Preslia, Praha, 64:327-342, 1992

The influence of human activities on the vegetation of the subalpine zone of the Monts du Forez (Massif Central, France)

Vliv lidské činnosti na subalpinskou vegetaci Monts du Forez (Massif Central, Francie)

Joop H. J. Schaminée and M. Hettie Meertens

DLO Institute for Forestry and Nature Research, P. O. Box 23, 6700 AA Wageningen, The Netherlands

Schaminée J. H. J. et Meertens M. H. (1992): The influence of human activities on the vegetation of the subalpine zone of the Monts du Forez (Massif Central, France). - Preslia, Praha, 64:327-342.

Keywords: Alpine vegetation, heathlands, grasslands, phytosociology, grazing, management practices, succession, Massif Central, France

In the Monts du Forez, composition of heathlands and grasslands in the subalpine belt is highly determined by traditional management practices. For centuries, the highest parts of the massif were used for cattle grazing during summer. In winter time, cattle and farmers stayed in the valleys. At the beginning of the 20th century, however, this system collapsed. In some parts of the subalpine zone, grazing stopped completely; in other parts, the way of grazing changed as the flock did not roam freely any longer, but was kept in movable fences. Besides, farmers switched to sheep instead of cattle. During the last decades, an increasing number of heathlands on the plateaus were changing from *Genistion* (*Vaccinio myrtilli-Genistetum pilosae*) towards *Nardion*; some of them are completely destroyed by land reclamation and plantations of *Picea abies*. The heathlands on the slopes and ridges (*Genisto-Vaccinion*) are more stable. On the slopes (*Allio victorialis-Vaccinietum*), nevertheless, a gradual transition towards *Sorbus* shrubland can be observed, whereas the communities on the ridges (*Alchemillo saxatilis-Vaccinietum*) are influenced by tourists walking around; some of the best examples were destroyed by the construction of a radar station at the summit of Pierre-sur-Haute. The hay meadows (*Polygono-Trisetion*) are also strongly modified as a consequence of recent changes in land use. Still, there are some good examples of the original vegetation (*Centaureo nigrae-Poetum chaixii*). However, modern agricultural techniques have caused an increase of nitrophilous species. The meadows that were abandoned are mainly dominated by grasses like *Poa chaixii* and tall forbs. Some of the grasslands are nowadays permanently grazed and are changing into grasslands that resemble the *Violo-Nardetum*, as described for the Vosges, and the *Nardo-Leontodontetum pyrenaici*, described for the Monts Dore.

Introduction

Since 1984, phytosociological investigations have been carried out in the subalpine heathlands and adjacent communities of the Monts du Forez (Massif Central, France; Fig. 1). From a nature conservation point of view, the Monts du Forez prove to be one of the most interesting and diverse low mountain ranges in Europe (Schaminée et al., in press; Thébaud 1988). The preservation of the plant communities, however, is by no means guaranteed. As a consequence of socio-economic developments, the traditional agricultural systems, which strongly influenced the present vegetation, has collapsed.

In the present paper, firstly, the traditional land use system is discussed, comprising three characteristic elements: (1) grazing areas on the plateaus and higher mountain ridges, (2) farmhouses near the forest boundary, and (3) hay meadows near these farmhouses. In a separate section, attention is paid to the disappearance of this system and the development

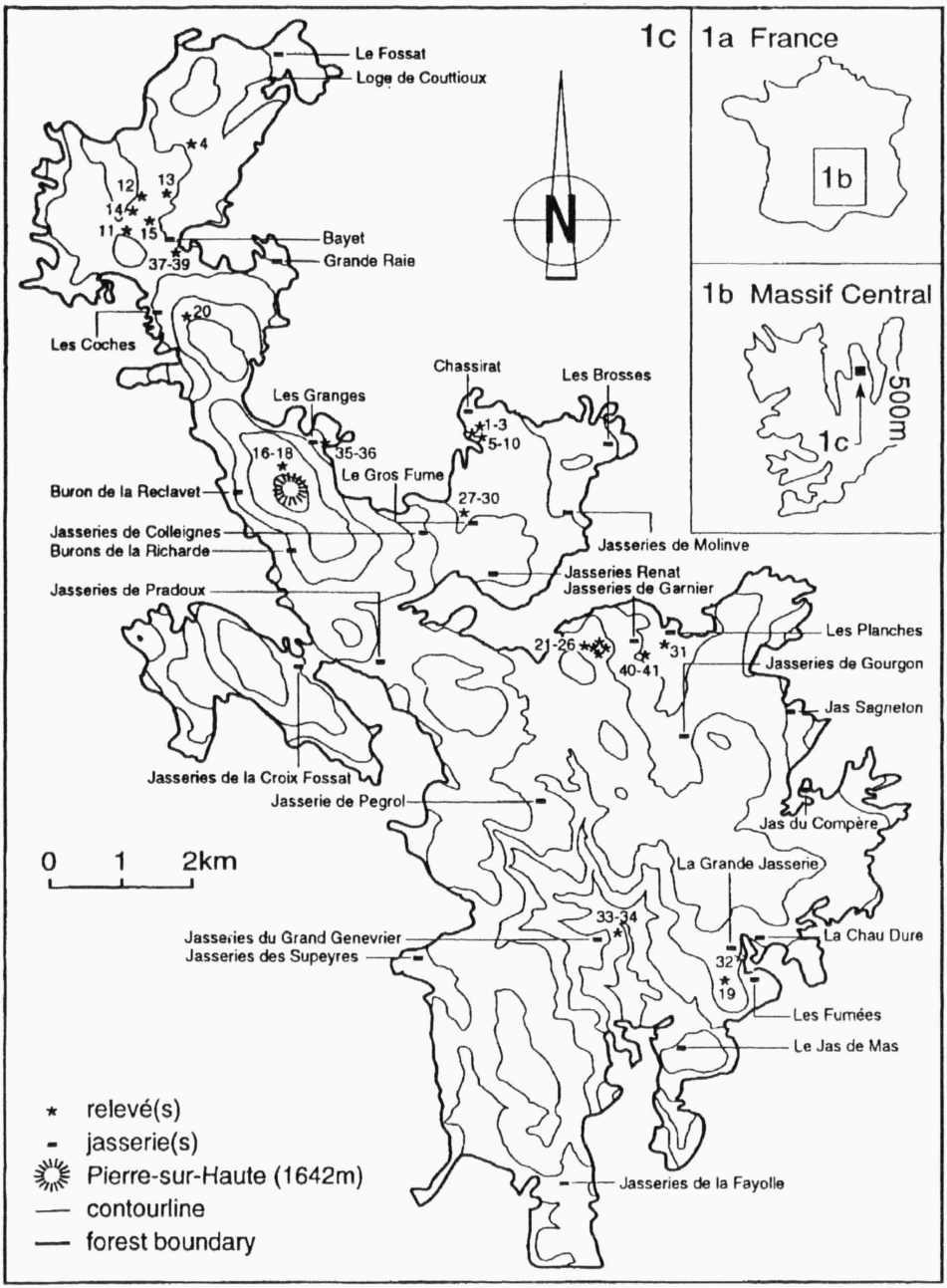

Fig. 1. - Situation of the study area within France (a) and the Massif Central (b). In Figure 1c, the distribution of the main jasseries and the location of the relevés are indicated.

of new activities during the last century. Finally, a reconstruction of the vegetation changes during the last decades is presented on the basis of detailed phytosociological analyses of the various stages of plant communities combined with broad enquiries of local farmers on former and present land use. Pastured land and hay meadows are treated separately.

