Exploring the ancient occupation of a high altitude site (Lake Lauzon, France): Comparison between pollen and non-pollen palynomorphs

Jacqueline Argant a,*, José Antonio López-Sáez b, Pierre Bintz a

a UMR 6636-ESEP, Institut Dolomieu, 15 rue Maurice Gignoux, F-38031 Grenoble Cedex, France
b Laboratorio de Arqueobotánica, Departamento de Prehistoria, Instituto de Historia, CSIC, Duque de Medinaceli 6, 28014 Madrid, Spain

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Abstract

Next to Lus-la-Croix-Haute (Southern Alps, Drôme, France), Lake Lauzon is located in a small basin 1980 m above sea level, 500 m above the actual timberline, in the middle of typical sub-alpine grasslands. A drilling for samples in the wetland area bordering the lake made it possible to obtain a core of clayey fine sediments with a high organic matter content, in which pollen as well as many micro-organisms had been particularly well preserved. The pollen analysis and the non-pollen palynomorphs analysis both cover a period from ca. 8000 cal. BP to sub-recent time. The pollen analysis reveals the presence of a thriving forest vegetation dominated by Abies, and the first signs of human activity near the lake and its nearby basins in the Atlantic period. These signs become more pronounced during the Sub-boreal period from 5450 cal. BP on, with the clear presence of cereal and weed pollen. This evolution is totally confirmed by the non-pollen palynomorphs. Since the Neolithic, every time pollen analysis points to clearings or cultivation, the non-pollen palynomorphs indicate that man has burnt the vegetation to obtain openings (occurrence of Chaetomium sp.). Increased erosion during the Sub-atlantic period is revealed by the occurrence of Glomus cf. fasciculatum. Furthermore, non-pollen palynomorphs give information on eutrophication of the lake which may be explained by more nutrient-rich habitats around the lake due to grazing and possibly agriculture. The combination of both types of analysis makes it possible to prove that this elevated site has been occupied and cleared at an early stage by man to obtain pasture lands and possibly arable land. This led to deforestation, which increased during the Sub-atlantic period, and has led to the present grasslands. © 2006 Elsevier B.V. All rights reserved.

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1. Introduction

Palynological research on a core from Lake Lauzon near Lus-la-Croix-Haute (Drôme, France) was carried out in the context of a survey program on the Mesolithic and on the processes of neolithisation of the North Western Alps in which we were seeking understanding of human occupation and exploitation of the alpine mountains. The aim of this program was to investigate sites favourable to human occupation and which would also contain sediments allowing us to perform pollen analysis. The archaeological survey targeted on the Haut-Buêch and the Dévoluy, was then conducted by
Alexandre Morin and his team. The picture of the vegetation given by pollen analysis is at the same time local, regional and some long distance transport is to be expected. Besides this, the study of non-pollen palynomorphs was undertaken to define more precisely our understanding of the local evolution of the environment and the role of man in this evolution.

2. Geographic, geological and archaeological context

2.1. Geographic location and geological context

Lake Lauzon is situated at the junction of three strongly contrasting geographic zones: the basin of the Trièves, the massif of Dévoluy and the region of the middle mountain of the Beauchêne, crossed by the Buëch river. This river lies at the northern limit of the “Department de la Drôme” where it flows into the Lauzon, a tributary of the Buëch which flows along the Jarjatte valley at the northern extremity of Beauchêne close to Lus-la-Croix-Haute. Situated at an altitude of 1980 m a.s.l., surrounded by grassy alpine slopes sheltered from the northern winds, Lake Lauzon is in a basin scoured by a glacier in the Gargasian and Albian marls belonging to the diverted northern side of the anticlinal of the Jarjatte. This region is of karstic origin because of the presence of Barremian limestone below the Gargasian marls. This double origin probably explains the presence of the lake in a limestone environment, normally not favourable for the formation of wetland, which are potential sites for pollen to be preserved. The lake is dominated on the north and east by the discordant, sub-horizontal Senonian, which frames the countryside and forms the line of the ridge of the Devoluy. The ridge reaches 2278 m a.s.l. at the head of the Lauzon, to the north and 2188 m a.s.l. at the head of the Vautes, to the east. On this crest, the Charnier pass, at 2183 m a.s.l., allows entry into the massif of the Dévoluy. From a geological point of view the site of the Lauzon belongs therefore to the massif of the Dévoluy, but its climatic and botanical characteristics are rather those of the Trièves or of Beauchêne (Figs. 1 and 2).

