Suo 43(1):11–24, 1992

ANDRÉ–JEAN FRANCEZ, JEAN–JACQUES BIGNON and ANNE–MARIE MOLLET

THE PEATLANDS IN FRANCE: LOCALIZATION, CHARACTERISTICS, USE AND CONSERVATION

Ranskan suot ja niiden käyttö

Francez, A.–J., Bignon, J.–J. & Mollet, A.–M. 1992: The peatlands in France: localization, characteristics, use and conservation. (Tiivistelmä: Ranskan suot ja niiden käyttö.) — Suo 43:11–24. Helsinki. ISSN 0039-5471

We find in France two main peatlands-types: topogenous *Carex*-fens, in the north and east of the country, and ombrogenous *Sphagnum*-bogs, in the medium montanes. In total, there are about 100 000 ha peatlands which correspond to a volume of 2×10^9 m^3. The amount of extracted peat in France was, in the eighties, 200 000 t (dry matter). Peat is essentially used as fuel or, mixed with German or Soviet peat, as soilless substrates. The fens of the floodplains have long been used for market gardening (tradition of 'hortillonnages' in Amiens or Bourges). Two national surveys were made during energy crises, during the Second World War and at the end of the 1970s following the oil shortage. The law of July 1976 on the preservation of the countryside lists 19 peatlands plant species that are nationally protected. Ten peatlands have been classified as nature reserves and two projects are in preparation.

Keywords: agriculture, bog, fen, peat utilization

A.–J. Francez & J.–J. Bignon, C.E.R.E.M.C.A., rue du Tisserand, Rouillas-Bas, F-63 970 Aydat, France.
A.–M. Mollet, Station Biologique, F-63 610 Besse-en-Chandesse, France.

INTRODUCTION

There have been few estimates of the total area covered by peatlands in France and they vary considerably, from 60 (Moore and Bellamy 1974) to 120 000 hectares (Taylor 1964, Goodwillie 1980). A national survey carried out during the Second World War (Direction des Mines 1949) reports an overall area of about 100 000 ha which estimate was accepted by Kivinen and Pakarinen (1981). Whatever the surface, it is only a very small proportion of the area of the country, at most 0.2%. According to the wartime survey quoted above, the total volume of peat amounts to 2×10^9 m^3. This is, however, an overestimation, as according to Goodwillie (1981), more than half of the French peatlands (63 000 ha) have been destroyed.

Amateur naturalists have taken a great interest in peatlands throughout France and we have reliable basic knowledge about their flora and avifauna. However, except for investigations by laboratories interested in the horticultural potential of peat (André 1976 and 1978, Rivière et al. 1984) or by paleological researchers (De Beaulieu et al. 1982), little scientific work has been done on the ecosystem of peatlands. Some studies on the functioning of peatlands have nevertheless been made (De Barjac 1955, Le Borgne et al. 1967, Miouze 1985, Francez and Mollet 1990, Francez 1991). Furthermore, the Ministry of Environment has recently begun to actively support research programmes and in 1988 the third international conference on wetlands was organized in France (Lefeuvre 1990).

In this article we describe the different types of French peatlands and their main characteristics and localization. The problem of their use and conservation will also be discussed, the influence of human activity, even in France, being a strong factor in their evolution, survival or disappearance.

LOCALIZATION AND CHARACTERISTICS

Topogenous and eutrophic peatlands are mainly found in the alluvial valleys of the north and east of France (Fig. 1). They

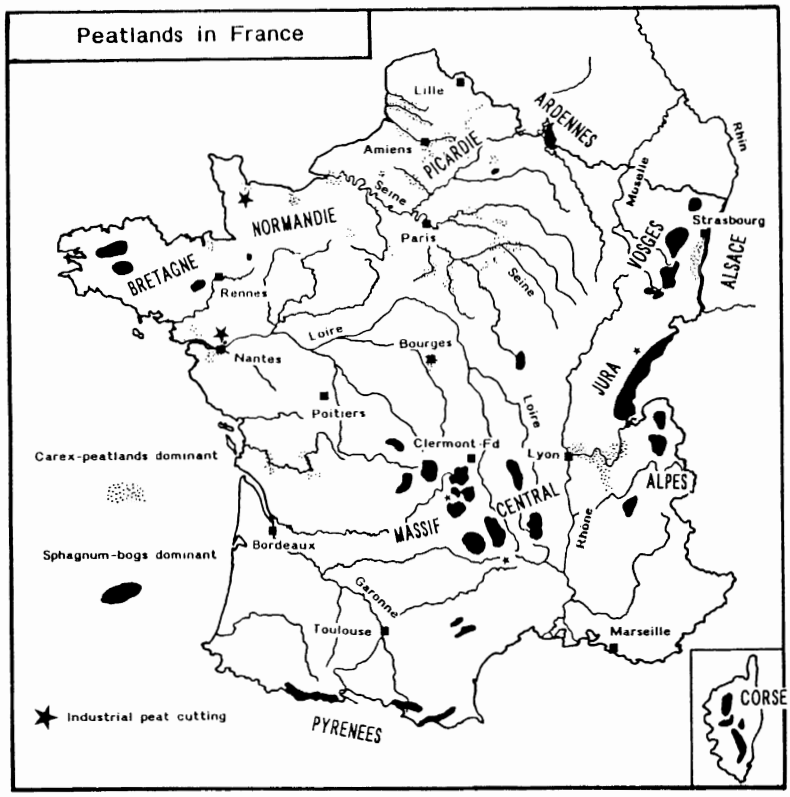

Figure 1. Localization of the main peatlands regions in France. In the floodplains, the peatlands are essentially eutrophic (dotted area) and in the mountains, oligotrophic (solid black). The principal extraction sites are indicated (size of the stars in proportion to that of the exploitation).

