10.2 Temperature effects on terrestrial ecology

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10.2.1 Introduction

To obtain an impression of direct temperature effects on the species composition of wet and moist riverine grasslands it was decided to use a reference area. In this area geological and hydrological conditions should be more or less comparable to those in the Dutch lowland pleistocene areas (brook valleys with wet grasslands in a region with predominantly non-calcareous sands) and the climate should resemble the conditions predicted for the Netherlands in the next century.

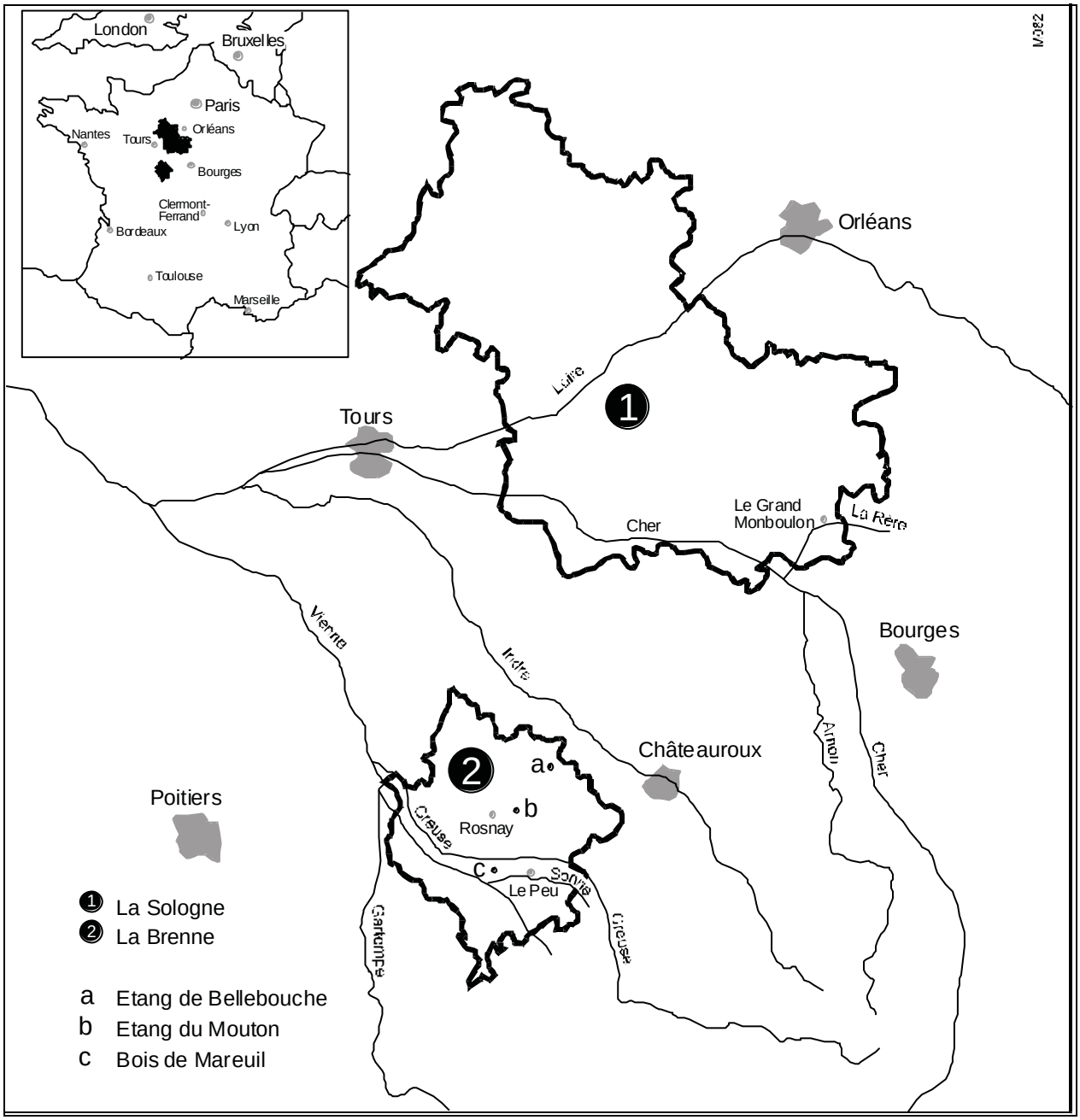
For the period 2070-2100, that has been chosen as a reference period in the present study, an increase in temperature of 2.8°C is predicted (Section 2.2). From comparison with data in the database given by Van der Voet *et al*. (1996), it appears that the Hadley climate scenario is reasonably well approximated by conditions in North-central France. For instance, a location with 2.25^{o} Eastern Longitude and 46.75^{o} Northern Latitude has a mean annual temperature of 11.9 ^{o}C and a mean annual precipitation of 710 mm/yr, as compared to the Hadley values of respectively 12.6 ^{o}C and 777 mm/yr. It was therefore decided to choose central France as a reference area in the study on the direct effects of climate change.