Area of investigation

Natural conditions

The Monts du Forez include a low mountain range of Hercynic origin, situated in the northeastern part of the Massif Central on the border of the departments Loire and Puy-de-Dôme. The mountain range roughly runs from north to south and extends over an area of 60 x 30 km approximately. The summit (Pierre-sur-Haute) reaches to 1642 m altitude. The highest parts of the massif include a north-south oriented ridge with relatively steep slopes and strongly wind-exposed tops, and a number of extensive plateaus. Generally, the slopes have been cultivated or afforested up to 1300 m; in the close surroundings of Pierre-sur-Haute, the woods extend up to 1500 m. The area above the forest boundary, usually referred to as hautes chaumes, includes dwarfshrub heathlands, grasslands, communities dominated by tall forbs, and peatlands. The overall surface of the hautes chaumes measures about 8000 ha. Like in other low mountain ranges in western Europe, the local climate of the Monts du Forez is characterized by a high annual precipitation (1800 mm), a large number of days with frost (almost 200 per year), a prolonged snow cover in spring and early summer (on average 175 days per year), heavy winds and storms especially in wintertime, and a frequent occurrence of fog (Suchel 1985, 1990; also Thébaud 1988).

The Forez mountains mainly consist of granitic bedrock; locally, vulcanic sediments outcrop. The summit area is largely covered by a weathering layer of variable thickness, alternating with rocks and rock streams. The soils, going uphill, are classified as acid brown soil, ochric podzolic soil, brown cryptopodzolic soil, podzolic soil, and cryptopodzolic ranker (Nobbe et Nouwens 1987). The content of organic matter is relatively high; the humus forms are of the mor and moder type. The majority of the soil types points to a secondary soil development after deforestation (Martin 1975, Nobbe et Nouwens 1987).

These pedological features coincide with palynological data. Until the Roman period, human influences must have been negligible. The highest parts of the massif were covered by woodlands, apart from some rock streams and a small area around Pierre-sur-Haute (Janssen 1990). During the Roman period, extensive clearing of woodland, however, must have taken place as can be concluded from analyses of pollen diagrams studied at Plateau des Egaux (Janssen et Van Straten 1982) and Gourds des Aillieres (Janssen et Etlicher 1984). Some 2000 years ago, a strong decline in the pollen values of *Fagus sylvatica* and *Abies alba* took place associated with an increase of the values of anthropogenic indicators such as *Plantago lanceolata*, *Pteridium aquilinum*, and *Rumex acetosella*, whereas the first pollen of *Cerealia* were observed.

The traditional agricultural system

In addition to pedological and palynological data, a lot of information on former human influences on the vegetation of the Monts du Forez is provided by historical investigations (d'Alverny 1907, Fel 1962, Damon 1972, Boithias 1977, also Thébaud 1988). These studies all emphasize the long tradition of land use.

Archaeological findings of grains of corn, flounders of cattle, and tools from Roman times prove the existence of agricultural exploitation in that period; to what extent, however, is unclear. From about 1000 A. D. records are more precise, showing that in medieval times land use was already highly organized. This historical setting corresponds with data from other low mountain ranges, like the Vosges (de Valk 1981) and the Black Forest (Schwabe-Braun 1980).

In late medieval time, the phenomenon 'cattle-lease' (baile commande or cheptel de bestiaux) was introduced: the urban capital was invested in herds of cattle, leased and managed by local farmers. This system was beneficial to both parties, explaining its great and long-lasting success. The farmers lived on the agricultural products and did not have to bear financial risk, caused by wet summers, long periods of drought or severe winters. In return, the owners received a part of the produce of the herd; moreover, they were entitled to terminate the contract at any time. The cattle was moved to grazing grounds at higher altitudes during spring and back to lower elevations in fall (transhumance). Generally, the yearly period of grazing on the hautes chaumes lasted four months and ended August the 15th. The cattle grazed in small herds, tended by cowherds. The grazing took place in a heterogeneous way, dependent on the instructions of the cowherd and the preference of the animals. At night, cattle and farmers stayed in small farmhouses, called cabanes, loges or jasseries. The hautes chaumes were commonly grazed (montagnes communales in the north and montagnes en copropriété in the south; Damon 1972). The jasseries and the adjacent meadows were private property. Initially, the jasseries were separate units and the farmers worked individually; in the course of time, however, especially in the southern parts of the Monts du Forez, the jasseries were grouped together (jas) and the herds were tended collectively. There was strong legislation about numbers of animals and periods of grazing; sheep were not allowed to graze in the same places as cows. The community decided on the location of the jasseries. Jasseries were constructed of wood; after a couple of years, they were taken down and rebuilt at a more favourable place. From the beginning of the 19th century, the jasseries were permanent and completely constructed of stone; between 1850 and 1890, the traditional land use system reached its maximum development.

Fig. 2. - Les Granges, east of Pierre-sur-Haute. Nowadays, most of the jasseries in the Monts du Forez have fallen into decay.

From the beginning of the 19th century, the heathlands were not exclusively used as grazing grounds. At intervals of 3-6 years, the vegetation on the plateaus was mown to stimulate the growth of grasses and young heather; the cut-off vegetation was used as additional winter fodder for the animals, especially in wet years for lack of hay. Every year, according to the needs, small pieces of heathland were cut in late summer or early autumn after the flowering of the heather.

Yarding of cattle, that is the maintenance of cattle in a small, enclosed area for a period of several weeks at intervals of fifteen to twenty years to fertilize the stands is probably not applied much in the Monts du Forez, in sharp contrast with other mountain regions in the Massif Central. According to Braun-Blanquet (1932), „the whole maintenance of meadow in the subalpine level of the mountains of central France is based upon the yarding method".

The jasserie played a central role in the traditional land use system, also by serving for fabrication of cow cheese (fourme), an important product of the region. A water reservoir just above the jasserie (la serve) provided the farmers with water. Every morning, a certain amount of water was led into the stable, mixed with the dung of the animals, and conducted into an ingenious irrigation system, flowing into the lower situated hay meadows (fumades). The fertilization of the meadows could have been controlled by means of simple partitions or just by closing off the smallest gullies with some earth. The meadows were mown once a year at the end of July or the beginning of August; only rarely (d'Alverny 1907) they were grazed afterwards. The hay was stored in the jasseries for periods of bad weather.

Changes in land use during the 20th century

By the end of the 19th century, the traditional land use system collapsed, first of all due to a strong depopulation of the rural landscape in favour of the cities. This process started by changing social securities and new legislation like compulsory education. Detailed information on socio-economic changes is given by Damon (1972) for the community of Valcivieres in the southwestern part of the Monts du Forez. He distinguished three periods. Between the beginning of the 20th century and the First World War, the jasseries were still occupied in spite of a decrease of the population. Between the World Wars, there was a decline in agricultural activity on the hautes chaumes, but the production of fourme remained important; 68 jasseries were still occupied (against 160 in 1891). After the Second World War, the traditional land use almost stopped and the production of non-industrial fourme became unimportant; almost all jasseries fell into decay or were transformed into summer houses. In some parts of the subalpine zone, the grazing ceased completely; in other parts, the way of grazing changed. The developments in other sections of the Monts du Forez must have been likewise, as it is confirmed by various studies carried out or supervised by the Parc Natural Régional Livradois-Forez (e.g. Thébaud 1983, Roumet 1984, Paris & Renard 1985). In the northern parts of the Monts du Forez (mainly north of Col du Béal), there is still much cattle breeding; however, the herd is not led freely over the hautes chaumes anymore, but kept in movable fences. In the central and southern parts of the Forez massif, many farmers switched over to the keeping of sheep instead of cattle. It concerns both private initiatives and co-operations, such as Coopérative de Nerses (Puy-de-Dôme) and SICA de Garnier (Loire). The Coopérative de Nerses was established in 1958. In the course of time, the flock of sheep has reached 2200 animals. Partly they graze a fenced-off area of 160 ha, partly they pasture an area of 800 ha tended by a shepherd. The SICA de Garnier, established in 1965, manages more than 3000 sheep (even more than 5000 in 1976; in that extremely dry year, they received a larger number of animals from lower situated areas). The pastured area amounts to 700 ha, divided into some 50 enclosed parcels. Exploitation comprises: application of organic and artificial fertilizer, putting on of litter of heather, intensive grazing, sowing of grasses (*Dactylis glomerata*) and clover (*Trifolium repens*), and/or burning (Couhert 1988). At some places on the lower situated plateaus, farmers tried to reclaim the heathlands by ploughing the land and sowing of grass, subsidized by the state.