Kuva 1. Ranskan soiden pääesiintymisalueet. Vesistöjen varsilla olevat suot ovat pääasiassa eutrofisia (pisteytetty) ja vuoristoissa olevat oligo- ja ombrotrofisia (mustattu). Turpeennostoalueet on merkitty tähdillä siten, että tähden koko on suhteutettu noston suuruuteen.

are ecosystems in which Hypnaceae, rushes (*Phragmites*) and sedges (*Carex* spp.) play an essential role in the creation of peat (Fig. 2).

Ombrogenous and oligotrophic peatlands develope principally in medium mountain ranges from an original lake (Fig. 3), as in the Jura, Massif Central and Vosges (Fig. 1). They are peat-bogs (*Sphagnum* spp., *Eriophorum vaginatum, Trichophorum cespitosum*) which with age form the characteristic convexity of the raised bog. The area of the initial fen varies, depending on the size of the basin hollowed out by glacial erosion and on the evolution of the peatland. Thus, in the Jura we find large eutrophic and mesotrophic fens (Gillet et al. 1980).

Transitory marshes develope once contacts are established with the bog. They still have two sources of water supply. Their typology is, however, not yet fully understood.

The first reported studies on the typology of peatlands date from the beginning of the century when Bruyant (1913) described and classified the peatlands of Auvergne. Like German workers, such as Harnisch (1929) for example, the authors used topography as the main criterion for classification: eutrophic and mesotrophic peatlands are classified as low or flat in contrast to oligotrophic peatlands, which are designated as raised bogs. Reffay (1980), in a useful bibliographical review, compiled the french terms and their foreign equivalents.

The vegetation and phytosociology of peatlands have been studied in detail in various regions (see the proceedings of the symposium "La végétation des sols tourbeux" in Géhu 1980). The main phytosociological alliances in peatlands, as set out by Goodwillie (1980), are to be found in France. According to Tombal and Schumacker (1981), the vegetation of french peatlands can be divided up into the following six phytosociological classes:

Figure 2. Eutrophic fen no longer exploited (altitude about 90 m). Peat was extracted by dredging machine. A pond was formed, which has been partly recolonized (Boves near Amiens, Picardy). (Photo: A.–J. Francez).

Kuva 2. Hylätty turpeennostoalue Picardyn alueella Luoteis-Ranskassa. Ruoppauksen loputtua alue on osittain jo alkanut palautua suokasvillisuudelle. (Kuva: A.–J. Francez).

Scheuchzerio-Caricetea fuscae (pioneer communities with a vegetation that is not stable),

Oxycocco-Sphagnetea (communities of raised bogs),

Utricularietea intermedio-minoris (communities of peat pools and ponds in which Hypnacea predominate),

Phragmitetea (helophytic communities with eutrophic tendency),

Vaccinio-Piceetea (boreo–alpine forest communities in which conifers predominate),

Alnetea glutinosae (caducifoliate forest community).

Conifer-wooded peat-bogs are rare in France except in the Jura where *Pinus mugo* communities seem to form a climax. This is not the case for the few *Pinus uncinata* stations found in the Pyrénées and

Figure 3. Peat-bog-lake of Lacoste (near Clermont-Ferrand, Auvergne). The *Sphagna* colonize the free water. This type of facies is common in the Jura, Massif Central and Vosges. (Photo: A.–J. Francez).

Kuva 3. Lacosten umpeenkasvava suolampi lähellä Clermont-Ferrandin kaupunkia Ranskan keskiylängöllä. Tämän alueen lisäksi kuvan tapaisia suomaisemia tavataan Jura- ja Vogeesien vuoristojen alueella. (Kuva: A.–J. Francez).

the Massif Central (Reille 1989). Alders (*Alnus glutinosa*) and willows (*Salix* spp.) are common in eutrophic fens, particularly in the north of France. They develope during drainage periods and their growth is sometimes so rampant that the marsh's survival is threatened. Appropriate measures must then be taken such as cutting and pasturing, to prevent the fen from being completely overgrown.

The main works in the regional phytosociological studies of the peat-bogs have been written by Gillet et al. (1980) and Bidault (1982) in the Jura, Bruyant (1913), Lemée (1945), Julve (1983) and Thébaud (1983) in the Massif Central, Kaule (1974), and Muller 1987) in the Vosges. *Sphagnetum magellanici typicum* and *S. m. trichophoretosum* (Fig. 4) are found in different bog regions, even in Britanny where only two raised bogs are known (Touffet 1982, Clément 1984). A few rare species have been observed, such as *Sphagnum pylaesi* in Britanny (Touffet 1969) or the 4 species of *Eriophorum* in the bog of Cessières-Montbavin (M. Bournérias, personal communication).

Bournérias (1968) made a close study of the dynamics of the vegetation of the alkaline peatlands of the Paris basin, distinguishing between the series of large helophytes growing on peat (alliances of *Caricion lasiocarpae* and *Phragmition)* and the vegetation of Pleurocarp neutro-alkaline peatlands *(Caricion davallianae).* Less is known about the fauna than the flora of peatlands. The field of study is vaster and more difficult both because of climatic conditions, which are often unfavourable, and of the small numbers of certain groups, which make it difficult to assess population dynamics. However, there is increasing knowledge of the ecology of certain groups of invertebrates, including rotifers (Francez 1987 and 1988, Francez and Dévaux 1985), spiders (Villepoux 1984) and orthopters (Guégen and Clément 1984).