10.2.2 Description of the reference area

Two regions in central France were chosen as a reference to study the direct effect of climate change on wet and dry grasslands: La Sologne and La Brenne (Figure 10.9). These regions are situated on the border of the high Massif Central and the low-lying basin of Paris. The area can be characterized as a lowland area with brook valley systems and non-calcareous sandy soils. In this respect, the area is comparable with the Beerze and Reusel drainage basin.

La Sologne is situated to the south of Paris. The soil consists of Pleistocene sand that to a large extent is derived from the Massif Central. It is mentioned as a 'zone atlantique faiblement podzolique' (Allorge & Gaume 1931). Clay deposits in the sand form impermeable layers. Therefore, especially in the central part of La Sologne, many lakes are found. In the

Figure 10.9 La Sologne and La Brenne in France



twelfth and thirteenth century, this area of France was very prosperous with large vineyards, meadows and pastures. As a result of several wars and the plague, the area deteriorated, as large parts of France and Europe did in the Middle Ages. La Sologne became abandoned and desolated during that time. Heathland and woodland covered most of the area. Presently, the area is very popular to people from Paris. Much land is owned by them, and made into hunting ground. This process is called 'solognification' in France.

La Brenne is situated west of Châteauroux. It is divided in a northern and southern part by the river Creuse. The area has the status of a 'parc naturel régional'. It consists of 166.000 ha. It is famous because of the more than one thousand lakes (*étangs*) and the small hills (*boutons*). The lakes are artificial. The people of La Brenne made them by damming the lower lying places, that used to be the wettest sites. In the Middle Ages monks, who created the lakes to keep fish in, initiated this habit. The impermeability of the soil is caused by clay layers, comparable to that found in La Sologne. The making of lakes is still going on. Some decades ago ca. one thousand lakes were counted in the area, while currently about twelve hundred lakes are present. The small hills (*boutons*) consist of sandstone. Their mean height is about five meters, the diameter is between ten and thirty meters. A dry vegetation (heathland or woodland) is found on these small hills. The *boutons* are a characteristic element in the landscape. The area used to be in agricultural use. Mixed farms were most commonly found. During the last two decades, a lot of farms have been abandoned. Like La Sologne, the soil in La Brenne consists of pleistocene sand. Clay layers are found in the soil in most of La Brenne. The deeper soil consists of chalk, that was formed during the Cretaceous period (Ledoux 1995).

The climate in La Sologne and La Brenne is Atlantic. The summer period is very dry. From the second half of June till September or October there is hardly any rainfall. In autumn, however, a lot of rain may fall. Because of the clay layers that are found in a large part of La Brenne, the soil may be very wet until June. When the dry period starts, the watertable falls sharply. The watertable is therefore fairly variable.

In the reference areas La Sologne and La Brenne, five transects were described in the period 27 June to 30 June 1998. On each of these transects, three to seven vegetation relevés were made. The relief, hydrology and abiotic conditions (soil texture, pH) were recorded on the relevé sites. Table 10.2 gives a list of the study sites and the type of vegetations found.

Table 10.2 Studied sites in the reference area in France and the vegetation types that were examined.

Area	Location	Vegetation types
La Sologne	La Rère	Filipendulion Alno-Padion
La Brenne	La Carrière	Calthion
	Etang de Mouton	Caricetum elatae Junco-Molinion Calluno-genistion Plantagini-Festucion
	La Sonne	Calthion Filipendulion
	Bois de Mareuil	Caricion gracilis Calthion
	Etang de Bellebouche	Caricetum elatae Hydrocotylo-Baldellion Junco-Molinion Nardo-Galion

