

Subalpine forest history and dynamics in the French Alps (Queyras)

Mélanie Saulnier¹, Brigitte Talon¹ and Philippe Touflan¹

¹ Institut Méditerranéen d'Ecologie et de Paléoécologie, Bâtiment Villemin, Europôle de l'Arbois - BP 80, 13545 Aix-en-Provence cedex 04, France

Summary: In the context of global change, the assessment of the species and forest past dynamics at timberline is essential to improve knowledge about the present landscape and its evolution. Several paleoecological approaches are simultaneously used for reconstructing past landscape and its evolution. The dynamics of subalpine forest are subjected to natural disturbances most particularly fires. By the end of the Atlantic period, human perturbations by agro-sylvo-pastoral practices became an important factor that explains the landscape dynamics and the dominance of some ligneous species. First results of the pedoanthracology approach reveal an early recolonization by stone pine and larch following the last glaciation. In the past, the timberline was higher than nowadays. Considering the present change, particularly the abandonment of human practices, current conditions at high altitude might potentially allow forest establishment. The poor frequency of shrubs in charcoal samples raises question about their status and possible presence in past understoreys and their settlement conditions.

Key words: high altitude ecosystems, Queyras, pedoanthracology forest dynamics, species history

INTRODUCTION

High-altitude forest dynamics are considered to be of special interest with respect to global changes and are frequently investigated in ecological and palaeoecological studies. To date, paleoecological data from Queyras (southern French Alps) have been provided mainly by pollen sequences (de Beaulieu, 1977; David, 1995; Nakagawa *et al.*, 2000). Apart from data from small peat bogs, these studies have generally reported vegetation dynamics on a regional scale. However, studies based on charcoal found in soils (pedoanthracology) are of high interest to specify forest dynamics at local scale (Talon *et al.*, 1998; Talon, 2010; Touflan *et al.*, 2010). These local vegetation variations are most often imprecisely recorded by pollen sequences. Consequently, in order to understand local vegetation dynamics, history of the species and treeline variation in response to climatic and/or human pressure, it is important to carry out studies based on charcoal in natural soils.

DATA AND RESULTS

The study area is located in the Natural Park of Queyras in the inner French Alps comprising a massif centred on the Guil Valley. The woody vegetation is composed of woodlands spreading between 1700 and 2400 m asl, and is dominated by *Larix decidua*, *Pinus cembra* and *Pinus uncinata*. The understorey is dominated by *Rhododendron ferrugineum* L., *Vaccinium uliginosum* L. (mostly on north-facing slopes), *Arctostaphylos uva-ursi* (L.) Spreng. (on south-facing slopes) and *Juniperus communis* L. The tree line on the north-facing slopes is formed by a mosaic of *L. decidua* woodlands, spreading up to 2400 m asl. On the south-facing slopes, traditional land use has been devoted mainly to livestock grazing (mostly sheep), resulting in large areas of meadows and heathland slopes, where trees are absent above 2000 m.

Six sites were investigated following previous studies and current forest composition. At each site two or more pits were dug along an altitudinal gradient: at least one at the uppermost limit and one in the forest. The sampling strategy was based first on the observation of the soil profiles and on the subsequent soil description. Undisturbed soil samples were collected at 10 cm intervals from all of the soil profiles. Approximately 10 kg of soil material were collected per soil horizon. Charcoal was extracted using protocols described by Carcaillet and Thion (1996). Only charcoals larger than 1.25 µm were identified, weighted and sometimes dated.

About 3000 fragments were identified and weighted. *Pinus cembra*, *Larix/Picea* and *Pinus sylvestris uncinata* (i.e. *Pinus sylvestris/uncinata*) were the most represented species with respectively 28%, 24% and 8.5% (Fig. 1). Pine species are well represented at mid to high altitude, while larch fragments are more frequent at mid-altitude. Both shrubs and *Abies alba* charcoals are present in relatively small quantities compared with other species. Shrubs and vitrified fragments are more often present in high altitude soils.

Species distribution in soils varies between sites and within the profiles. Results of the correspondence factor analysis performed (Fig. 2) on number of fragments per species per soil profile show neither significant difference between sites for larch nor for pine forests. Both fir forest and grassland sites seem to reveal different dynamic or history.

Currently, 6 fragments issued from 5 different sites were dated (Table 1). The radiocarbon dates obtained indicate mid- to late- Holocene fires. The oldest date involves *Pinus cembra* (8702-9024 cal BP) in Jal3 and corresponds to the earliest date for this species.