USE OF PEATLANDS

Historical background

Archeological studies have shown that while peatlands and the peat they contained may not have been directly exploited, diverse social events took place on and around the sites. The remains of pottery and arms and coins from ancient Gaul found in some peatlands in the north of France are evidence that there was human activity in the vicinity. In Loire-Atlantique, in western France, articles of pottery encased in protective wooden boarding and buried in the peat were found while a drainage ditch was being dug (Visset 1984).

It is known that during the Middle Ages local lords and abbots were already aware of the interest of peatlands and purchased tracts of marshland.There was a shaning among individuals of the valuable resour-

ces of the peatland: peat used as fuel, bulrushes and sedges for litter and thatch for making roofs.

In the seventeenth and eighteenth centuries wood was the prime raw material. Peat was not widely available and was only of local importance in the economy even if for some communities it was a source of considerable income. Like wood it was used for heating but already there was concern that these two supplies would be swiftly depleted if their exploitation was not better organized.

The great marsh-draining programmes in France were begun under Henry IV at the turn of the sixteenth century. At the time, the management of peatlands was programmated (fishing, culture, ...). Chevallier (1978) recounts that various attempts were made to develope the peat-bog-lake of Bouverans in the Franche-Comté (East of France), beginning in 1780. The first dike was built in 1792 to facilitate the extraction of peat but the scheme met with failure, last project has been abandoned in ... 1972.

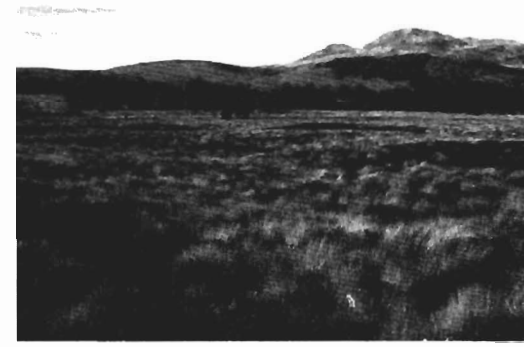

Figure 4. *Trichophorum cespitosum* bog (La Barthe, near Clermont-Ferrand). Pools formation triggers the renewal of turfigenous activity. (Photo: A.–J. Francez).

Kuva 4. Lyhytkortinen neva Ranskan keskiylängöllä lähellä Clermont-Ferrandin kaupunkia. Kuljujen ja ruoppien muodostuminen estää nopean turpeen kerrostumisen. (Kuva: A.–J. Francez).

Peat resources and extraction

The only overall estimations of the amount of peat in France were made during the Second World War (Direction des Mines 1949) and gave a value of 2×10^9 m^3, which represents about 0,01% of the worldwide total (Taylor 1964). There are 140 peatlands in France whose peat volume is equal or greater than one million m^3, making up 3/4 of French resources (Direction des Mines 1949, Favrot 1981).

According to Favrot (1981), the main deposits are in the eutrophic peatlands in the northeast and southwest of France: peatlands of Baupte (Manche), Mazerolles (Loire-Atlantique), Châteauneuf (Côtes d'Armor) and those of the Marais Vernier and Heurtauville (Seine-Maritime) of a volume greater than 10×10^6 m^3; peatlands of the Marais d'Arandon (Isère) and those of Echets and Lavours (Ain).

From 1845 to 1878, production of peat in France ranged between 350 000 and 600 000 tonnes of dry peat, after which it gradually declined until 1915 when it basely reached 20 000 t. Despite a slight revival in 1918 (120 000 t), production remained at around 30 000 t between 1919 and 1940. It increased during the Second World War, rising to 190 000 t. According to Chepeau (1984), production between 1965 and 1980 rose from 65 000 to 220 000 t.

Normandy and the area around Nantes have the highest levels of industrial peat extraction, about 2×10^5 m^3 yr^{-1} and 1,3 to 1,8 $\times 10^5$ m^3 yr^{-1} respectively. The peat from Normandy is mainly for use in the fuel and chemical industries with some being used in agriculture. In most of the other deposits exploited, peat is extracted for soilless substrates (Fig. 5). In most cases, the peat is mixed with so called

Figure 5. The industrially extracted peat is dried loose and then taken to be mixed with imported peat (Champeix, Auvergne). (Photo: A.–J. Francez).

Kuva 5. Turpeenkuivatuskasoja Keski-Ranskassa (Champeix, Auvergne). Kuivatuksen jälkeen turve sekoitetaan Saksasta tai IVYn alueelta tuotuun turpeeseen, jota yleensä vasta käytetään esim. kasvuturpeena. (Kuva: A.–J. Francez).

Figure 6. Drying of bricks extracted by hand with peat-shovels (peat-bog of La Landie, Massif Central). (Photo: A.–M. Mollet).

Kuva 6. Lapiolla irrotettujen turvebrikettien kuivatusta La Landien suolla Ranskan keskiylängöllä. (Kuva: A.–M. Mollet).

white peat imported from Germany or the former U.S.S.R.

In some regions, peat is still locally exploited on a small scale. In the Massif Central, it is used as fuel to heat farmhouses at high altitude in summer. Extraction is done by hand with peat shovels (= 'louchet', in French), and the blocks are left to dry on the spot (Fig. 6).

Agricultural uses of French peatlands

Eutrophic and mesotrophic fens

The alkaline peatlands of the floodplains, which are fairly easy to drain, have long been used for market gardening (Coquidé 1912). This tradition of 'hortillonnages' is still alive today in places like Amiens or Bourges.