The periodic use of fire for management purposes probably dates from the beginning of the 20th century, after the decline of the traditional land use system. The burning of the dwarfshrubs rejuvenates the ageing heathlands and the ashes favour the growth of herbaceous plants. No general figures exist on intensity of burning and surface area involved. In the last decades, the use of burning for agricultural purposes has diminished in favour of mechanised mowing (Thébaud 1988).

Tourism and afforestation are recent developments that also highly influence the original vegetation. Recreational facilities include the construction of ski-lifts and ski-runs on the east-facing slopes of the central mountain ridge, i.e. spots where the best boundary situations between heathland communities and woodlands can be observed (Col de la Chamboite, Pierre-sur-Haute). Afforestation comprises the large-scale plantation of *Picea abies*, among others south of Col des Supeyres and between Roche Gourgon and Pierre Bazanne.

Methods

Field work was carried out during the years 1984-1988. Information on former and present land use was gathered by interviewing local farmers and from the literature. On selected sites, 41 relevés were made according to the Braun-Blanquet method (Braun-Blanquet 1928, 1951, Westhoff et van der Maarel 1973). Sample plot size varied from 9 to 25 m^2. Analyses included vascular plants and terrestrial bryophytes. For estimates of the quantitative occurrence of each species the Braun-Blanquet scale as refined by Barkman et al. (1964) was used. The location of the relevés is given in Fig. 1. In the synthetical phase, the TWINSPAN program (Hill 1979) was used to get a first insight into the floristic variation. The computer program CEDIT (van Tongeren 1991) was used for obtaining an optimal classification by relocating relevés and species 'by hand'. The relevés are divided into two subtables, comprising pastured land (Table 1) and hay meadows (Table 2). The communities are arranged according to an ecological gradient from rather nutrient-poor to more nutrient-rich substrates, mainly resulting from differences in management. Species nomenclature of vascular plants follows Flora Europaea (Tutin et al. 1964, 1968, 1972, 1976, 1980). The bryophytes are named according to Smith (1978).

Changes in vegetation

Heathlands and grasslands

The proportion between heathlands and grasslands in subalpine areas largely depends on the way and intensity of grazing. In many of the low mountain ranges in central and western Europe, grassland communities with abundance of *Nardus stricta* have become widespread under the influence of excessive pasturing. In this respect, the low-density grazing by cattle over the centuries in the Monts du Forez brought about a stable vegetation pattern. The importance of a constant management, i.e. based on the breeding of dairy cows for the production of fourme, was already stressed by Braun-Blanquet (1926) in a study on mountain heathlands in the Monts du Cantal. Braun-Blanquet stated that the main reasons for the existence of a variety of plant communities with a high degree of stability in the Monts du Cantal, without any doubt, were the low population density in the higher parts of the massif, the extent and good quality of the grazing grounds within easy reach of the jasseries (called burons in the Cantal), and especially the absence or rarity of sheep and goats.

In the Monts du Forez, the large-scale changes in land use during the 20th century have strongly influenced the original vegetation pattern. An overall extensive grazing regime has been converted into abandonment on the one hand and intensification on the other. The individual heathland types have been affected to a various extent.

The heathland communities on the wind-exposed tops of the ridges (*Alchemillo saxatilis-Vaccinietum uliginosi*; Schaminée et Hennekens in press) are mainly physiographically determined (for definitions see Vos et Stortelder 1988) as they are subject to extreme climatic conditions and bound to shallow soils with a very low nutrient availability. The maintenance of these heathlands, that only cover a small area, is more endangered by direct damage than by alterations in grazing pressure. A considerable loss was caused by the construction of a military radar station at Pierre-sur-Haute in the early years of the sixties. Just this spot was famous for its alpine and subalpine flora

(Braun-Blanquet 1923). Quite a number of both vascular plants (e.g. *Cerastium alpinum, Sisymbrium pinnatifidum, Sedum anacampseros*) and cryptogams (e.g. *Cladonia alpicola, Gyrophora tornata, Dicranum blyttii*) seem to have disappeared. Mechanical harm to plants and soils is caused by tourists walking around and by motocrossing and mountain biking for sport.

The heathland communities on the slopes of the highest parts of the mountains and on eastern exposed parts of the plateaus, where influences of snowcover are preponderant (*Allio victorialis-Vaccinietum*; Schaminée et Hennekens, in press), show more mesotrophic conditions, resulting from both physiographic and vegetation-controlled factors. Nowadays, human impact is almost absent here, apart from incidental grazing by flocks of sheep and some gathering of blueberries in autumn. At some places (e.g. south of Col du Béal; le Chesseton), this brings about a gradual succession towards *Sorbus* shrubland.

The heathland communities on the plateaus (*Vaccinio-Genistetum pilosae*; Schaminée et Hennekens, in press), characterized by a rather small amount of snow during winter and early spring and by relatively deep, acid and nutrient-poor soils, are the most influenced by human activities. Intensive grazing causes a rapid succession from heathland towards grassland. Generally, these *Nardion* grasslands have little botanical value in contrast with the more natural grassland communities along ombrotrophic peatlands and in snowbeds, that have been paid attention to in other papers (Schaminée et Meertens 1991, Schaminée et al. 1992).

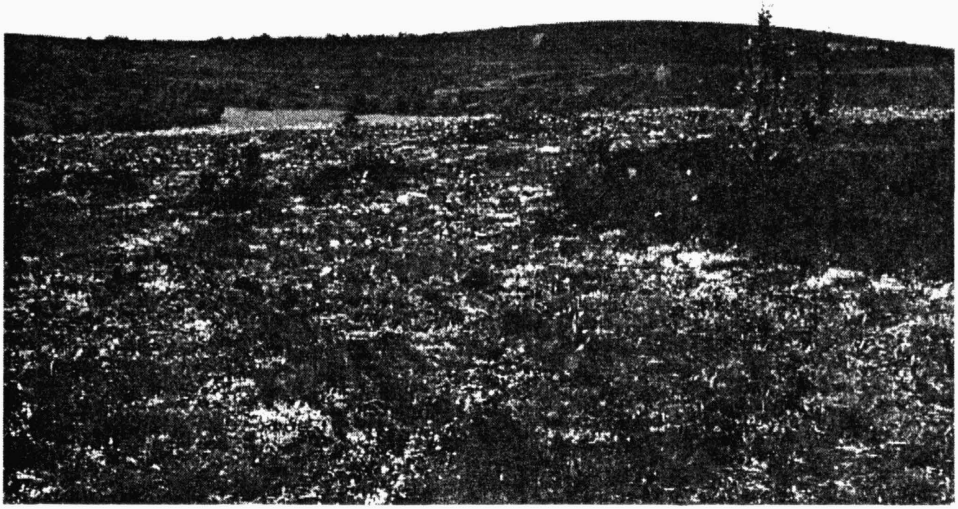

Fig. 3. - At the plateaus, the heathlands are mown mechanically at intervals of 3-6 years to stimulate the growth of grasses and young heather.

