et al., 2009). At Sestri-Levante, c. 6222-5990 BCE, great heather, which reaches 10% of the pollen sum, is associated with cereal "mainly *Hordeum* group", which represents some 7% of the pollen sum (Bellini et al., 2009, p. 1165). Although this off-site sequence is not directly linked to any material remains of early Neolithic occupation, the assemblage might suggest, if the date obtained from an unspecified wood fragment is accepted, early cereal cultivation on the alluvial soils around the coastal lagoon-marshes and fire clearing of the forest (Branch et al., 2014). At a broader scale, in the Northern Apennines, the anthropogenic or natural origin of the evergreen formations, before the mid-6th millennium, is still debated (Lowe et al., 1994a, b; De Pascale et al., 2006; Branch and Marini, 2014; Branch et al., 2014).

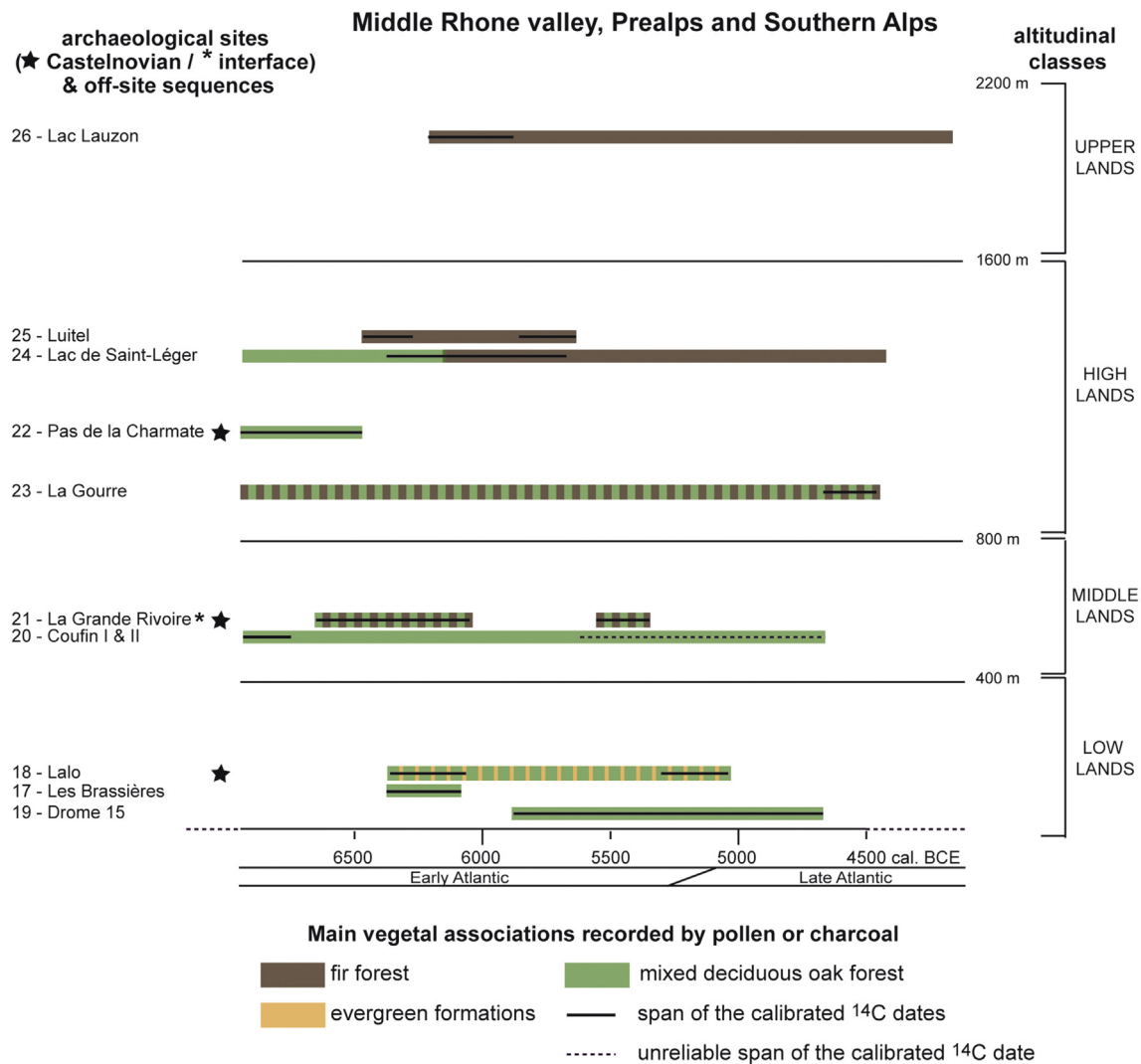


Fig. 4. Main vegetal associations reconstructed using pollen and charcoal from ¹⁴C dated archaeological and off-site sequences in the middle Rhone valley/Prealps and Southern Alps. The data are classified according to their altitude. Castelnovian archaeological sites are marked by a black star. "Interface" refers to archaeological layers at the interface between Mesolithic and Neolithic layers that currently cannot assigned with confidence to one or other of the two cultural facies. The spans of the ¹⁴C calibrated dates are given by the black lines (IntCal 13 OxCal 4.2.4, Reimer et al., 2013). The importance of each vegetal association is indicated by the length of the strips. For the meaning of the vegetal associations, see Table 5.

5. Discussion: environmental and cultural factors involved in location strategies

5.1. The attraction of open areas in a globally forested landscape