The excess water is evacuated by a drainage system based on dug out ditches. The canal network has a series of sluice gates which are operated for both drainage and irrigation and maintain the water at a constant level. The peat extracted from the ditches is used to build up the small islands formed by the digging of the drains. The technique is very similar to that used in the Everglades of Florida (Donahue 1958). The peat on the islets gradually settles down under the effect of drainage and the maintenance of the water level at about –0,60 m but is replaced by other peat which is dug out during ditch cleaning and spread over the top surface.

This system requires a lot of upkeep and is therefore costly (Henin et al. 1969). In addition, because the soil obtained is more aerated and the microbial activity greater, it is vulnerable to wind erosion. The structure of the peat soil changes with drainage and is transformed into fine particles or simply into dust (Okruszko 1989) that the wind blows away. This obviously results in a considerable loss of revenue.

Vegetables grown are mainly cabbages, leeks, potatoes, carrots, peas, ... and, on a small scale, beetroot and maize (Fig. 7). At one time, hops were grown in the eutrophic fens of the marshes of La Souche, in Picardy (Fig. 8).

Attempts have been made in certain regions to use peatlands for intensive cultivation, in particular for the growing of maize. The experiments have met with little success, as related by Chepeau (1984), for example in the peatland of Mazerolles, near Nantes, in which grazing is now the main activity.

Figure 7. Beetroot and maize cultivation on a eutrophic peatland ('hortillonnage') in Picardy (marsh of La Souche, Picardy). (Photo: J.–J. Bignon).

Kuva 7. Juurikkaiden ja maissin viljelyä ravinteisella suoalueella Picardyn alueella Luoteis-Ranskassa ('hortillonnage' ranskaksi). (Kuva: J.–J. Bignon).

Raised-bogs

In the past, farmers used peat from bogs as litter because it has a power of absorption two or three times greater than that of straw. Rushes (*Juncus* spp.) and sedges (*Carex* spp.) also supplied a complement to normal animal feed.

Traditional methods of cultivation are still used by old farmers in a few regions, in particular in the Massif Central (Artense, Cézallier, Monts de Lacaune): cutting, organic manuring and cutting, burning and pasturage (Bignon and Francez 1991). The least wet facies, drained by small shallow ditches, have evolved into peat grassland on which animals can graze in summer. However, the quality of the pasture does not seem to be very good, and it is sometimes difficult to gain access with farm machinery.

Nevertheless, we made a survey of the experiments carried out in the Monts de la Margeride and the Massif du Mézenc to intensify the agricultural use of peatbogs, which were sometimes backed by help from the Institut National de la Recherche Agronomique (de Montard 1983). The draining of surface water, enrichment and fertilization produced a significant increase in forage production. This improvement was confirmed by results obtained at our experimental station located in the Monts du Forez, in the east of the Massif Central (Francez 1991). But in the same time, we have shown that the peat deposits would disappear in about 250 years with the new modalities of functioning (Francez 1991, Francez and Vasander in preparation).

Raised bogs are also planted with conifers but by owners living in town, unwilling to see their land unproductive, and not by foresters. In nearly all cases, the experiment is a failure (Fig. 9). Ditch draining is not appropriate, no account is taken of the hydraulic properties of ombrogenous peat and the species chosen (*Picea abies*) is unsuitable: the trees are affected by summer frosts and, in winter, are unable to withstand the wind and snow.

Figure 8. Eutrophic fen formerly used for growing hops (Marsh of La Souche, Picardy). Some poles used as stakes can still be seen. (Photo: J.-J. Bignon).

Kuva 8. Humalan viljelyyn käytettyä suoaluetta Picardyn alueella Luoteis-Ranskassa. Muutamia humalasalkoja on vielä nähtävissä. (Kuva: J.-J. Bignon).

PROTECTION AND CONSERVATION

Problems

Peatlands in France have received little scientific attention. Although studies have shown that they harbour unusual flora and fauna, including newly discovered species (see, for example, Haenni and Brunhes 1983, Francez and Pourriot 1984) and despite the fact that for some time the European authorities have drawn attention to the richness and fragility of these ecosystems (Goodwillie 1980), the irreversible destruction of the environment continues.

Traditional methods of cultivation have helped to maintain certain species or facies. Cutting and burning, when they are not too drastic, can have a beneficial role in the upkeep of the marsh. Extraction of peat in small quantities by creating pools stimulates new growth and formation. With the new agricultural policy of the E.E.C. (freezing of lands, rural depopulation), these activities are under threat.

In the present situation, two opposing trends emerge: a lack of knowledge of the causative factors in the disappearance of these ecosystems and the likely cessation in the near future of those activities that are empirically known to favour the long-term survival of the environment.

Surveys

Before an environmental protection policy is implemented, detailed surveys are carried out and typological studies made. Topographical maps and inventories seem to be drawn up periodically in France, particularly during energy crises. Thus, the two most thorough national surveys were made during the Second World War (Direction des Mines 1949) and at the end of the 1970's following the oil shortage (Géhu et al. 1981).

The first survey contains a fairly exhaustive list of eutrophic and oligotrophic peatlands of France and the potential amount of peat they could provide. The aim was clear: to find an alternative source of energy in the event of the shortage in supply. Thus, each peatland was analyzed as regards the quality (physicochemistry, fibre and ash content) and the quantity of the peat. There is a record of each river and its versant basin, summarizing the main properties of the different sites listed.

The aim of the second survey was to identify and locate peatlands of local, national and international importance on the basis of their flora and fauna and their ecological and paleological interest. The result was a list of 86 peatlands of national and international interest (Fig. 10). However, there are gaps in the survey, since

it was not a methodical piece of fieldwork but more a review and compilation of existing knowledge.