Table 1 presents a range of anthropogenically determined communities in transition between heathland and grassland. They are dominated by graminoids like *Agrostis capillaris, Carex pilulifera, Deschampsia flexuosa, Festuca rubra*, and *Nardus stricta*, whereas dwarfshrub species like *Calluna vulgaris, Genista pilosa*, and *Vaccinium myrtillus* are less preponderant. Constant species are: *Danthonia decumbens, Galium saxatile, Leontodon helveticus, Meum athamanticum*, and *Potentilla erecta*. Syntaxonomically, the communities can be assigned to the class *Nardo-Callunetea* Preising 1949. Within this class they show the strongest resemblance to the *Nardion* Br.-Bl. 1926, because of the abundance of *Leontodon helveticus* and *Meum athamanticum*, and the occurrence of *Potentilla aurea* and *Selinum pyrenaeum*. It concerns phytosociologically unsaturated communities that cannot be classified at the association level. We prefer to describe them as a basal community *Galium saxatile-Nardus stricta* - [*Nardion*] in the sense of Kopecký et Hejný (1974, 1978; see also Schaminée et al. 1992). The communities show some affinity to syntaxa described from other European low mountain ranges. Cusset et De Lachapelle (1962), for example, distinguished a *Nardo-Festucetum* in the Monts Dore. In the Vosges, Carbiener (1966) described a *Violo-Nardetum* (see hereafter); Bartsch et Bartsch (1940) described a *Leontodonto helvetici-Nardetum* in the Black Forest. Generally, these syntaxa are richer in species, less oligotrophic, and characterized by larger number of alpine and subalpine species.

The first group (10 relevés) shows the succession after mowing of the heathlands. The succession starts with short communities, characterized by dead remnants of the

Fig. 4. - Jasseries de la Croix Fossat. The hay meadows near the jasseries are clearly visible, surrounded by dwarfshrub heathlands.

Table 1. - Phytosociological table of the anthropogenic determined *Nardion*-grasslands of the Monts du Forez. See text for the explanation of particular groups of relevés.

Number of relevé	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Antennaria dioica	+	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Leucorchis albida	+	+	+	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Lilium martagon	.	+	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Calamagrostis arundinacea	+	.	+	.	+	.	+	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hypnum cupressiforme	.	.	1	.	+	.	+	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hieracium lachenalii	.	+	+	.	.	+	+	+	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Hieracium umbellatum	.	+	+	1	+	+	+	+	+	+	1	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.
Stachys officinalis	+	+	+	.	+	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Serratula tinctoria	+	1	1	.	1	1	1	2a	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Festuca ovina	+	1	1	+	1	1	1	1	+	+	2a	1	2a	+	.	.	.	.	1	.	.	.	.	.	.	.
Arnica montana	3	2b	2a	2a	+	1	1	1	+	+	1	.	1	+	.	.	.	.	+	1	.	+	.	.	.	.
Succisa pratensis	+	+	+	.	+	+	1	1	+	+	+	.	.	.	.	.	.	.	.	1	.	.	.	+	.	+
Pleurozium schreberi	.	.	1	.	+	.	+	+	2a	1	.	+	.	+	.	.	.	+	+	2a	.	.	.	+	.	.
Narcissus pseudonarcissus	.	.	.	.	.	.	.	.	.	.	+	+	+	+	+	1	+	+	+	.	.	.	.	.	.	.
Selinum pyrenaeum	.	.	.	+	.	.	.	.	.	.	+	+	.	.	.	1	+	1	.	.	+	.	+	+	.	.
Gentiana lutea	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	1	2a	+	.	.	.	.	.	.	.	.
Luzula multiflora	.	.	.	.	+	.	.	.	+	.	+	+	.	.	2a	1	1	2m	+	+	+	2m	2a	+	.	.
Polygonum bistorta	.	.	.	.	.	.	.	.	+	.	.	r	.	.	.	+	1	1	+	+	+	+	+	+	1	1
Potentilla aurea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	+	2m	1	1	+	+	+
Carex caryophyllea	.	.	.	.	.	+	1	+	.	.	.	.	.	.	.	.	.	+	+	2a	+	+	+	.	+	.
Veronica officinalis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	1	1	1	1	+
Stellaria graminea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	+	+
Euphrasia nemorosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	1	1	.
Cerastium fontanum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	+	1	1
Poa chaixii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	+	+	1	+	1
Viola lutea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	+	.	.
Rhytidiadelphus squarrosus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	2a	.	.	.	+	.	.
Calluna vulgaris	2a	1	1	+	2b	2a	2b	3	5	5	2a	2a	2a	2b	.	+	+	+	2b	2a	+	.	1	3	+	.
Vaccinium myrtillus	1	1	2a	2b	1	1	1	+	2a	+	2m	2m	1	1	3	1	+	2a	1	.	+	.	1	1	.	.
Anemone nemorosa	1	1	.	+	.	+	+	+	+	+	1	.	.	.	.	2a	2b	1	.	.	1	+	+	.	.	.
Genista pilosa	2b	2b	2b	2a	2b	2b	2b	2b	2b	3	+	+	+	+	+	.	.	.	+	1	+	+	+	1	+	+
Deschampsia flexuosa	+	1	2m	2a	2a	2a	1	1	1	+	+	+	1	1	2a	1	1	1	2a	2b	+	2m	2a	1	+	+
Leontodon helveticus	1	1	+	1	+	2m	1	+	+	.	+	+	+	.	+	2m	1	1	.	1	2a	+	2m	1	+	1
Potentilla erecta	1	1	2a	2b	2a	2a	1	1	1	2a	2a	2a	2a	2b	3	2b	1	2a	2a	1	2m	1	2a	1	+	1
Carex pilulifera	2m	2m	2a	1	2m	2m	2a	.	1	+	2a	2a	2m	+	2a	2m	2m	2a	2m	1	2b	2a	2a	2a	2m	+
Galium saxatile	1	1	+	+	2b	2b	2a	2a	+	+	2b	2b	2m	2m	2b	2b	2a	2b	2a	2m	2a	3	2b	2b	2a	+
Nardus stricta	2a	2b	2b	2a	3	2a	2b	2a	+	+	4	4	4	5	3	5	5	4	3	1	3	3	2b	2b	3	+
Festuca rubra	+	1	1	1	2a	2a	1	1	1	+	+	+	1	.	2a	1	1	2m	1	2m	3	3	4	2b	3	4
Meum athamanticum	1	+	1	+	1	1	1	1	1	+	.	.	.	.	+	+	.	.	+	.	+	1	1	+	1	1
Agrostis capillaris	+	.	+	.	+	2m	+	+	+	.	.	.	.	.	1	1	2a	.	.	3	2a	2b	2a	2m	2a	2b
Danthonia decumbens	+	+	1	+	+	+	1	1	.	.	+	.	.	.	.	.	.	.	+	.	.	+	+	1	+	+
Dicranum scoparium	.	.	.	.	.	+	.	+	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Polygala serpyllifolia	.	.	+	+	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.
Dactylorhiza maculata	.	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hylocomium splendens	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.
Molinia caerulea	.	.	.	+	.	.	.	.	.	.	+	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.

Addenda

In two relevés: *Allium victorialis* (4,+; 13,+); *Campanula recta* (20,+; 21,+); *Carex panicea* (12,+; 20,+); *Hypericum maculatum* (19,+; 24,+); *Lathyrus montanus* (5,+; 24,+); *Rumex acetosa* (23,+; 26,+); *Thesium alpinum* (5,+; 17,+).