While the landscape seems to have been rather open in Western Provence, elsewhere the abundance of fir and deciduous oak, as well as the high proportions of the arboreal pollen, suggest the dominance of dense forests from the low lands up to (at least) 1450 m high. In the low lands, especially on the coastal fringe, where the *Impressa* settlements are found, an evergreen formation with evergreen oak and tree heather, is better represented than anywhere else (Guillon, 2014a; Magri et al., 2015). These heliophilous, thermophilous and meso-xerophilous taxa (Rameau et al., 2008) suggest stands with more open canopy which benefit from high insolation but low edaphic and atmospheric humidity. In a landscape that is globally densely forested, the opening up of the canopy is assumed to be favourable to agriculture and the grazing of herds (Berger and Guilaine, 2009; Nisbet, 2013; Battentier et al., 2015). This could partly explain why the *Impressa* seafarers settled

on the coastal margin, although they probably also ventured deeper into the forested hinterland where sources of lithic raw material are located. However, for now, we lack evidence to allow us to determine whether lithic resources were procured directly or through exchange with the Castelnovians (cf. *supra*).

In the Northern Apennines, the Castelnovian settlements of Passo della Comunella, Monte Bagioletto Alto and Lama Lite seem to have been surrounded by light-demanding taxa suggesting the existence of (limited?) open stands (Panizza et al., 1982; Cremaschi et al., 1984; Castelletti et al., 1994), probably at the upper edge of the forest. This landscape is currently attractive for herbivorous mammals (i.e. ibex, chamois and marmot). Pollen data from the upper lands of Provence/Western Liguria (Laghi dell'Orgials) and pedoanthracological data from Marassan II, Ayes II and Prarousin I (Touflan and Talon, 2008a, b; Touflan et al., 2010; Saulnier et al., 2015), in the Southern Alps (Queyras range), suggest that between c. 6500 and 5500 BCE larch - and to a lesser extent arolla pine - developed between (at least) 1600/1800 m a.s.l and 2400 m a.s.l. Larch and arolla pine are primarily light-demanding taxa suggesting the existence of open stands (Ali et al., 2005; Touflan and Talon,