Separate surveys have also been carried out in different regions, of which the most detailed, to our knowledge, are those concerning the Jura (Gillet et al. 1980) and Britanny (Touffet 1982). Several topographical maps of the Auvergne have been produced (Carene 1986) but to a large extent they duplicate each other and are less thorough than those mentioned above. Attempts have been made to determine which peatlands might be economically profitable to exploit.

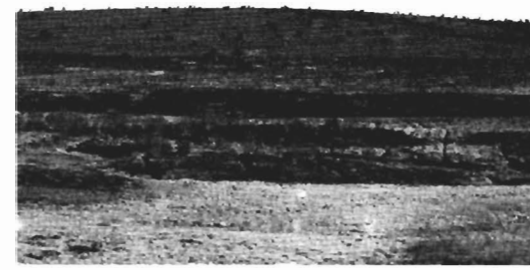

Figure 9. Plantation of *Picea abies* in a raised bog of the Monts du Forez (Massif Central) at 1 300 m altitude. The drainage ditches are wrongly placed and ineffective and the species of tree chosen is ill suited to the harsh climate. Unfortunately, this type of plantation is still common. (Photo: A.–J. Francez).

Kuva 9. Kuusen istutusala Monts du Forez-vuoriston kohosuolla 1300 m:n korkeudella Ranskan keskiylängöllä. Ojaverkosto on huonosti suunniteltu ja tehoton. Suo on liian karu kuuselle, joka kärsii myös lähes jokakeväisistä halloista. Valitettavasti tällaiset yksityismaiden istutusalat eivät ole harvinaisia. (Kuva: A.–J. Francez).

Protective measures

Protected species

The law of July 1976 on the preservation of the countryside lists all the species that are nationally protected. The peatland plants covered by this legislation, and the regions in which they are to be found, are given below:

Andromeda polifolia (throughout)
Betula nana (Margeride, Jura)
Carex limosa (Auvergne, Alps, Picardy), *C. chordorrhiza* (Auvergne, Aubrac, Jura, Vosges), *C. heleonastes* (Jura)
Calla palustris (East of France)
Cicuta virosa (Auvergne, East of France)
Dianthus superbus (Alsace, Jura, Alps)
Drosera anglica (East and North of France, Pyrénées, Alps, Jura), *D. intermedia* (Britanny, Limousin, Auvergne, East of France, Picardy), *D. rotundifolia* (throughout)
Eriophorum gracile (Haute-Loire, Picardy)
Gladiolus palustris (East of France, Haute-Savoie)
Lycopodiella inundata (throughout)
Ligularia sibirica (Côte d'Or, Auvergne, Pyrénées)
Liparis loeselii (Picardy, East and West of France, Jura, Alps)
Schoenus ferrugineus (East of France, Jura, Alps)
Salix lapponum (Auvergne, Pyrénées orientales)
Saxifraga hirculus (Jura)
Trientalis europaea (Ardennes, Vosges, Savoie)
Vaccinium oxycoccos (Loire atlantique, Anjou, Normandy, Paris basin, Morvan, Jura, Alps, Auvergne)
Swertia perennis (Jura, Alps, Puy-de-Dôme).

Nature reserves

Various measures for the protection of the environment are in force in France, with designations ranging from "conservation area" to "totally protected site". About ten peatlands have been classified as nature reserves (Fig. 10, the numbers correspond to those in the text below) to which can be added the peatland of Frasne in the Jura, which is a voluntarily protected reserve.

(1) Peat-bog of the Lac du Luitel (6.2 ha, in extension) near Grenoble (Alps), the first nature reserve created in France (1961). Twelve species

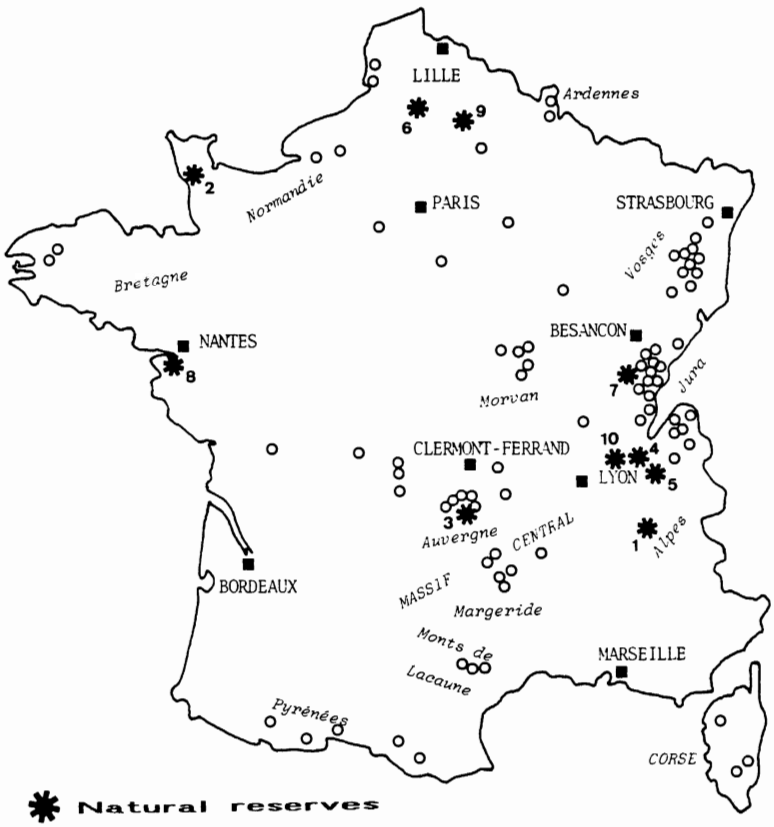

Figure 10. Localization of peatlands of greatest interest (according to Géhu et al. 1981, modified) and of nature reserves (the numbers correspond to those of the text).