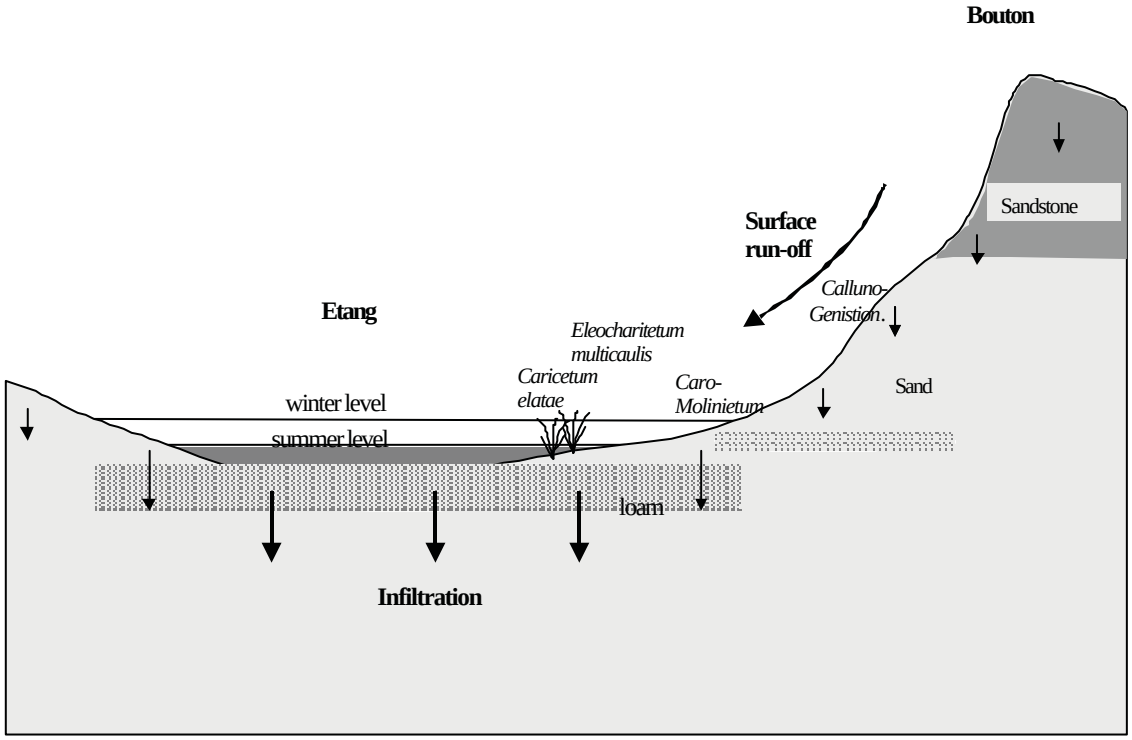
10.2.3 Description of wet grasslands in the reference areas

Species-rich grasslands on wet and moist soils with a low availability of nutrients, as described for the Beerze-Reusel study area in the Netherlands (*Junco-Molinion*), are only marginally found in La Brenne. The abiotic characteristics of the French reference site differ from those in the Netherlands. In the Beerze-Reusel area the *Junco-Molinion* grasslands belonging to the *Cirsio-Molinietum* are found in seepage areas. These grasslands are dependent on groundwater. French *Junco-Molinion* vegetations belonging to the related *Caro verticillati-Molinietum* (Nomenclature according to De Foucault 1984) are found on hydromorphic soils with pseudogley, i.e. on soils in which percolating rainwater stagnates during part of the year.

Figure 10.10 gives a generalized description of the gradient in which the *Caro-Molinietum* vegetations were found in La Brenne along the Etang de Bellebouche and Etang de Mouton. They occur in a narrow zone that is flooded in winter. In the summer the water level drops quickly, from (far) above the surface level to 1 or 1.5 m below surface level. Because of

Figure 10.10 Position of *Caro-Molinietum* vegetations as found at the Etang de Bellebouche and Etang de Mouton locations. The 'boutons' form the remnants of a sandstone carapace that once covered the plateau. In the lower parts loam deposits occur on which water stagnates. The *Caro-Molinietum* vegetations occur on the places that are flooded in winter only.