2.2. Climate and vegetation

From the data given by the meteorological station of Lus-la-Croix-Haute (1035 m a.s.l.), the annual average temperature of the region reduced to the altitude 0 is between 13.1 °C and 13.8 °C, slightly higher than that of the Grenoble region and close to that of Gap. The temperatures are less changeable than in Dévoluy, with smaller seasonal gaps and winter temperatures that are less severe than we might have feared as a result of the altitude (Cadel et al., 1963). Annual rainfall is relatively high but in summer it falls to quite a low level. As a consequence of infiltration of water into the limestone and of the evaporation there is a certain dryness (ibid.). Above all the northerly and westerly winds dominate throughout the year. In summer, during hot weather, there is a southerly wind which is called the “vent blanc” (Hundt-Corbier, personal communication).

Today the lake is pretty much at the sub-alpine stage. It is surrounded by wetland. Further down, the forests up to an average of 1550 m a.s.l. form an almost continuous belt on the slopes of the Jarjatte at the south west and of Tréminis at the north west. This is the region of fir and beech forest, always dominated by Abies especially on north-facing slopes. Picea is much rarer in natural

Fig. 1. Location map of Lake Lauzon in S–E France.
stands. *Pinus silvestris* and *Pinus uncinata* occur equally, more plentiful on the south facing slopes, as well as *Quercus pubescens* which sometimes reaches as high as 1300 m a.s.l. in a mixture with *Buxus*, *Fraxinus* and *Acer* or with *Abies* at the upper limit (Enderlain, oral commun.). *Betula* grows on a facies of fallen rocks which leads up to the sub-alpine level.

2.3. Archaeological context

Numerous indications of human occupation were discovered in the region. Flints were collected on the surface at different points: at the side of Lake Lauzon, on the Aurias pass, under the crest of Beau Serret, on the slopes and terraces as far as the Charmier pass (Bintz, 1993; Chaffenet, personal communication). Nevertheless there is no evidence of archaeological sites around Lake Lauzon.

To the west of Lake Lauzon, the mesolithic site of La Bergerie, at 1500 m a.s.l. on the northern slopes of the pass of La Croix (Tréminis, Isère), revealed activity of the Sauveterriam where the characteristics indicated that man had been there on short hunting trips. Close to the site some flints were collected on the surface, and notably a flint identical to the material revealed in the early neolithic Corrédardes shelter.

About 8 km to the south west, in the Corréardes shelter, (Lus-la-Croix-Haute, Drôme), on the edge of the Buëch at 1060 m a.s.l., two levels of occupation could be seen. They revealed an abundant lithic activity of the early neolithic type, very fragmented ceramic pieces and an axe in eclogite (Chaffenet and Cordier, 1999). The faunal remains belong exclusively to wild species clearly dominated by *Ibex* (Chaix, 1999). The occupation of the site corresponds to a seasonal visit by a group of hunters. The pollen analysis of a sample (at 175 cm depth), even though poor in pollen, carries an interesting indication: the presence of a cereal pollen grain leads us to think that there were settled cultures existing close to the site (Argant, ongoing study).