In one relevé: *Anthoxanthum odoratum* (24,+); *Cerastium arvense* (26,+); *Cladonia chlorophaea* (8,+); *Cladonia furcata* (8,+); *Dactylis glomerata* (26,+); *Dianthus seguieri* (23,+); *Juniperus communis* (10.+); *Luzula campestris* (14,+); *Lycopodium clavatum* (12,+); *Pinus sylvestris* (15,+); *Polytrichum formosum* (12,+); *Polytrichum piliferum* (25,+); *Populus tremula* (4,1); *Ranunculus nemorosus* (24,+); *Scorzonera humilis* (20,+); *Sorbus aucuparia* (3,r); *Trifolium repens* (26,+); *Viola riviniana* (20,+).

Table 2. - Phytosociological table of the hay meadows near the jasseries in the Monts du Forez. See text for the explanation of particular groups of relevés.

Number of relevé	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
Carex pilulifera	1	+	+	.	.	.	.	.	.	.	.	.	.	.	.
Euphrasia hirtella	2m	+	2m	+	.	.	.	.	.	.	.	.	.	.	.
Luzula campestris	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.
Hylocomium splendens	.	2a	+	3	.	.	.	.	.	.	.	.	.	.	.
Dianthus seguieri	+	+	+	+	.	+	.	.	.	.	.	.	.	.	.
Narcissus pseudonarcissus	+	+	+	+	+	.	.	.	+	.	.	.	.	.	.
Deschampsia flexuosa	1	2a	+	1	.	2m	3	3	.	+	.	.	.	.	.
Ajuga reptans	+	+	.	+	1	+	+	+	+	+	.	.	.	.	.
Anemone nemorosa	1	+	+	+	1	+	+	.	+	+	.	.	.	.	.
Lotus corniculatus	.	.	.	+	+	+	.	+	+	+	.	.	.	.	.
Galium pumilum	+	.	.	.	+	.	1	2m	.	.	.	.	.	.	.
Crepis mollis	.	.	.	.	+	.	.	+	.	+	.	.	.	.	.
Veratrum album	.	.	.	.	.	.	+	1	+	.	.	.	.	.	.
Narcissus poeticus	.	.	.	.	.	3	2a	2b	.	.	.	.	.	.	.
Leontodon hispidus	.	.	.	.	+	.	+	+	.	.	.	.	.	.	.
Lathyrus montanus	.	.	.	.	+	2m	2m	1	.	.	.	.	+	.	.
Stachys officinalis	.	.	.	.	2a	+	+	+	.	.	.	.	.	.	.
Luzula multiflora	.	.	.	.	1	+	1	1	+	1	+	+	.	+	+
Veronica chamaedrys	.	.	.	.	+	+	.	+	+	+	.	+	+	1	+
Cerastium fontanum	.	.	.	.	+	.	.	+	.	.	1	+	+	1	1
Thlaspi sylvestre	.	.	.	.	.	+	.	+	.	.	.	.	.	+	+
Silene dioica	.	.	.	.	.	+	.	+	.	.	.	.	.	+	+
Galium verum	.	.	.	.	1	+	.	.	.	.	.	.	.	+	+
Achillea millefolium	.	.	.	.	+	+	.	.	.	.	.	.	.	1	+
Dactylis glomerata	.	.	.	.	+	.	+	+	.	.	+	+	.	1	2a
Centaurea montana	.	.	.	.	.	1	.	+	.	.	.	.	.	.	1
Geranium sylvaticum	.	.	.	.	+	1	1	2b	.	.	.	.	.	+	1
Plantago lanceolata	.	.	.	.	+	.	.	+	.	.	.	1	.	.	.
Cynosurus cristatus	.	.	.	.	+	.	.	.	.	.	1	2a	.	.	.
Deschampsia caespitosa	.	.	.	.	+	.	.	.	.	.	.	.	.	+	2a
Taraxacum officinale	.	.	.	.	+	.	.	.	.	.	+	.	.	+	1
Trisetum flavescens	.	.	.	.	+	.	.	.	.	.	1	2a	+	+	1
Conopodium majus	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+
Alchemilla xanthochlora	.	.	.	.	.	.	.	+	.	.	2a	1	+	.	.
Poa pratensis	.	.	.	.	.	.	.	.	.	.	1	.	.	+	1
Trifolium repens	.	.	.	.	.	.	.	.	.	.	2a	1	1	1	+
Poa chaixii	1	1	1	1	+	1	2b	2m	2b	2b	+	+	1	+	.
Centaurea nigra	.	1	1	1	1	+	+	+	.	1	+	+	1	.	+
Viola lutea	1	.	1	1	1	1	1	1	2a	2m	+	+	+	+	+
Ranunculus nemorosus	+	+	+	+	1	+	+	+	+	+	2a	1	1	+	.
Hypericum maculatum	2a	+	2a	1	1	+	1	+	2a	1	+	1	1	1	+
Potentilla aurea	2m	1	2a	1	+	+	.	+	+	+	+	+	1	1	+
Meum athamanticum	2b	2a	1	2b	2a	2a	2b	2b	3	3	1	2b	2b	1	+
Anthoxanthum odoratum	2m	2m	1	1	2a	1	.	1	1	1	+	2a	2	.	+
Polygonum bistorta	1	.	+	1	+	1	2a	2a	2b	2b	1	1	1	+	2a
Phyteuma spicatum	.	+	+	+	+	2a	1	+	+	+	.	.	.	.	1
Festuca rubra	1	+	2b	+	3	3	3	2b	2b	2a	4	2a	2a	4	2m
Agrostis capillaris	2b	2b	2a	.	1	2m	2m	2a	2a	2a	2a	1	2m	2a	3
Stellarica graminea	+	+	.	+	+	.	.	+	+	+	+	+	+	+	1
Trifolium pratense	+	.	1	+	2a	1	.	+	.	.	2a	1	1	+	+
Rumex acetosa	.	.	.	+	+	+	+	1	+	+	2a	1	+	.	1
Galium saxatile	+	+	2m	1	.	2m	.	.	2b	2m	.	.	2a	1	+
Leontodon helveticus	1	1	1	1	.	.	.	.	1	+	+	.	2b	+	1
Rhinantus minor	2a	2m	1	1	2m	.	+	+	+	+	1	2a	+	.	.
Rhytidiadelphus squarrosus	4	.	5	3	+	.	2a	+	.	+	1	2b	2b	.	.
Gentiana lutea	1	1	2a	+	2a	.	.	+	2a	2a	.	+	.	.	.
Potentilla erecta	.	+	+	+	+	.	.	.	.	+	+	.	+	.	.

Table 2. - Continued

Number of relevé	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
Nardus stricta	.	4	.	4	1	+	.	.	1	+	.	1	2b	.	.
Briza media	1	1	2m	1	1	+	+	+	.	.	.	+	+	.	.
Leucanthemum vulgare	.	+	+	+	.	+	+	+	.	.	1	+	.	.	.
Carex caryophyllea	1	+	2m	1	2m	+	+	.	.	+	.	+	.	.	.
Thymus pulegioides	1	+	.	1	1	.	+	.	.	.	+	.	+	.	.
Veronica officinalis	+	+	1	+	+	.	.	.	+	.	+	.	+	+	.
Campanula recta	1	+	.	+	.	+	+	1	+	+	.	+	+	.	.
Polygala vulgaris	.	+	.	+	+	+	+	.	.	.	.	.	+	.	.
Knautia dipsacifolia	.	.	+	.	.	+	+	+	.	+	.	+	.	.	.
Trollius europaeus	+	.	.	+	+	.	+	+	.	.	.	+	.	.	.
Alchemilla pastoralis	+	.	.	.	.	+	.	.	.	.	.	+	.	+	+

Addenda

In two relevés: *Alchemilla glabra* (31,1; 36,+); *Brachythecium rutabulum* (28,+; 33,+); *Brachythecium glareosum* (27,+; 32,+); *Carex ovalis* (37,+; 39,+); *Cirsium palustre* (31,r; 37,1); *Dicranum scoparium* (30,+; 39,+); *Euphrasia rostkoviana* (32,+; 37,1); *Euphrasia* sp. (38,+; 39,1); *Hieracium pilosella* (29,+; 30,+); *Holcus lanatus* (37,+; 41,2a); *Knautia godetii* (27,+; 28,+); *Plagiomnium affine* (27,+; 38,+); *Polytrichum formosum* (29,+; 30+); *Ranunculus acris* (40,+; 41,1); *Rumex obtusifolius* (37,+; 41,+); *Selinum pyrenaeum* (37,1; 39,+).