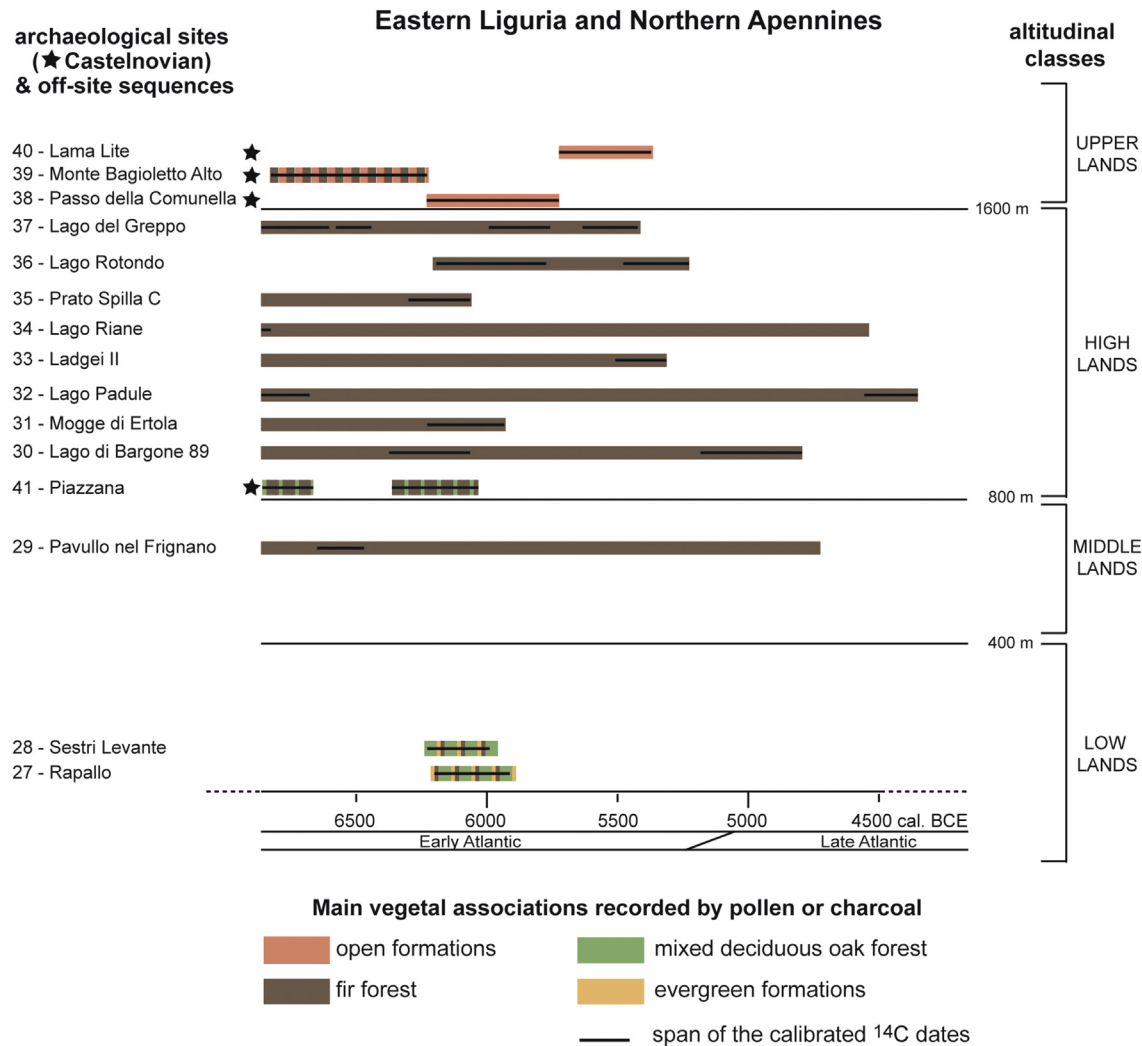


Fig. 5. Main vegetal associations reconstructed using pollen and charcoal from ¹⁴C dated archaeological and off-site sequences in Eastern Liguria and Northern Apennines. The data are classified according to their altitude. Castelnovian archaeological sites are marked by a black star. The spans of the ¹⁴C calibrated dates are given by the black lines (IntCal 13 OxCal 4.2.4, Reimer et al., 2013). The importance of each vegetal association is indicated by the length of the strips. For the meaning of the vegetal associations, see Table 5.