On the eastern slopes of the massif of Dévoluy recent surveys conducted by A. Morin, have revealed several sites, between 1400 and 1800 m a.s.l., with many mesolithic lithic artefacts and some early and late Neolithic armatures (valley of the Aiguilles, les Egayères, Lachaup at Agnières-en-Dévoly). Further south, in the Agnielles valley, the small tributary of the Buëch, the cave of Agnielles (La Faurie, Hautes Alpes) has revealed an important layer of middle and late Neolithic age, of the Iron Age and of the Gallo–Roman period (Ulysse, 1976). The abundant material, among which ceramic, lithic and several thousand bone remains of the Ovicaprid type (under study by J.Ulysse and A. Morin), attests to pastoral activity. The archaeological data recently collected in the Haut–Buëch and the Dévoluy testifies in favour of an early occupation by Mesolithic hunters–gatherers who were succeeded by the first early and late Neolithic herdsmen–farmers.

3. Material and method

In July 1997 a core was taken in the centre of the basin occupied by the lake, thanks to the relatively low level of water during this part of the year. A Russian corer of diameter 40 mm was used in the south marshy zone close to the open water. The core reached 450 cm
The Lambert III coordinates of the core are: X = 875.20; Y = 3272.68; H = 1980 m a.s.l.

Description of the stratigraphic log:

a) from 0 to 65 cm, fairly dense brown peat
b) from 65 to 125 cm, grey silts
c) from 125 to 180 cm, dark grey brownish silts
d) from 180 to 345 cm, grey brownish silts
e) from 345 to 365 cm, more light grey silts
f) from 365 to 380 cm, grey brownish silts
g) from 380 to 385 cm, grey silts
h) from 385 to 450 cm, dark grey silts.

All these silts are relatively homogeneous and rich in well preserved pollen grains. As a result, it is possible to easily recognise pine, fir and even hazel pollen from the deepest samples, using a magnifying glass ×40. The pollen grains appear in relief. Their white exine stands out against the dark grey silt.

The pollen concentration is always high (20,000 to 100,000 pollen grains per gram of wet sediment, estimation done by the volumetric method). The non-pollen palynomorph are equally very abundant. Unfortunately, the small section of the corer did not allow us to collect many macroremains, but seeds of Carex and many fragments of carapaces of insects were observed. Fragments of leaves and bark were also found at 249, 284 and 394 cm as well as angular microcharcoal, overall between 100 and 370 cm deep.

The extraction of the pollen grains has been carried out using the classical method of concentration in a heavy liquid (Thoulet s.g. = 2) after treatment with HCl and the destruction of silica by HF (Argant, 1990). Pollen and non-pollen palynomorph counts have been done using the same volume of the preparation and in both cases the percentages have been calculated on the pollen sum, Cyperaceae excluded. The number of counted grains in each sample varies between 206 and 1532 (mean value: 510). Eighty pollen taxa and thirty-one types of non-pollen palynomorphs have been identified. Non-pollen palynomorph nomenclature conforms to that of Bas van Geel (University of Amsterdam). Four AMS radiocarbon dates (Table 1) have been obtained both by the Laboratory of the Radiocarbon Center of Lyon and the Laboratory of Oxford (Great Britain). These dates have been calibrated to calendar age with the program CALIB 5.0 (Stuiver and Reimer, 1993). The calibrated dates are given as “cal. BP” (i.e calendar years before 1950 AD).

4. Results

4.1. Pollen data

The pollen analysis of the core has already been published (Argant and Argant, 2000), so the pollen record will be briefly described here. Three main pollen zones have been inferred (Fig. 3).

Zone LAU 1-a (450–319 cm) is marked by a high percentage of trees (on average 85%). Abies (40 to 63%) and Pinus (23 to 55%) largely dominate a forest area, including many broadleaved trees (above all Corylus, Quercus, Alnus, Ulmus, Tilia). Abies was probably growing at short distance because of the large amount of pollen (de Beaulieu, 1977). Fagus appears in small but frequent amounts. There is some indication of open woodlands, of montane type, with some taxa requiring light (Juniperus, Betula and Corylus) suggesting the existence of clearings not far from the lake. The two 14C dates (Table 1) which enclose this zone (at 450 cm and 327 cm) point to the Atlantic period.