In one relevé: *Agrostis stolonifera* (38,1); *Arnica montana* (31,+); *Atrichum undulatum* (34,+); *Avenula pubescens* (32,+); *Chenopodium bonus-henricus* (41,+); *Danthonia decumbens* (31,+); *Galeopsis tetrahit* (41,+); *Genista sagittalis* (31,+); *Gnaphaliun sylvaticum* (35,+); *Gymnadenia conopsea* (31,+); *Heracleum sphondylium* (41,+); *Hieracium lactucella* (31,+); *Hypericum perforatum* (41,+); *Myosotis sylvatica* (41,+); *Phleum pratense* (41,+); *Poa trivialis* (40,+); *Pohlia nutans* (27,+); *Primula veris* (31,+); *Prunella vulgaris* (37,+); *Ranunculus repens* (41,+); *Sanguisorba officinalis* (31,+); *Serratula tinctoria* (33,+); *Silene vulgaris* (34,+); *Solidago virgaurea* (33,r); *Succisa pratensis* (31,+); *Thesium alpinum* (31,+); *Vaccinium myrtillus* (37,+).

dwarfshrubs and by hemicryptophytes colonizing bare soil. Dominance of *Arnica montana* turns up, especially after burning. In the early stage of succession, *Leucorchis albida* and *Antennaria dioica* may occur. Within a couple of years, the vegetation is mainly determined by graminoids like *Nardus stricta, Deschampsia flexuosa*, and *Carex pilulifera*, in combination with *Galium saxatile* and young plants of *Calluna vulgaris* and *Genista pilosa*. Finally, the stands will be dominated again by the dwarfshrubs. The regeneration of dwarfshrubs is opposed, when mowing is accompanied by (intensive) grazing. This is illustrated by the second group (5 relevés). The graminoids (mainly *Nardus stricta*) dominate. The mean number of species per relevé is low. Of the few invading species, *Narcissus pseudonarcissus* can be mentioned. The strong resistance of this species to grazing is demonstrated even better in the third group (3 relevés), made on former cattle tracks in the highest parts of the mountains. Here again, *Nardus stricta* is dominating. The higher altitude can be concluded from the presence of orophytes like *Gentiana lutea* and *Potentilla aurea*, and species like *Anemone nemorosa* and *Polygonum bistorta*, indicating a high atmospheric humidity. The last group (8 relevés) illustrates some grassland communities that have been fertilized. Next to *Nardus stricta*, grasses with a higher nutritional value are co-dominating, like *Festuca rubra* and *Agrostis capillaris*.

Hay meadows near the jasseries

Within the oligotrophic and extensive heathland landscape of the subalpine zone of the Monts du Forez, the fertilized, mesotrophic hay meadows near the jasseries form a conspicuous component. The traditional land use system as described previously has brought about grassland communities, that must have been stable and very rich in species for a very long time. Nowadays, most of these meadows are strongly modified due to recent changes in management regime. In this respect, the Monts du Forez are no exception, as can be concluded from the voluminous documentation with regard to this subject (e.g. Daniels et al. 1987, Klapp 1965, Kornas et Dubiel 1991, also Dierschke 1981). In the Monts du Forez, three divergent trends can be distinguished. At several places, the hay meadows are not mown anymore but transformed into grasslands under permanent grazing. Most commonly, the meadows are being treated by modern agricultural techniques like liming (to raise the pH value) and manuring with artificial fertilizer. Some of the less accessible meadows have come into complete disuse, mainly on forest edges on the slopes of the central mountain ridge. No examples are left that are fully managed according to the traditional method, although fertilizing with stable dung by using the old irrigation system and mowing for hay making are still practised at some localities.

Table 2 presents an overview of grassland communities near jasseries, originally used as hay meadows. The communities are all rich in species; the mean number of species per relevé amounts to 39 with a maximum of 58. They occur between 1200 and 1500 m altitude (cf. Thébaud 1988). The stands are dominated by grasses like *Agrostis capillaris, Deschampsia flexuosa, Nardus stricta*, and *Poa chaixii*, and many attractive flowering herbs such as *Centaurea nigra, Gentiana lutea, Knautia dipsacifolia, Meum athamanticum, Phyteuma spicatum, Polygonum bistorta*, and *Viola lutea*. By far the largest part of the species are characteristic of either the *Nardo-Callunetea* Preissing 1949 or the *Molinio-Arrhenatheretea* Tx. 37. *Galium saxatile, Leontodon helveticus, Meum athamanticum, Nardus stricta, Potentilla aurea,* and *Viola lutea* characterize the first class. *Briza media, Leucanthemum vulgare, Polygonum bistorta, Rhinanthus minor, Rhytidiadelphus squarrosus, Rumex acetosa, Stellaria graminea,* and *Trifolium pratense* are indicators of the second one. This vegetation can be assigned to the alliance *Polygono-Trisetion* Br.-Bl. et Tx. ex Marshall 1947 nom. inval. (class *Molinio-Arrhenatheretea*). The syntaxonomy of these montane to subalpine meadow communities has been studied by Dierschke (1981) and Oberdorfer (1983). Apart from the coexistence of species of the *Nardetalia* and *Arrhenatheretalia*, the *Polygono-Trisetion* is characterized by (among others) *Alchemilla pastoralis, Crepis mollis*, and *Geranium sylvaticum*. Dierschke (l.c.) distinguished three suballiances, mainly based on altitudinal and phytogeographic differences, namely the *Campanulo-Trisetenion* of the Alps and Jura, the *Alchemillo-Trisetenion* of the Carpathians Mountains, and the *Lathyro-Trisetenion* of the low mountain ranges in the northwest of central Europe (Vosges, Black Forest, Harz). The author remarks that the less documented communities in the southwestern part of the distribution area of the alliance probably can be put in a fourth suballiance, differentiated by *Narcissus pseudonarcissus* and *N. poeticus* subsp. *radiiflorus*. In the synthetic table presented by Dierschke, two associations of this group are mentioned: the *Agrostidetum* of the Cévennes, described by Braun-Blanquet (1915), and the Association a *Agrostis capillaris* of the Monts Dore, described by Luquet (1926). A number of additional differential species (*Campanula recta, Conopodium majus, Gentiana lutea, Leontodon*

pyrenaicus, Viola lutea), mentioned by Thébaud (1988) confirm the distinction of a separate suballiance. On the other hand, the phytocoenoses of the Monts du Forez also show a resemblance with the *Lathyro-Trisetenion* (*Anemone nemorosa, Deschampsia flexuosa, Lathyrus montanus, Poa chaixii*) and, more particularly, with the associations *Geranio-Trisetetum* Knapp 1951 and *Meo-Festucetum* J. et M. Bartsch 1940 belonging to this suballiance. Nevertheless, we agree with Thébaud (1988) that the hay meadows of the subalpine zone of the Monts du Forez can be described as a separate association, the *Centaureo nigrae-Poetum chaixii*. The name of this syntaxon was not validly published by Thébaud, as it was suggested as a provisional one. According to the Code of Phytosociological Nomenclature (Barkman et al. 1986), the correct author citation should be:

***Centaureo nigrae-Poetum chaixii* Thébaud ex Schaminée ass. nova**

Type relevé: Table 2, rel. 6

The association is well characterized by the name-giving species *Centaurea nigra* and *Poa chaixii*. Compared with the *Geranio-Trisetetum*, the *Centaureo-Poetum* is richer in the *Nardion*-species (e.g. *Leontodon pyrenaicus, Potentilla aurea, Viola lutea*), contains more subatlantic species (*Centaurea nigra, Conopodium majus, Meum athamanticum*) and is bound to higher altitudes which is reflected by the occurrence of species like *Gentiana lutea, Thlaspi sylvestre, Veratrum album* whereas many species having their optima at lower altitudes are lacking. Compared with the *Meo-Festucetum*, the *Centaureo-Poetum* is considerably richer in species. The Association a *Agrostis capillaris* of the Monts Dore and the *Agrostidetum* of the Cévennes also strongly differ from each other. They comprise more species of *Arrhenatheretalia* in proportion to *Nardetalia*, whereas the *Polygono-Trisetion* itself is weakly represented. In the Cévennes, some species (e.g. *Campanula carnica, Armeria alliacea*) occur that are missing in the northern parts of the Massif Central.

The first group (4 relevés) represents communities that are under permanent cattle grazing now, causing a succession towards *Nardetalia*. The accumulation of organic material is favoured compared to the original situation when all biomass was removed each year by mowing (cf. Daniels et al. 1987). The differential species (*Carex pilulifera, Dianthus seguieri, Euphrasia hirtella, Hylocomium splendens, Luzula campestris*) are all indicators of oligotrophic conditions. The vegetation resembles the *Violo-Nardetum* of the Vosges (e.g. Carbiener 1966, Oberdorfer 1983); it also has affinity to the *Nardo-Leontodontetum pyrenaici* of the Monts Dore, described by Cusset et De Lachapelle (1962). The best examples of the *Centaureo nigrae-Poetum chaixii* are to be found in the second group (6 relevés); particularly those relevés that have been made in the southern part of the Monts du Forez (Col des Supeyres) probably get near to the original hay meadows. The first relevé of this group, very rich in species, shows a transition towards permanent cattle grazing. The last two relevés were located in meadows that have been abandoned for more than 20 years; the vegetation is still dominated by grasses (*Poa chaixii*) and further characterized by a high cover of tall forbs such as *Gentiana lutea, Meum athamanticum*, and *Polygonum bistorta*; the regeneration of dwarfshrubs proves to be very slow. The third group (5 relevés) comprises communities under intensified agricultural management, resulting in the occurrence of species like *Cerastium fontanum, Dactylis glomerata, Trifolium repens*, and *Trisetum flavescens*.

Acknowledgments

The authors are greatly indebted to Jean-Claude Fayard and Marie-Antoinette Rozier for their advice during the fieldwork. Dr. G. Thébaud provided important literature and additional information. The text has been read critically by Professor C. W. P. M. Blom, Dr. H. J. P. A. Verkaar, T. A. W. van Rossum, and Professor V. Westhoff. We also wish to thank S. M. Hennekens for the determination of bryophytes and printing the tables. The illustrations were prepared by J. van Westreenen of the Graphics Department of the Faculty of Sciences (University of Nijmegen). The research was made possible thanks to financial support of the Reinhold-Tüxen Stiftung (Hannover) and the Laboratory of Palaeobotany and Palynology of the University of Utrecht.

Souhrn

Vřesoviště a travní porosty v Monts du Forez, stejně jako v ostatních nižších pohořích Evropy, jsou ovlivněny tradičními postupy obhospodařování. Nejvyšší části masivu (tzv. hautes chaumes) jsou po staletí využívány k pastvě dobytka. Během léta farmáři přebývali v tzv. jasseries, zatímco na zimu sháněli stáda do údolí. Na začátku 20. století však tento způsob hospodaření přestal fungovat. Pokles počtu obyvatel vedl k silnému omezení pastvy a téměř všechny jasseries byly opuštěny. V některých částech subalpinského stupně se s pasením přestalo úplně, jinde se změnil způsob pastvy: stáda se nepotulovala po hautes chaumes volně, nýbrž byla držena na ohražených místech. Navíc farmáři začali chovat ovce namísto dobytka. Během posledních desetiletí prodělává stále vzrůstající počet vřesovišť na vrcholovém plateau přechod od svazu *Genistion* (as. *Vaccinio myrtilli-Genistetum pilosae*) ke svazu *Nardion*; některá z nich jsou úplně zničena rekultivacemi a výsadbou *Picea abies*. Vřesoviště na svazích a hřbetech (*Genisto-Vaccinion)* jsou stabilnější, i když u svahových porostů *Allio victorialis-Vaccinietum* lze pozorovat postupný přechod k jeřábovým křovinám. Společenstva hřbetů (*Alchemillo saxatilis-Vaccinietum*) jsou silně ovlivněna turistikou a některé nejlepší příklady tohoto typu vegetace byly zničeny při stavbě radarové stanice na vrcholku Pierre-sur-Haute. Také sečené louky v okolí jasseries (*Polygono-Trisetion*) jsou silně poznamenány současnými změnami v obhospodařování; přesto lze však nalézt cenné ukázky původní vegetace (*Centaureo nigrae-Poetum chaixii*). Moderní způsoby obhospodařování se projevují zvýšeným výskytem nitrofilních druhů. Na opuštěných loukách většinou dominuje *Poa chaixii* a vysoké širokolisté byliny. Část těchto luk je v současnosti permanentně spásána a mění se v porosty připomínající *Violo-Nardetum*, popsané z Vogéz, a *Nardo-Leontodontetum pyrenaici*, udávané z Monts Dore.

References

d'Alverny A. (1907): Les hautes-chaumes du Forez. - Bull. Diana 15:160-211.

Bartsch J. et Bartsch M. (1940): Vegetationskunde des Schwarzwaldes. - Pflanzensoziologie, Vol. 4, Jena [229 p.].

Barkman J. J., Doing H. et Segal S. (1964): Kritische Bemerkungen und Vorschläge zur quantitativen Vegetationsanalyse. - Acta Bot. Neerl., Amsterdam, 13:394-419.

Barkman J. J., Moravec J. et Rauschert S. (1986): Code of phytosociological nomenclature - 2nd edition. - Vegetatio, The Hague, 67:145-195.

Boithias J. L. (1977): L'estivage familial et la fabrication de la fourme sur les Hautes-Chaumes foréziennes dans l'entre-deux-guerres (l'exemple d'une famille auvergnate). - Bull. Hist. Scient. Auvergne 88:371-388.

Braun-Blanquet J. (1915): Les Cévennes méridionales (massif de l'Aigoual). - Ms., 208 p. [Diss. Université de Montpellier].

Braun-Blanquet J. (1923): L'origine et le développement des flores dans le Massif Central de France avec apercu sur les migrations des flores dans l'Europe sud-occidentale. - Paris et Zürich [282 p.].

Braun-Blanquet J. (1926): Le „climax complexe" des landes alpines (*Genisteto-Vaccinion* du Cantal). - Arvernia 2:29-48.

Braun-Blanquet J. (1928): Pflanzensoziologie. Grundzüge der Pflanzensoziologie. - Berlin [330 p.].

Braun-Blanquet J. (1932): Plant sociology. The study of plant communities. - New York et London [translated, revised and edited by G. D. Fuller et H. S. Conard, 439 p.].

Braun-Blanquet J. (1951): Pflanzensoziologie. Grundzüge der Vegetationskunde. Ed. 2. - Wien [632 p.].