2008a, b; Touflan et al., 2010). Moreover, larch has sparse and deciduous needles which are not acidic and thus do not hinder the development of a well decomposed litter. Because of the low density of trees, the soil also receives a relatively high level of insolation. Given these characteristics, these stands may have been favourable to the development of grasslands (Didier, 2001; Saulnier et al., 2015) which would have been attractive for herbivores. Thus, the Castelnovian upper land settlements in the Southern Alps (Jausiers-Sagnes and Faravel XVIII) and in the Northern Apennines (Passo della Comunella, Monte Bagioletto Alto and Lama Lite) seem to be located between the upper limit of the forest (timberline) and the upper limit of the trees (treeline), in relatively open stands which may have been favourable both for hunting and for gathering firewood.

5.2. The consequences of increasing seasonality on livelihood

The second half of the 6th millennium BCE seems to have been a period of increasing seasonal contrasts in the North-Western Mediterranean area, characterized by summer drought and concentrated rainfall during spring and fall. This climatic trend is recorded by various proxies: sedimentary proxies, e.g. the frequent truncation of sediment deposits (due to episodes of strong erosion)

in the middle Rhone valley or the precipitation of secondary carbonates in soils and sediments influenced by high evapotranspiration rates (Berger and Brochier, 2000; Bruneton et al., 2000, 2001; Berger, 2005; Berger and Guilaine, 2009); geomorphological data, e.g. the frequent shifts of coastal rivers in Eastern Provence (Guillon, 2014b); and isotopic data ($\delta^{13}\text{C}$ and $\delta^{18}\text{O}$) which indicate heavy and concentrated rainfall from Eastern Liguria to Northern Apennines (Antro del Corchia, Zanchetta et al., 2007). During periods of low anthropogenic impact, fire activity and colluvial sedimentation increase as a result high seasonal contrasts. Both were particularly recorded respectively in Lago dell'Accesa (south of Northern Apennines) between 6000 and 5500 BCE (Vannièr et al., 2011), and in Charanc catchment (Southern Alps) between 7000 and 5000 BCE (Brisset et al., 2014).

These strong seasonal contrasts may have had an influence on the subsistence activities of both hunters and farmers. In Liguria and Provence, *Impressa* agriculture mainly relied on *Triticum dicoccum* and *Hordeum vulgare* (*Triticum monococcum* being added to the list in Languedoc, Marinval, 2007). These cereals are considered to be rather frugal (Comet, 1992) and thus probably well adapted to hydric stress (Monneveux and Depigny-This, 1995; Ykhlef and Djekoun, 2000).

In the upper lands, stronger seasonal contrasts and particularly

warmer and dryer summers participated in the shortening of seasons of snow-cover and to the retreat of remaining glaciers, and thus may have influenced the duration of the hunting season as well as the size and location of the hunting territories. Ibex and chamois, the main mountainous prey of the Castelnovian groups, cluster during the warmer months forming significant herds in the open or semi-open lands above the timberline, where marmot is also abundant (Gauthier et al., 1991; Tarnaud, 1998; Lenti Boero, 2003). Despite the current distribution of these animals, probably in part influenced by anthropogenic pressure, the rise of the timberline may have led to an expansion of Castelnovian summer hunting activities into higher altitude areas.