Zone LAU 1-b (319–179 cm) shows the development of hardwood forest (Fagus) to the detriment of Abies, and the regular occurrence of cereal pollen. Heliophilous taxa, ferns and nitrophilous taxa (such as Chenopodiaceae) indicate the gradual opening up of the area by people. This development characterises the Sub-boreal, as indicated also by the dates of the beginning (4660 ±40 BP, 5473/5310 cal BP) and the end of this period (2700 cal BP, interpolated date).

Zone LAU 1-c (179–40 cm) is characterised by the decrease of fir and the intensification of signs of human impact: cereal pollen is observed frequently, as well as Juglans and Cannabis. Poaceae, Juniperus and Plantago lanceolata point to extension of pastures. The interval of 124–94 cm corresponds to the estimated
Fig. 3. Pollen diagram of the Lake Lauzon core.
maximum human occupation between 2140 and 1780 cal. BP (La Tène — Gallo–Roman).

4.2. Non-pollen palynomorphs

The zonation established for the pollen diagram applies equally to the diagram of the non-pollen palynomorphs but significant variations were observed within the three main periods described above. In order to facilitate the description and interpretation of these variations several subzones have been identified (Fig. 4).

4.2.1. Zone Lau 1-a (450–319 cm)

The presence of Cyanobacteria (Aphanizomenon, Anabaena) pioneers of the very moist to lacustrine zones (van Geel et al., 1994, 1996) which are in general poor in organic material and with an oligotrophic tendency, characterises this zone. In the same way, remains of Cladocera (cf Type 72) are continuously present (5–22%) as well as Rivularia type (T. 170) easily exceeding 10%. The waters of the lake would have a quite considerable depth (López Sáez et al., 1998). Remains of Acari–Oribatei are present in percentages between 5 and 8%. The presence of Chaetomium sp. can be ascribed to fires at a local level — around the lake — and a quite short period of drought (López Sáez et al., 1998), and can be linked with activities associated to cereal culture (between 419 and 414 cm). The use of fire would have helped to develop cultivated zones (López Sáez et al., 2000) during a phase of a small drop in the level of the lake. The more anthropogenic character of this microphase would be responsible for the evolution of the water of the lake towards more mesotrophic conditions as shown by the slight rise in Spirogyra sp. up to 8%, a possible consequence of the use of fire by man in the framework of agricultural activities (López Sáez et al., 1998, 1999). Local burning by Man, would cause superficial erosion of the soil and the rise of chlamydospores of the soil-inhabiting Glomus cf. fasciculatum (van Geel et al., 1989; López Sáez et al., 2000).

Subzone Lau 1-b2: (300–288 cm)

The most remarkable fact is the reduced presence of ascospores of Chaetomium sp. and the new appearance of Cladocera (T. 72) and of Type 66.

This subzone seems to correspond to a time of a sensitive lowering of anthropogenic activities, above all those dealing with the use of fire (decline of Chaetomium sp.), and the system becomes more mesotrophic (Haas, 1996; López Sáez et al., 1998) as is shown by the reappearance of Type 66 (van Geel, 1978). A decline of Glomus indicates less erosion of soils near the lake.

Subzone Lau 1-b3: (288–255 cm)

This subzone much resembles zone Lau 1-a with low values of green algae (Spirogyra above all, with less than 5%) and with the oocytes of Turbellaria. On the other hand Cyanobacteria are present, in particular Rivularia type which shows more than 10%, while the percentages of Cladocera are rising. All this indicates the end of the anthropogenic activity and the absence of the erosive process and an oligotrophic character of the lake water (van Geel, 1978; van Geel et al., 1989; López Sáez et al., 2000).