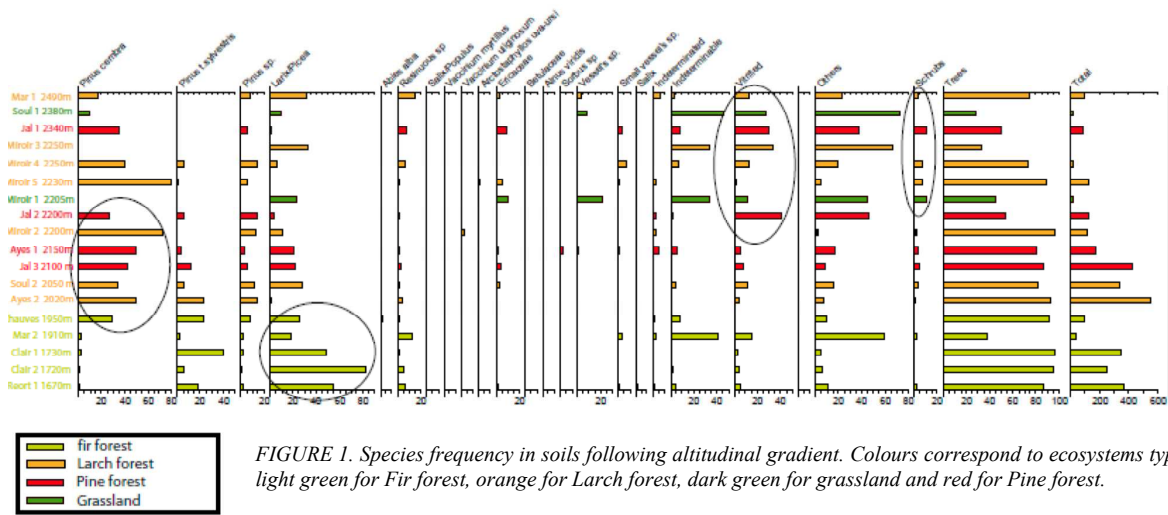


FIGURE 1. Species frequency in soils following altitudinal gradient. Colours correspond to ecosystems types: light green for Fir forest, orange for Larch forest, dark green for grassland and red for Pine forest.

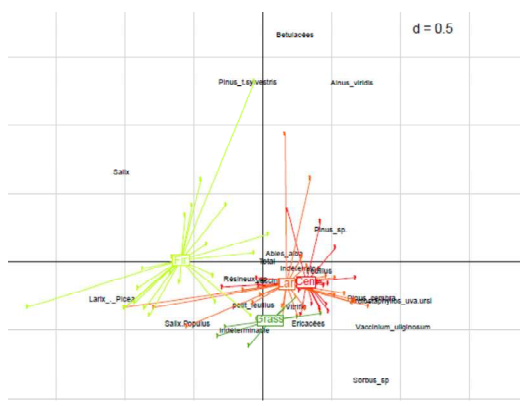


FIGURE 2. Correspondence factor analysis on soil profiles grouped following current vegetation.

Nomination	Profondeur	Peuplement	Espèce	Age 14C (BP)	Age calibré (BP)
Jal3A	40-50	cembraie	<i>Pinus cembra</i>	8020 ± 50	8702-9024
Jal3B	40-50	cembraie	<i>Pinus sylvestris</i>	4295 ± 30	4827-4891
Ayes2	40-50	cembraie	<i>Pinus cembra</i>	7560 ± 40	8315-8427
Mirroir2	5-15	mélèzin	<i>Pinus cembra</i>	1060 ± 30	927-1009
Mirroir4	10-20	mélèzin	<i>Pinus cembra</i>	2110 ± 30	1995-2152
Clair1	20-30	sapinière	<i>Pinus sylvestris</i>	2380 ± 35	2339-2491

TABLE 1. List of radiocarbon dates.

DISCUSSION

Radiocarbon dates confirm results from another study carried out in the inner French Alps where Touflan *et al.*, (2010) evidenced an earlier colonisation by larch (8213-8105 age14C BP) and pine following the last glaciation. Other radiocarbon dates are in progress in the aim of providing information about the history of fir and Ericaceae species. To date, in the Queyras area, there is a lack of archaeological studies that could bring essential knowledge about human installation.

The large representation of pine fragments at mid to high altitude could reveal a long-lasting pastoral exploitation of these sites. The current presence of larch at mid-altitude in closed-forest environment also evidences a long silvo-pastoral system involving larch stands. The low charcoal frequency in grassland soils

could attest a long past history of open ecosystems related to pasture land exploitation.

Vitrified charcoals are more present at high altitude sites, which raises questions about the local environment conditions (specific environment, specific type of fire, taphonomy).

REFERENCES

CARCAILLET, C. and THINON, M., 1996. Pedoanthracological contribution to the evolution of the upper treeline in the Maurienne Valley (North French Alps): methodology and preliminary data. *Review of Palaeobotany and Palynology* 91, 399-416.

DAVID, F., 1995. Vegetation dynamics in northern French Alps. *Historical Biology* 9, 269-295.

DE BEAULIEU, J.L., 1977. Contribution pollenanalytique à l’histoire tardiglaciaire et holocène de la végétation des Alpes méridionales Françaises. Ph.D Thesis, Université d’Aix-Marseille.

NAKAGAWA, T., EDOUARD, J.L., BEAULIEU, J.L., 2000. A scanning electron microscopy (SEM) study of sediment from Lake Cristol, southern French Alps, with special reference to the identification of *Pinus cembra* and other alpine *Pinus* species based on SEM pollen morphology. *Review of Palaeobotany and Palynology* 108, 1-15.

TALON, B., 2010. Reconstruction of Holocene high altitude vegetation cover in the French Southern Alps: evidence from soil charcoal. *The Holocene* 20 (1), 35-44.

TALON, B., CARCAILLET, C., THINON, M., 1998. Apport de la pédoanthracologie à l’étude des variations de la limite supérieure des arbres au cours des derniers millénaires dans les Alpes françaises. *Géographie physique et Quaternaire* 52, 195-208.

TOUFLAN, P., TALON, B., WALSH, K., 2010. Soil charcoal analysis: a reliable tool for spatially precise studies of past forest dynamics. A case in the French Southern Alps. *The Holocene* 20 (1), 45-52.