5.3. Did the expansion of alluvial plains favoured farmers settlement?

Notwithstanding the hardness of the crops, the first Neolithic farmers probably established their fields on the stable, deep, moist soils that developed from c. 6000 BCE in the low lands due to the formation of alluvial plains linked to the progradation process (Sivan et al., 2010; Guillon et al., 2010; Guillon, 2014a and b). These soils were favourable for cereal growing (Biagi and Nisbet, 1987) but were also conducive to the development of forests which were attractive environments for wild and domestic grazers. Given that the expansion of alluvial soils was triggered by the progradation process, the evolution of the shoreline may also have influenced the distribution of sites. However, while the presence of cereal pollen at La Cagne and Le Loup is evidence for the early establishment of cultivation on the alluvial soils of the expanding coastal plain (cf. *supra*), the related *Impressa* settlements are still unknown: this may be due to the taphonomy of the sites during this period of marked geomorphological changes.

5.4. Could fir expansion have played a role in the settlements distribution?

During the 7th and 6th millennia BCE, the post-glacial expansion of fir in the Tosco-Liguro-Provençal area – most likely originating from refugia in the Northern Apennines (Terhürne-Berson et al., 2004; Muller et al., 2007) – is well documented, mainly through pollen and macroremains. These data attest to fact that the altitudinal distribution of fir was wider in the Early Holocene than it is today (Beaulieu, 1977; Carcaillet and Muller, 2005; Guillon, 2014a; Magri et al., 2015). The combination of dryer and warmer climatic conditions, increasing fires and anthropogenic pressure in the form of pastoral activities and clearing, were the main factors in

the decline of fir since the Mid/Late Holocene (Tinner and Lotter, 2006; Wick and Möhl, 2006; Colombaroli et al., 2007; Cruise et al., 2009). Fir requires constant and significant soil and air moisture, suggesting the presence of a closed canopy and dense forests (Tan and Bruckert, 1992; Rameau et al., 1993; Carcaillet and Muller, 2005; Muller et al., 2007). Because they bear abundant needles that can orient themselves in order to capture as much sunlight as possible (Pages et al., 2003), the understoreys of fir forests are dark (Fig. 6). Moreover, the acidity of the needles participates in humus depletion with an ensuing negative impact on the development of most other plants, including crops. During the 7th and 6th millennia BCE, the high proportion of fir in the middle-high land pollen spectra (and, regarding charcoal, only in the small assemblage from Piazzana) suggests that it formed dense, almost monodominant forests (Castelletti, 1984; Muller et al., 2007). The darkness and the humus depletion under these stands, which result in their being unfavourable for the growth of understorey plants, may have also rendered them unattractive to herbivores (lack of food for browsers and grazers), which constituted the main prey of the Castelnovian groups, and to the livestock of the *Impressa* groups. In addition, fir is a self-pruning tree. This renders fir forest unattractive for herbivores since they are unable to reach leaf-bearing branches. Nevertheless, dense fir forest, despite the fact that it appears to be less favourable for browsing than other vegetation (more deciduous and/or more open formations), may have provided a refuge where herbivorous game could take cover. Therefore, the expansion of fir, in the form of dense and monodominant forests, over a broad altitudinal range, could have created extensive areas of limited attractivity, but whose margins (lower edge, timberline and openings), in contrast, may have been favourable for the main subsistence activities of both *Impressa* and Castelnovian populations: farming, pastoralism and hunting of their preferred prey.

According to ecological investigations, fir is – and was in the past – sensitive to drought and fire (Rameau et al., 1993; Carcaillet and Muller, 2005; Colombaroli et al., 2007; Henne et al., 2013). In the low lands, fir seems to have been less competitive than in the middle-high lands (deciduous oak is dominant or co-dominant with fir), perhaps because of the increasing seasonality described above. All of the *Impressa* sites and some of the Castelnovian settlements at low altitude seem to have been surrounded by mixed stands which included fir along other species, indicating that these vegetal associations were not repulsive, in contrast to the dense monodominant fir forests of the middle-high lands. At La Grande Rivoire, which is located in the middle lands, the charcoal assemblages from the Castelnovian levels yield a diversity of species that



Fig. 6. Fir forest (1250 m a.s.l., La Léchère, Northern-Alps, France; © J. Battentier). A: mature stand; B: young stand.

suggests a location at the edge of the fir forest. Most of the other Castelnovian settlements are distributed in the high-upper lands, in the zone where fir appears to be less competitive, due to its sensitivity to late frost (Rameau et al., 1993; Branch, 2013). The Castelnovian and *Impressa* location strategies, which seem mainly directed towards the lower and higher lands, may have been influenced by, among other factors, the expansion during this period of pure fir forests, an ecosystem which we assume to have been rather unfavourable for the main subsistence activities of both groups.