Subzone Lau 1-b4: (255–247 cm)

This short phase is characterised by a development to mesotrophic conditions as shown by the slight rise of Pediastrum (5%) and of certain Neorhabdocoela, above all Gyraetrix hermaphroditus and Mesostoma lingua (Haas, 1996), a peak of Type 66 (van Geel, 1978), and ascospores of Type 16A (van Geel, 1978; van Geel et al., 1980–1981). Plantago lanceolata starts to demonstrate a continuous rise attesting to a
Fig. 4. Non-pollen palynomorph percentage diagram of the Lake Lauzon core.
renewal of the anthropogenic activities. Glomus indicates some erosion.

**Subzone Lau 1-b5**: (247–215 cm)

This subzone resembles Lau 1-b3, with the rise of Rivularia type, Aphanizomenon and Anabaena as well as Cladocera (Type 72). The disappearance of Glomus cf. fasciculatum witnesses the end of anthropogenic activities.

**Subzone Lau 1-b6**: (215–198 cm)

This concerns a new meso-eutrophic phase, characterised by rise of Pediastrum, Botryococcus and various species of Turbellaria, and the presence of Cyanobacteria like Anabaena and Aphanizomenon. Chaetomium sp. reappears, while Rivularia type and Cladocera disappear. The record of non-pollen palynomorphs probably indicates a renewal of anthropogenic activities around the site.

**Subzone Lau 1-b7**: (198–174 cm)

This subzone marks the return of oligotrophic conditions similar to those of subzone Lau 1-b5 (decline of Glomus, Chaetomium, Botryococcus and Pediastrum, and rise of Rivularia and Cladocera.

4.2.3. Zone Lau 1-c (174–40 cm)

**Subzone Lau 1-c1**: (174–159 cm)

This subzone is characterised by the strong rise of Anabaena and Aphanizomenon, but above all by the large peak of Pediastrum, and the presence of Botryococcus and oocytes of Turbellaria like Gieysztoria virgulifera, Gyraetrix hermaphroditus, Mesostoma lingua, Microdalyellia armigera and Stronglylostoma radiatum. This group is characteristic of an enrichment with organic material (van Geel et al., 1994, 1996; Haas, 1996).

Eutrophication allows the development of Zygnemataceae populations such as Spirogyra and Mougeotia (López Sáez et al., 1998) and causes the almost complete disappearance of microfossils typical of oligotrophic conditions and low input of organic material, as in the case for Cladocera (T. 72) and Rivularia type (van Geel, 1978; van Geel et al., 1989; López Sáez et al., 1998). Possible indicators of anthropogenic activities (Chaetomium, Glomus) are not found in any large quantities: human activities were limited.

**Subzone Lau 1-c2**: (159–139 cm)

This subzone is characterised by a small rise of Anabaena and Aphanizomenon, but above all by the fall of Pediastrum below 10%, and the continuation of certain populations of Turbellaria. Chaetomium sp. and Glomus cf. fasciculatum show maxima. Rivularia type and Cladocera are almost absent, and we find again the spectrum of non-pollen palynomorphs indicating mesotrophic conditions like Types 119, 128A and 181. An intensification of human activities is evident from the rise of Chaetomium sp. while erosion of soils is indicated by the rise of Glomus cf. fasciculatum.

**Subzone Lau 1-c3**: (139–129 cm)

Pediastrum and Botryococcus show maxima and Spirogyra rises above 5%. Chaetomium sp. and Glomus cf. fasciculatum are present as well as the mesotrophic taxa previously described.

**Subzone Lau 1-c4**: (129–99 cm)

Pediastrum shows a decline while Rivularia and Cladocera characterise the first half of this subzone. Glomus re-appears when Rivularia and Cladocera show a decline. This subzone corresponds to a period during which human activity initially was low, but increased afterwards.

**Subzone Lau 1-c5**: (99–60 cm)

During this subzone the lake becomes relatively rich in nutrients with rises in Pediastrum, Anabaena, and Spirogyra as well as oocytes of Turbellaria, above all Gyraetrix hermaphroditus.