Carbiener R. (1966): La végétation des Hautes-Vosges dans ses rapports avec les climats locaux, les sols et la géomorphologie, comparaison a la végétation subalpine d'autres massifs montagneux a climat 'allochtone' d'Europe occidentale. - Ms., 122 p. [Diss., Université de Paris-Orsay].

Couhert J.-P. (1988): Les hautes chaumes des Monts du Forez. Bilance de l'utilisation et perspectives d'aménagement d'un territoire. - Ms., 205 p. [Diss., Université de Clermont-Ferrand].
Cusset G. et de Lachapelle B. (1962): Etudes botaniques dans les Monts Dore (Deuxieme partie). - Rev. Sci. Nat. Auverges, Clermont-Ferrand, 28:13-81.
Damon M. (1972): Les jasseries des Monts du Forez, sociologie de la vie pastorale. - Ms., 250 p. [Diss., Université de Lyon II].
Daniels F. J. A., Bobbink R., Braber L. I. et Schild R. (1987): The present and past grassland vegetation of the Chajoux and Moselotte valleys (Vosges, France). 1. The present day dwarfshrub and grassland communities. - In: Proc. Kon. Nederl. Akad. Wetensch., [Amsterdam], C 90 (2):87-114.
Dierschke H. (1981): Syntaxonomische Gliederung der Bergwiesen Mitteleuropas (*Polygono-Trisetion*). - In: Dierschke H. [red.], Syntaxonomie, Ber. Int. Symp. Rinteln, p. 311-340.
Fel A. (1962): Les hautes terres du Massif Central. Tradition paysanne et économie agricole. - P. U. F. Paris [340 p.].
Hill M. O. (1979): TWINSPAN - A FORTRAN program for arranging multivariate data in an ordered two-way table by classification of individuals and attributes. - New York [90 p.].
Janssen C. R. (1990): Histoire de la végétation des Monts du Forez. - In: Berger G. et al. [red.], Les Monts du Forez. Le milieu et les hommes, p. 65-79, Centre d'Etudes Foréziennes, Saint-Etienne.
Janssen C. R. et Etlicher B. (1984): Monts du Forez: geomorphology, recent surface pollen diagrams and late glacial Holocene vegetational history of Pierre-sur- Haute. - In: XI. Réunion Internat. Bot. Europ. Quaternaire, p. 26-28 et 50-53.
Janssen C. R. et van Straten R. (1982): Premiers résultats des recherches palynologiques en Forez, Plateau Central. - Compt. Rend. Acad. Sci. Paris 294 (2):155-159.
Klapp E. (1965): Grünlandvegetation und Standort, nach Beispielen aus West-, Mittel- und Süddeutschland. - Berlin et Hamburg [384 p.].
Kopecký K. et Hejný S. (1974): A new approach to the classification of anthropogenic plant communities. - Vegetatio, The Hague, 29:17-20.
Kopecký K. et Hejný S. (1978): Die Anwendung einer deduktiven Methode syntaxonomischer Klassifikation bei der Bearbeitung der strassenbegleitenden Pflanzengesellschaften Nordostböhmens. - Vegetatio, The Hague, 36:43-51.
Kornas J. et Dubiel E. (1991): Land use and vegetation changes in the hay meadows of the Ojcow National Park during the last thirty years. - Veröff. Geobot. Inst. ETH, Stiftung Rübel, Zürich, 106:208-231.
Luquet A. (1926): Les associations végétales du massif des Monts-Dore. Essai sur la géographie botanique de l'Auvergne. - Saint-Dizier [266 p.].
Martin G. (1975): Itinéraire pédologique dans les Monts du Forez. - Université de Saint-Etienne [175 p].
Nobbe C. et Nouwens R. (1987); De bodems onder de hautes chaumes van de Monts du Forez (Frankrijk). Forezverslag 3. - Katholieke Universiteit Nijmegen [54 p.].
Oberdorfer E. [red.] (1983): Süddeutsche Pflanzengesellschaften. Teil III. Ed. 2. - Stuttgart et New York [455 p.].
Paris F. et Renard F. (1985): Réflexions sur l'aménagement des Hautes-Chaumes du Forez d'apres la cartographie de sa végétation: communes de Grandrif, St-Antheme, Valcivieres. - Université de Rennes [132 p.].
Roumet C. (1984): Cartographie de la végétation des Hautes-Chaumes de la commune de St.-Pierre-la-Bourlhonne (Forez). Réflexions sur l'aménagement. - Université de Rennes [105 p.].
Schaminée J. H. J., Coolen C. et Siebum M. B. (1992): The vegetation of „snowbeds" in the Monts du Forez (Massif Central, France). - Phytocoenologia, Stuttgart, 21:175-206.
Schaminée J. H. J. et Hennekens S. M. (1992): Subalpine heathland communities of the Monts du Forez (Massif Central, France). - Doc. Phytosociol., Camerino, 14 [in press].
Schaminée J. H. J., Hennekens S. M. et Thébaud G. (in press): A syntaxonomical survey of subalpine heathland communities (*Genisto-Vaccinion* Br.-Bl. 26) of the low mountain ranges of western Europe. - J. Veget. Sci., Uppsala.
Schaminée, J. H. J. et Meertens M. H. (1991): A vegetation analysis of the transition between subalpine heathlands and their surroundings in the Monts du Forez (Massif Central, France). - Acta Bot. Neerl., Amsterdam, 40(2):139-159.
Schwabe-Braun A. (1980): Eine pflanzensoziologische Modelluntersuchung als Grundlage für Naturschutz und Planung. Weidfeld-Vegetation im Schwarzwald: Geschichte der Nutzung, Gesellschaften und ihre Komplexe, Bewertung für den Naturschutz - Urbs et Regio, Kassel, 18:1-212.
Smith A. J. E. (1978): The moss flora of Britain and Ireland. - Cambridge [706 p]..
Suchel J. (1985): Quelques données sur le climat de Pierre-sur-Haute (sommets des Monts du Forez). - Université de Saint-Etienne [9 p.].

Suchel J. (1990): Le climat des Monts du Forez. - In: Berger G. et al. [red.], Les Monts du Forez. Le milieu et les hommes, p. 81-89, Centre d'Etudes Foréziennes, Saint-Etienne.

Thébaud G. (1983): Contribution a l'étude des Hautes-Chaumes du Forez: phytoécologie des communaux du Brugeron (Puy-de-Dôme), éléments pour leur gestion a long terme. - Ms., 187 p. [Diss., Université de Clermont-Ferrand].

Thébaud G. (1988): Le Haut-Forez et ses milieux naturels. Apports de l'analyse phytosociologique pour la connaissance écologique et géographique d'une moyenne montagne cristalline subatlantique. - Ms., 330 p. [Diss., Université de Clermont-Ferrand].

van Tongeren, O. (1991): CEDIT, Cell EDITor, Canoco EDITor, Cornell EDITor. Preliminary manual. - Limnological Institute, Nieuwersluis [123 p.].

Tutin T. G., Heywood V. H. et al. (1964, 1968, 1972, 1976, 1980): Flora Europaea. Vol. 1-5. - Cambridge [464, 455, 370, 505 and 452 p.].

de Valk E. J. (1981): Late holocene and present vegetation of the Kantelberg (Vosges, France). - Ms., 294 p. [Diss., Rijksuniversiteit Utrecht].

Vos W. et Stortelder A. H. F. (1988): Vanishing Tuscan landscapes. Landscape ecology of a Submediterranean-Montane area (Solano Basin, Tuscany, Italy). Ms., 510 p. [Diss., Universiteit van Amsterdam].

Westhoff V. et van der Maarel E. (1973): The Braun-Blanquet approach. - In: Whittaker R. H. [red.], Ordination and classification of communities, Handbook of vegetation science, The Hague, 5:617-726.

Received 8 August 1992
Accepted 1 November 1992