6. Conclusion

During the 6th millennium, dense forests were dominant over a broad altitudinal range in south-eastern France and north-western Italy. Nevertheless, it seems that both Castelnovian and *Impressa* groups settled preferentially in the most open areas existing within this mainly forested landscape and avoided closed canopy. The *Impressa* populations found these favourable plots close to the coast which acted as their gateway into the region. The Castelnovian sites display a rather bimodal distribution, showing that these populations probably searched for seasonal hunting grounds in the mountains, above the timberline, but also sought to maintain a connection, at lower altitudes, between their dwellings and aquatic environments. This settlement model does not rule out the frequentation by these groups of dense fir forests, which, at the very least, were inevitably traversed during the transit from the low to the upper lands (and conversely). They could also have hosted activities whose archaeological footprints have not yet been detected.

The low lands were mainly covered by deciduous oak forests and characterized on the shoreline by the appearance of evergreen formations and by the development of stable, deep, moist, humus-rich soils as a result of the expansion of alluvial plains. These soils seem to have been particularly suitable for *Impressa* agriculture, and they could be the major reason why the first Neolithic farmers settled the low lands. In the upper lands, the vegetal landscape around the timberline, that was probably located at c. 1500/1600–1800 m a.s.l, was made up of sparse stands of larch (in the Southern Alps) and perhaps of broadleaved pioneer trees and shrubs (in the Northern Apennines). As they provided abundant and accessible prey and enough wood to ensure easy fuel supply, at least during certain seasons, these areas were convenient for the Castelnovian hunters. In the middle lands, fir extended in the form of deep, pure forests. These environments seem rather unfavourable for hunting, pastoralism and farming and thus may have been repellent for most of the subsistence activities (or at least for those that left archaeological traces) of both populations.

Thus, for the *Impressa* newcomers as well as for the Castelnovians, the settlement strategies appear to be linked both to cultural and environmental factors. The territories seem polarised towards those parts of the landscape which were most suitable for their subsistence activities. In particular, the expansion of fir forests may have driven both groups out of the mid-altitude zone, while the advantages of the lower and upper landscape units could explain the concentration of archaeological sites in these zones, Piazzana being an exception.

This review shows that the separate settlement distributions of the two groups can be explained by their different subsistence activities, but it has not allowed us to determine if an avoidance strategy is superimposed over that of economic determinism. On the contrary, the use of similar lithic resources suggests the sharing of some supply territories and/or the existence of a direct relationship (cf. *supra*). Nevertheless, the vast and contrasted Tosco-Liguro-Provençal area offers enough space to allow choice to

operate. Therefore, the settlement distribution of the small Castelnovian and *Impressa* groups may not have been solely determined by the requirements of their subsistence activities. The fact that Castelnovian and *Impressa* settlement distributions are distinct may also result from different cultural opinions of what is considered as a good place to settle. Hence, in an area providing a large range of possibilities, the landscape in which the groups establish themselves could be considered as just one of many cultural characteristics.

Acknowledgements

We wish to express our sincerest thanks to the CIMO project (ANR-14-CE31-009) for supporting this investigation. We also thank Université Côte D'Azur which financed the Janet Battentier's thesis. Claire Manen, André Raux, Robin Furestier, Alessandra Benatti, Lionel Gourichon and Erwan Messenger are gratefully acknowledged for their help and for giving us access to unpublished data.

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