**Subzone Lau 1-c6**: (60–40 cm)

The presence of Anabaena and Aphanizomenon, the disappearance of Pediastrum and Botryococcus as well as oocytes of Turbellaria except Gieysztoria virgulifera, characterise this subzone. The record indicates a change towards more mesotrophic conditions, causing the disappearance of colonial algae and oocytes of Turbellaria (Haas, 1996).

Glomus cf. fasciculatum increases to values above 30%, indicating considerable erosion of soils around the lake, while Chaetomium sp. is continuously present at around 5%, probably indicating the use of fire (López Sáez et al., 1998).

5. Discussion

Both pollen and non-pollen palynomorphs analysis show clear evidence of evolution of the environment at an altitude of 2000 m a.s.l. since about 8000 cal. BP, the basal date of the core. For a better reading of this development a synthetic simplified diagram (Fig. 5) gives the main information; from left to right:

1. The dates obtained and the lithology.
2. The three curves showing human impact:
   (i) anthropochores (Cerealia, Juglans, Cannabis)
   (ii) apophytes (Chenopodiaceae, Plantago, Centaurea cyanus, Centaurea jacea type, Artemisia, Cichorioideae, other Asteraceae, Rumex, Urtica, Apiaceae, Brassicaceae, Rubiaceae)
   (iii) Poaceae.
(3) The three summarising curves of non-pollen palynomorphs:
   (i) those indicating the use of fire and erosion: Coniochaeta xylariispora (T. 6), Chaetomium sp. (T. 7A), and Glomus cf. fasciculatum (T. 207);
   (ii) those indicating eutrophication: Aphanizomenon, Anabaena, Pediasastrum, Botryococcus, Gieysztoria virguligera, Gyratrix hermaphroditus, Mesostoma lingua, Microdalyellia armigera, Strongylostoma radiatum, Mougeotia, Spirogyra, Neorhabdocoela unknown;
   (iii) Acari probably tied to forest.
(4) The Abies and Fagus curve and the curve of total tree pollen.
(5) The Cyperaceae curve.
(6) The Zonation and Archaeological Periods.

The curves in the figure confirm:

- The existence of a forested environment at the level of the lake (the amount yielded by tree pollen, of Abies in particular, and Acari abundant, especially in zone Lau 1-a).
- The evidence of some anthropogenic activity during the Atlantic and especially after the beginning of the Sub-boreal period:
  (a) Well marked development of Poaceae and apophytes, among which Chenopodiaceae, Urticaceae, Artemisia, Rumex, Plantago occur regularly.
  (b) Among the anthropochores, the presence of cereal pollen in most of the samples. By ca 2020 cal. BP, a small peak of Cannabaceae can be observed. As usual the problem of distinguishing Humulus and Cannabis arises. Based on the size of the pollen grain, its protruding pores and the steep slope of the annulus (Whittington and Gordon, 1987) we identified Cannabis. The association with other indicators of arable cultivation supports the identification (Fleming and Clarke, 1998).
  (c) We could link the evidence for fire with the presence of cereal pollen and the opening of the forest as early as phase Lau 1-a.
  (d) We could link the evidence for erosion and the use of fire with human impact. Probably trampling by domesticated animals caused erosion of soils.
  (e) Human impact could be linked with evidence for eutrophication of the lake water.
  (f) The development of the belt of Cyperaceae clearly appearing from the start of phase LAU 1-b, may indicate a reduction in the surface of open water of the lake, probably caused by an increased amount of sediment mobilised by the erosion and perhaps to a gradual relative lowering of the level of the outlet (source of the river Lauzon).

The signs of the opening up of the forested area around Lake Lauzon are contemporaneous with pollen and non-pollen palynomorph indicators of anthropogenic activity. Similar features are found in the French Alps at the timberline, above all from the Iron Age to the Gallo–Roman period onwards (de Beaulieu and Goeurly, 2004).