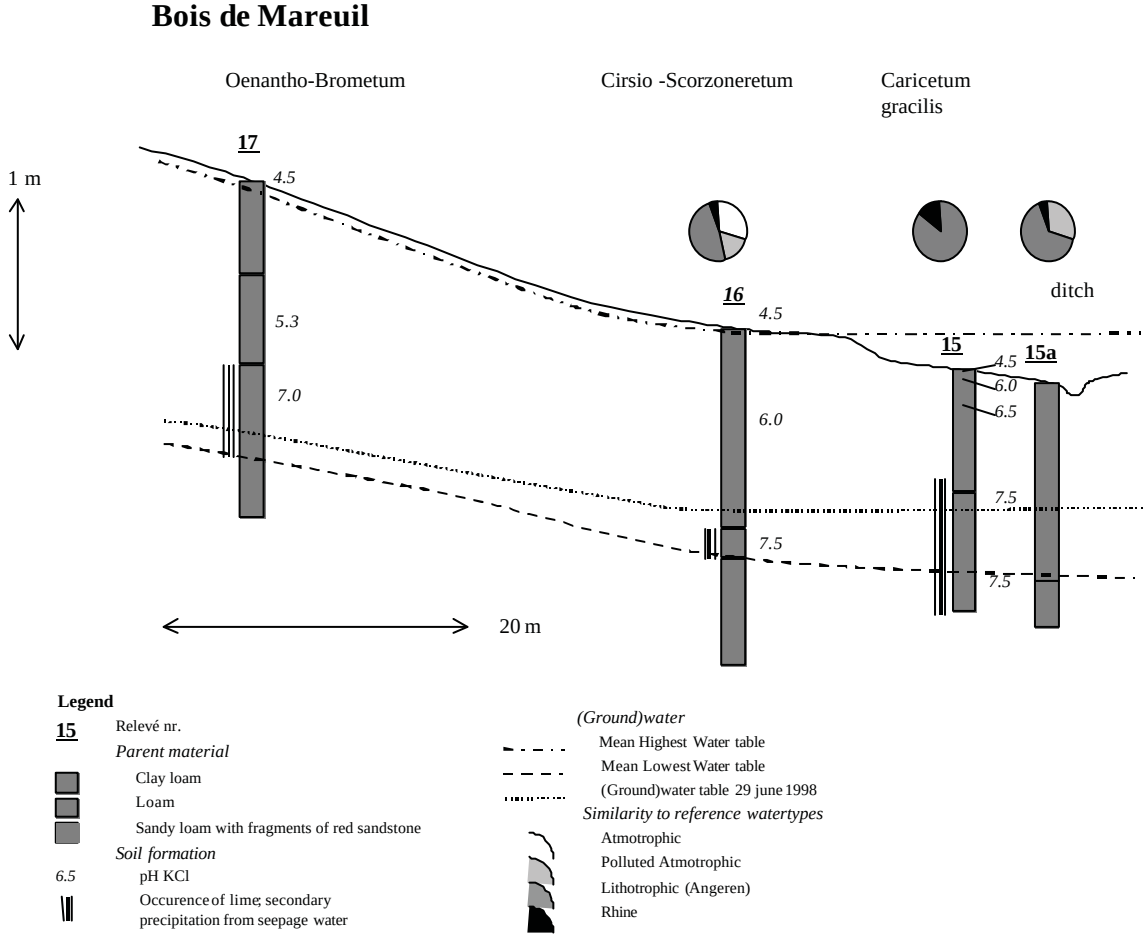
the high impact of rain water, that accumulates during winter lasting until the end of spring,



the *Junco-Molinion* grasslands are characterized by a low pH. Compared to the Dutch sites, the higher presence of the heathland species *Calluna vulgaris*, *Erica tetralix*, *Erica scoparia, Ulex minor* and *Genista anglica* is significant. Species that differentiate the *Caro verticillati-Molinietum* from the *Cirsio dissecti-Molinietum* are *Lobelia urens* and *Carum verticillatum*.

The Dutch nutrient rich wet grasslands of the *Calthion palustris*-type are most similar to the French meadows with *Oenantho peucedanifoliae-Brometum racemosi* vegetations (de Foucault 1984), and to a lesser extent with the *Cirsio dissecti-Scorzoneretum humilis*, that is intermediate between *Junco-Molinion* and *Calthion vegetations*. Meadows with these types of

Figure 10.11 Transect in the Bois de Mareuil location.



vegetation are found on hydromorphic soils with gley. The upper horizon of the soil is mineral or slightly organic. In La Brenne area they are best represented in depressions and brook valleys in the southern part (La Sonne, Bois de Mareuil). Figure 10.11 gives a description of one of the transects with these types of vegetation. The *Oenantho-Brometum vegetations* are floristically rather similar to the Dutch *Senecio-Brometum* vegetations. Species specific for the *Oenantho-Brometum* vegetations are *Oenanthe peucedanifolia, Bromus racemosus, Juncus acutiflorus, Lotus uliginosus* and *Alopecurus pratenis*.

In La Sologne and La Brenne we did not record a situation that can be floristically compared with the Dutch *Caricion nigrae*.