Kuva 10. Ranskan tärkeimpien suoalueiden (mukaeltu Gehun ym. 1981 perusteella) ja suojelualueiden sijainti. Numerot viittaavat tekstiin.

of *Sphagnum* and 12 of *Carex*, including *C. limosa*.

(2) Peatland of Mathon (16 ha) in Manche (Normandy). The reserve dates back to 1973 and is administrated by the Museum National d'Histoire Naturelle (Paris).

(3) Peat-bog-lake of La Godivelle (24 ha) in Auvergne (1975), eutrophic and oligotrophic peatland. Newly discovered invertebrate species (Haenni and Brunhes 1983, Francez and Pourriot 1984).

(4) Roc de Chère (68 ha) in Haute-Savoie (Alps), designated as a reserve in 1977. Two small peat-bogs in a wooded massif.

(5) Fen of Bout du lac (84.5 ha), Annecy (Haute-Savoie), created in 1980. Eutrophic peatland with *Carex* and *Phragmites* species; important wintering site for birds.

(6) Peatland of Saint-Ladre (13 ha), near Amiens in Picardy (created in 1979). Eutrophic fen with numerous *Sphagnum* species. Interesting avifauna.

(7) Peat-bog-lake of Remoray (427 ha) in the Jura (1980). Of botanical interest: 4 protected species and three species of *Vaccinium*.

(8) Lake and fen of Grand-Lieu in Loire atlantique, near Nantes (1980). One of the largest fens in France (2 700 ha). Numerous vertebrates, batrachians and birds with the largest heron colony in France (1 200 couples of *Ardea cinerea*) and the presence of *Lutra lutra* and *Mustela lutreola* among the mammals.

(9) Marsh of Isle (48 ha) in Saint-Quentin (1981), part of a built-up area. The land was formed as the result of previous exploitation of peat. Avifauna (migration and wintering).

(10) Marsh of Lavours (473 ha) near Culoz (Ain), the most recent peatland reserve (1984), a eutrophic fen of great botanical and ornithological interest (*Crex crex, Porzana porzana, Numenius arquata, Circus aeruginosus,* etc.).

Two natural peatlands reserves are in creation in the departement of Aisne (Picardy), a eutrophic and mesotrophic fen, the Marsh of Vesles-et-Caumont in the marshes-complex of La Souche (ornithological interest with the nidification of *Botaurus stellaris, Circus aeruginosus, Panurus biarmicus*) and a peat-bog, the peatland of Cessières-Montbavin (presence of eutrophic and oligotrophic facies, 4 species of *Eriophorum).*

CONCLUSIONS

The peatlands of France are part of the country's natural heritage and as such are of the greatest importance. Unfortunately, they do not always enjoy the status they deserve and many have been irreversebly damaged. Whereas traditional methods of exploitation help to renew these ecosystems, recent attempts at intensive cultivation and large-scale extraction of peat have only resulted in their destruction.

Peatlands represent a threefold interest: botanical (boreal species, glacial relicts) and zoological (new species for science); paleological (evidence of the history of local vegetation) and ecological (blockage of nutrient cycles); pedagogical and sociocultural (archaeological discoveries, cults and rites centred on the marsh).

We hope that this short review will have served to illustrate the original features of French peatlands and to heighten awareness of the need to conserve their vulnerable environment.

ACKNOWLEDGEMENTS

We would like to thank H. Vasander for his helpful comments and J. Watts for the English translation.

REFERENCES

André, J.–P. 1976: Les propriétés d'échangeur cationique de la tourbe de Sphaignes: échanges bicationiques entre le proton et un cation métallique. — Ann. Agron. 27:17–31.

André, J.–P. 1978: Prévision des équilibres d'échanges entre quatre cations dans un substrat de tourbe de Sphaignes. — Ann. Agron. 29:541–557.

Barjac, H. de 1955: Esai d'interprétation bactério–écologique de sols tourbeux acides. — 170 pp. Thèse Université Paris.

Beaulieu, J.–L. de, Couteaux, M., Gadbin, Cl., Pons, A., Reille, M. & Triat, H. 1982: Propositions pour une méthodologie de l'inventaire de la valeur paléoécologique des zones humides (l'exemple du Sud–Est de la France). — Bull. Ecol. 13:189–202.

Bidault, M. 1982: Les zones humides du secteur Frasne-Bonnevaux (Doubs). — Bull. Ecol. 13: 241–263.

Bignon, J.–J. & Francez, A.–J. 1991: Impact des activités agricoles sur l'écosystème tourbière dans le Massif central français. Résultats préliminaires. — In: Coquillart, H. and Doledec, S. (eds.), L'écologie en France. Des recherches aux applications: vers de nouvelles perspectives. 5ème colloque A.F.I.E., Lyon, novembre 1989:301–315.

Borgne, L. le, Junqua, S., Vidal, G., Hardisson, C., Robert–Gero, M. & Pochon, J. 1967: Etude biologique et biochimique d'une tourbière à Sphaignes. — Rev. Biol. Ecol. Sol 4:553–566.

Bournérias, M. 1968: Guide des groupements végétaux de la Région parisienne. — 290 pp. Paris, Sedes.

Bruyant, Ch. 1913: Les tourbières du Massif mont-dorien. — Ann. Biol. lacustre 6:339–391.

C.A.R.E.N.E. 1987: Inventaire des tourbières d'Auvergne. — Document D.R.A.E. Auvergne, Ministère de l'Environnement, publications C.A.R.E.N.E., Grenoble: 121 pp. + annexes + 4 cartes.