5.1. Chronology

The first impact on the forest is recorded around 7400 cal. BP (Neolithic), with isolated clearings and occurrences of cereal pollen. Clear traces of an agricultural economy can be seen from around 5450 cal. BP on, coinciding with the signs of ecological instability around the lake. However, these traces are irregular. The zones coloured yellow on the diagram (Fig. 5), indicate the periods of strongest human impact. They alternate with periods when the area was less impacted. Starting from the Sub-atlantic — at the beginning of the Iron Age — the impact of human activities increases in this region and becomes permanent. Signs of erosion and fire are particularly high during the early Middle Ages. This impact recorded by the lake is synchronous with the archaeological sites of the nearby valleys of the Trièves and the Beauchêne situated below (see archaeological context; Section 2.3). These sites show that the zones between 800 and 1000 m a.s.l. were relatively densely populated. Carpological and archaeozoological studies provide evidence of cultivation and breeding since the neolithic period (Beeching et al., 2004).

5.2. Do the spectra recorded by the lake represent a settlement at the edge of the lake or settlements in the valley?

Around the lake no archaeological indications for the presence of humans were found. It can be explained by the intense erosion and related sedimentation in the basin of the Lauzon. The only arguments for nearby human settlements are based on our palynological records.

5.3. Pasturing and/or cultivation?

Evidence for pasturing is not clear for the Neolithic period, but evident since the start of the Bronze Age.
Fig. 5. Lake Lauzon: synthetic diagram (palynology, non-pollen palynomorphs, archaeological chronology, anthropization).
Grazing by domesticated animals is shown by the indications of erosion, the eutrophication of the lake water and the increase of Poaceae and of apophytes (essentially Plantago lanceolata, Rumex, Urtica, Chenopodiaceae). The permanent water of the lake (an exception in the area; the only case in Dévoluy) could be used by humans and livestock for drinking and would be sufficient to justify the use of this site.

5.4. Were cultivated areas present at the elevation of the lake or only present in lower areas?

The evidence for arable land is limited to cereal pollen that was found continuously from the start of the Sub-boreal, and to that of hemp found during the Gallo–Roman period. It is disputed whether pollen assemblages from high altitude lakes reflect real vegetational changes in the vicinity of the lake or whether they are to a large extend determined by pollen and spores that are transported from the valley by strong upward flowing air currents (de Beaulieu et al., 1990; David, 1993). Yet cereal pollen is scattered with difficulty outside cultivated fields (Heim, 1970; Robinson and Hubbard, 1977; Diot, 1992) and the probability of finding it in samples collected in Lake Lauzon should be very low, especially because the forested environment at the level of the lake would have functioned as a barrier for the arrival of allochthonous pollen. The same can be said about Centaurea cyanus, a plant which grows in cereal fields; it occurs in several spectra from the Gallo–Roman period.

Another explanation for the presence of cereals and hemp together with ruderals and taxa such as Plantago lanceolata, Rumex, and Urtica is given by Moe and van der Knaap (1990). They observed that during transhumance sheep carry seeds from the valley in their wool. Seeds may germinate at this altitude near the animal tracks. In this way the pollen of ruderals and cultivated plants restricted to the lowlands would only indicate the presence of mountain trackways and would not be directly associated with intensively used areas. This would fit with the absence of archaeological sites.

Yet at Lake Lauzon, the non-pollen palynomorphs clearly indicate fire, erosion and the enrichment of the lake water with nutrients. It is almost impossible to explain this only by natural phenomena or long distance transport. The evidence mostly coincides with the anthropogenic pollen assemblages. Therefore we conclude that man occupied the surroundings of the lake and may have cultivated crop plants.

5.5. Temporary or permanent settlements?

In the Alps there is abundant evidence for periodic movement of people accompanied by animal herds, from the valleys to the mountains, at least since the early Neolithic (Fedele, 1990; Argant et al., 1991; Brochier et al., 1999; Beeching, 1999a,b). Reconsidering human occupation around Lake Lauzon since Neolithic times, the true question is whether people were present during the summer only, or permanently.