Chepeau, C. 1984: Un exemple d'exploitation. — In: Tourbières et marais, Penn ar bed 15:92–99.

Chevallier, A. 1978: L'aménagement des zones humides dans les communes de Bonnevaux et de Bouverans. L'exemple du lac de Bouverans et de la rivière Drugeron. — Publications C.U.E.R. de Besançon 2:424–436.

Clément, B. 1984: Origine et répartition des tourbières de Bretagne. — In: Tourbières et marais, Penn ar bed 15:50–56.

Coquidé, E. 1912: Recherches sur les propriétés des sols tourbeux de Picardie. — Thèse Université Paris. 180 pp. + 24 figs. + 19 pl.

Direction des Mines 1949: Les tourbières françaises I. Mémoires. II. Résultats des prospections. Imprimerie Nationale, Paris. 225 and 634 pp.

Donahue, R.L. 1958: Nature des sols et croissance végétale. — Intercontinental, New-York and Editions d'Organisation, Paris. 312 pp.

Favrot, J.–C. 1981: Estimation et caractérisation des ressources françaises en tourbe. — Rapport A.T.P. SES 509, I.N.R.A. Montpellier. 26 pp.

Francez, A.–J. 1987: Successions écologiques dans les tourbières: l'exemple du peuplement de Rotifères du lac-tourbière de Chambedaze (Puy-de-Dôme, France). — Bull. Ecol. 18: 31–38.

Francez, A.–J. 1988: Le peuplement de Rotifères libres de deux lacs-tourbières du Puy-de-Dôme (France). — Vie Milieu 38:281–292.

Francez, A.–J. 1991: Production primaire et accumulation de matière organique dans les tourbières à Sphaignes des Monts du Forez (Puy-de-Dôme). Influence des activités humaines sur leur fonctionnement et leur évolution. — Thèse d'Ecologie Université Paris 6. 320 pp.

Francez, A.–J. & Pourriot, R. 1984: Remarques taxonomiques sur quelques Rotifères des tourbières avec la description d'une espèce et d'une sous-espèce nouvelles. — Hydrobiologia 109:125–130.

Francez, A.–J. & Dévaux, J. 1985: Répartition des Rotifères dans deux lacs-tourbières du Massif central (France). — Hydrobiologia 128:265–276.

Francez, A.–J. & Mollet, A.–M. 1990: Influence des perturbations sur le fonctionnement de la tourbière de Gimel (Loire). Potentialités de régénération et évolution. — Rapport d'étude Parc régional du Pilat, C.E.R.E.M.C.A., Aydat, D.P.N. Paris. 81 pp.

Géhu, J.–M. (ed.) 1980: La végétation des sols tourbeux. — Documents phytosociologiques 7. 494 pp.

Géhu, J.–M., Mériau, J.–L. & Tombal, P. (eds.) 1981: Inventaire des tourbières de France. — Ministère de l'Environnement, Paris, et Institut Européen d'Ecologie, Metz.

Gillet, F., Royer, J.–M. & Vadam, J.–C. 1980: Rapport concernant une étude monographique des tourbières du département du Doubs et du Nord du département du Jura: phytosociologie, autoécologie et répartition des végétaux de la tourbière, typologie, monographie de chaque tourbière. — In: Bidault M. (ed.), Etude pluridisciplinaire des zones humides formant le complexe étangs, marais et tourbières de Frasne (Doubs): 125–273. Université de Franche-Comté, Besançon.

Goodwillie R. 1980: Les tourbières en Europe. — Collection Sauvegarde de la Nature 19. Conseil de l'Europe, Strasbourg. 82 pp.

Guegen, A. & Clément, B. 1984: Les criquets et sauterelles d'un marais tourbeux. — In: Tourbières et marais, Penn ar bed 15:84–91.

Haenni, J.–P. & Brunhes, J. 1983: Anapausis aratrix n. sp., un nouveau Scatopsidae (Diptera) des tourbières d'Auvergne. — Bull. Soc. Ent. France 86:223–226.

Harnisch, O. 1929: Die Biologie der Moore. — Die Binnen-gewässer 7. — E. Schweizerbartische Verlag, Stuttgart. 146 pp.

Hénin, S., Gras, R. & Monnier, G. 1969: Le profil cultural. — Masson, Paris. 331 pp.

Kaule, G. 1974: Die Ubergangs und Hochmoore der Vosgen. — Beitr. Naturk. Forsch. Südw. Dtl. 33:9–40.

Kivinen, E. & Pakarinen, P. 1981: Geographical distribution of peat resources and major peatland complex types in the world. — Annales Academiae Scientarum Fennicae, series A III, Geologica & Geographica 132:1–28.

Lefeuvre, J.–C. (ed.) 1990: Troisième Conférence Internationale sur les zones humides, Rennes 1988: Conservation et développement, gestion intégrée des zones humides. — Bull. Ecol. 21:3–80.

Miouze, C. 1985: Etude hydrologique et hydrogéologique du site expérimental de La Barthe. — D.E.A. Sciences de l'eau, Université Paris 6: 1–88 + annexes.

Montard, F.–X. de 1983: Production herbagère des prés et des pacages. — In: La Margeride, la montagne, les hommes: 457–473. Publications I.N.R.A., Versailles.

Moore, P.D. & Bellamy, D.J. 1974: Peatlands. — Elek Science, London. 221 pp.