As far as human occupancy of the mountain environment is concerned, we want to emphasise that:

1. The mountains and in particular the sectors of Haut-Buech and Dévoluy, have already been traversed by nomadic mesolithic hunters.
2. The holocene warming, at its maximum during the Atlantic, led to a significant increase of the timber line, up to 2200 m a.s.l. (de Beaulieu, 1977; Fauvette, 1995), above the elevation of Lake Lauzon.
3. Our present day understanding of life in the mountains is to give priority to settlements in the valleys, to facilitate transport and merchandise, and to find profitable arable flat land, easier to work. This concept does not apply to more ancient times.
4. In the mountains, more than anywhere else, movement has always been determined by the existing routes for man on foot or with livestock. People settled down, even at sites which are difficult to access today.
5. From historical sources it is known that mountain people could be snowed in. This was not problematic if they had enough wood for heating, food to eat, fodder for their animals, shelter and water. Fedele (1990) indicates permanent villages or graves in the Alps up to 2500 m a.s.l., since the Bronze Age.

Permanent settlements may have existed near Lake Lauzon, but the main problem that remains is the snow cover in winter. Nowadays there is permanent snow during 7 to 8 months of the year, but during warmer periods in a forested environment, such as during the Neolithic or the early Bronze Age the snow period may have been much shorter. Temporary seasonal settlements may have occurred near Lake Lauzon, as was the case in the southern Alps in more recent times (De Reparaz, 1999). Settlements were scattered at different levels on south facing slopes in the middle valley of Ubaye until the end of the 19th century:
– the main villages at the bottom of the valleys;
– big hamlets (the “villards”) between 1300 and 1500 m a.s.l. with irrigated cultivated areas, including cereal fields;
– small hamlets (the “villarets”) between 1600 and 1800 m a.s.l., less important than the “villards”, but also with irrigated cultivated areas;
– the zone of the “prés hauts” between 1800 and 2400 m a.s.l. where people lived in huts growing crops often with uncertain results. On the other hand, they were more successful with producing fodder;
– the high pastures, over 2400 m a.s.l.

As soon as summer began, whole families left the villages to go to the “villarets” and “prés hauts” with their domesticated animals. Fields were sown and crops could be harvested before going back to the valley at the end of the growing season.

We cannot prove that the flat south facing area near Lake Lauzon was used as “villarets” or “prés hauts” but technically it is possible.

6. Conclusion

Pollen analysis together with the analysis of non-pollen palynomorphs in a core from Lake Lauzon at 1980 m a.s.l. shows evidence of signs of the degradation of the original vegetation at a local and a regional scale from the Atlantic period on. There is evidence for fires and erosion and there are indications of pasturing and cultivation.

At Lake Lauzon, man’s intervention started early, at first with small clearings in the fir and broadleaved forest. Silex flints indicate that people passed around the lake during the Neolithic period. The use of fire is testified by non-pollen palynomorphs, and cereal pollen appears. The clearings intensify and the landscape opens progressively. Meadow plants and ruderals (Poaceae, Plantago, Rumex, Artemisia, Chenopodiaceae, Urtica) expand, especially during the Iron Age. We assume that the surroundings of the Lake Lauzon provided good conditions for human settlement and that man created pastures by removing forest.

The first human groups which arrived were not necessarily looking only for a temporary summer settlement. They had plenty of wood for building, heating and cooking. Water was permanently available and domesticated animals were able to graze freely under the trees and in the clearings and on the higher grassy slopes. Trees provided fodder for the bad season. We suppose that cultivation of crop plants was possible. Similar cases support the idea of cultivation and/or settlements at high altitude, for example in the Piemont in Italy (Nisbet, 1999) and the Pyrénées in France (Courtaud et al., 2004).

We do not know whether there were temporary settlements for summer farming, according to the model of the “villarets” or the “prés hauts” in the historical period, or if people were permanently present near the lake.

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