Muller, S. 1990: Phytogeographical originality and conservation of peat-bogs of "Pays de

Bitche" (Northern Vosges mountains, France). — Bull. Ecol. 21:65–69.
Okruszko, H. 1989: Transformation of wetlands under the effects of drainage. — International Peat Journal 3:85–95.
Reffay, A. 1980: La tourbe. — Bull. Centre Géomorph. Caen 25:81–83.
Reille, M. 1989: L'origine du Pin à crochets dans le Massif central français. — Bull. Soc. Bot. France 136, Lettres botaniques 1:61–70.
Rivière, L.M., Dartigues, A. & Lemaire, F. 1984: Some properties of french peats for use in ornamental horticulture. — Proc. 7th Internat. Peat Congress, Dublin 4:21–35.
Taylor, J.A. 1964: Distribution and development of the world's peat deposits. — Nature 201: 454–456.
Tombal, P. & Schumacker, R. 1981: Essai d'approche scientifique des tourbières. — In: Géhu, J.–M., Mériaux, J.–L. & Tombal, P. (eds.), Inventaire des tourbières de France: 6–14. Ministère de l'Environnement, Paris & Institut Européen d'Ecologie, Metz.
Touffet, J. 1969: Les Sphaignes du Massif armoricain. Recherches phytogéographiques et écologiques. — Thèse Université Rennes. 357 pp.
Touffet, J. 1982: Contribution à l'étude des zones humides de Bretagne. — Bull. Ecol. 13:329–338.
Villepoux, O. 1984: Note préliminaire sur les Araignées de quelques tourbières d'Auvergne. — Acta biol. mont. 4:267–275.
Visset, L. 1984: Des pots dans la tourbe. — In: Tourbières et marais, Penn ar bed 15:108–109.

TIIVISTELMÄ:
RANSKAN SUOT JA NIIDEN KÄYTTÖ

Ranskassa voidaan erottaa kaksi soiden suurtyyppiä. Vesistöjen varsilla olevia reheviä nevoja esiintyy lähinnä maan pohjois- ja itäosissa ja rahkasoita maan keskiosan vuoristoissa. Yhteensä soita on laskettu olevan n. 100 000 ha, mikä vastaa 0,2% maan pinta-alasta. Tosin on esitetty, että yo. soiden määrästä alle 40% olisi enää luonnontilaista tai ylipäänsä olemassa.

Pohjois-Ranskan soista on löydetty muinaisten gallialaisten astioita, aseita ja rahoja. Samoin Länsi-Ranskasta Loire-Atlantique alueelta on ojien kaivun yhteydessä löydetty puusuojukseen piilotettuja astioita. Näiltä varhaisilta ajoilta ei ole tietoja olemassa varsinaisesta soiden hyödyntämisestä, vaan niitä käytettiin ilmeisesti lähinnä piilopaikkoina. Keskiajalla tiedostettiin soiden merkitys, jolloin jo paikalliset suurmaanomistajat pyrkivät hankkimaan niitä omistukseensa. Jo tuolloin käytettiin turvetta polttoaineena, saroja karjanalusina ja ruokoa kattojen päällysteeksi. Ensimmäiset laajamittaiset kuivatustyöt aloitettiin Henrik IV:n hallituskautena 1500-luvun lopulla.

Turpeen määräksi Ranskan soissa on laskettu 2 000 milj. m^3. Maassa on laskettu olevan 140 suota, joissa on kussakin vähintään miljoona m3 turvetta. Näissä 140 suossa on 3/4 maan turvevaroista. Turvetta nostettiin tämän vuosisadan alkupuoliskolla n. 30 000 tonnia vuodessa. Toisen maailmansodan aikana määrä nousi energiakäytön vuoksi n. 190 000 tonniin. Turvetta nostetaan tälläkin hetkellä paikallisesti lämmittämään korkealla vuoristossa olevia taloja kesäaikoina. Turve nostetaan lapioilla ('louchet', ranskaksi) ja jätetään aurinkoon kuivumaan (kuvat 5 ja 6).

Vesistöjen varsilla olevia ravinteikkaita soita on jo pitkään käytetty puutarhakasvien tuotantoon ('hortillonnage', ranskaksi) varsinkin Amiensin (Pohjois-Ranska) ja Bourgesin (Keski-Ranska) alueilla. Viljelyjärjestelmä on hyvin samanlainen kuin Everglades-suolla Floridassa. Kanavajärjestelmällä johdetaan vettä alueelle kuivina kausina ja alueelta pois märkinä kau-

sina. Kanavien kaivussa nostetuista maista on rakennettu saarekkeita, joilla viljellään mm. kaalia, perunoita, porkkanoita, herneitä ja pienessä määrin jopa maissia (kuva 7). Onpa humalaakin viljelty Picardyn alueella Luoteis-Ranskassa La Souchen suoalueella (kuva 8).

Vuoristojen kohosoita on yritetty metsittää. Hyvin usein maanomistajat ovat itse vastanneet suunnittelusta ja toteutuksesta. Kuusi on yleinen kasvatettava puulaji vuoristoalueilla, ja niinpä sitä on yritetty istuttaa myös sille liian karuille kasvupaikoille (kuva 9).

Soiden suojelu Ranskassa on vasta alussa. 1970-luvun lopussa tehdyn suoinventoinnin mukaan maassa on 86 kansallisesti ja kansainvälisesti arvokasta suokohdetta. Kymmenen näistä on julistettu suojelualueiksi (numerointi kuvassa 10). Niihin voidaan lisätä Frasnen suoalue Jura-vuoristossa, joka on vapaaehtoisesti rauhoitettu suo. Useat soilla kasvavat kasvilajit kuuluvat joko alueellisesti tai kansallisesti rauhoitettujen lajien luetteloon. Koko maassa rauhoitettuja ovat esim. suokukka, konnanlieko ja pyöreälehtinen kihokki.

Received 20.XII.1991
Approved 7.IV.1992