10.2.4 Discussion

Despite the large distance and the differences in geography and climate, the floristic composition of wet mesotrophic grasslands in the reference area is often very similar to that in the Netherlands. Wet, nutrient-poor grasslands belonging to the *Caro-Molinietum* are relatively species-poor compared to the most related *Cirsio-Molinietum* vegetations in the Netherlands. However, this is probably due to the fact that in La Brenne they occur in sites that are rather unfavorable compared to the Dutch situation. In the Netherlands *Cirsio-Molinietum* vegetations occur in stable upward seepage areas whereas in the Brenne Caro-Molinietum vegetations occur only marginally in infiltration areas, in places that are inundated in winter and that are much more dynamic and more acid.

Wet nutrient-rich grasslands are more comparable in terms of abiotic conditions. The *Senecio-Brometum* associations in the Netherlands and the *Oenantho-Brometum* in La Brenne both occur on wet base-rich gley soils, often in places with upward seepage. Comparing the species composition of the Dutch and French nutrient-rich wet grasslands, the frequent occurrence of umbelliferous plant species in the French situation is striking. *Oenanthe silaifolia*, *Oenanthe peucedanifolia*, *Silaum silaus* and *Carum verticillatum* are frequently found in the French sites, often as dominating species. Most umbelliferous plant species have a taproot and make no stolons (Weeda et al. 1987). This may explain their abundance in the vegetation types that have been studied in the reference area in France. These sites have summer groundwater levels that are relatively low in summer, which is more favorable for deep-rooting species.
The umbelliferous species mentioned all have a more atlantic distribution range and are absent or rare in the Netherlands, although some of them were more common in the past (Weeda et al. 1987; Cools 1989; van der Meijden 1996). The species may possibly become accustomed in the Netherlands when there is a lasting temperature increase as a result of climatic change, on the understanding that stand conditions are favorable. This is also found for *Scorzonera humilis.* Four species are presently not found in the Netherlands: *Gaudinia fragilis, Orchis laxiflora, Galium debile* and *Lobelia urens.* They may invade the Netherlands when temperature will rise for 2 or 3°C for a longer lasting period.

A remarkable difference is that in the reference area no *Caricion nigrae* vegetations were found. In the Netherlands, the grasslands of the *Caricion nigrae* type often occur on the borders of brook valleys, often in places were rainwater lenses are formed that cause a

superficial acidification of the site. In the study area in La Sologne and La Brenne we did not record situations that are floristically or hydrologically similar to the dutch *Caricion nigrae* sites. The most likely explanation is that evaporation deficits in summer are too large to permit the presence of permanent wet places with rainwater lenses. The relatively low summer groundwater levels are probably also the cause for the absence of peat in the reference situation: the combination of good aeration and high temperatures stimulates the oxidation of organic matter. In general peatland ecosystems in France are rare and have a scattered distribution pattern (Goodwillie 1980).

In permanently wet mesotrophic places with accumulation of organic matter sedges (*Carex spec.*) often form the predominant life form. The fact that many sedges have a more northern geographic distribution or are rare in France may be caused by this dependency on permanent wet sites. In La Brenne the number of *Carex* species is limited, with *C. elata* that occurs along the fringes of the Etangs as most common species. Species such as *C. elongata, C. pseudocyperus, C. nigra and C. remota,* that are common in the Netherlands, are absent.

It is not certain how long it will take more southern species to invade the Dutch brook valleys. To invade areas outside the present distribution area seed or plant parts have to disperse. Abiotic vectors for dispersal (wind, water) are particularly associated with open and impermanent habitats. In more stable habitats (e.g. woodland), dispersal by animals may become more important (Hodgson & Grime 1989). Usually, wind dispersal is not far-reaching. Dispersal distances of less than 10 m are found for chalk grassland species (Verkaar et al. 1983) as well as for Asteraceae (Sheldon & Burrows 1973). Patterns of seed rain follow a bell-shaped curve, with a small proportion dispersing over long distances and the majority falling close to the parent (Harper 1977, Strykstra & Bekker 1997, Strykstra et al. 1996). Sometimes long-distance transport is achieved by water or wind-dispersal (Nip-Van der Voort et al. 1979, Marshall & Hopkins 1989). However, some authors think that long-distance dispersal is often overemphasized, based on rare accidental dispersal (Stieperaere & Timmermans 1983).

With regard to the Umbelliferous species that are characteristic for the French situations the conditions for dispersal may be favorable. Some of them already occur in the southern parts of the Netherlands or in nearby border areas, and seeds may easily be distributed with river water. *Oenanthe silaifoila,* that is a common species in the reference area, was considered to

be extinct in the Netherlands since 1899. Recently, one individual of *Oenanthe silaifolia* has been found in the Netherlands (Schaminée 1999). It is expected to have been dispersed over a long distance by the water of the river Maas. However, for some of the other, more southern species dispersion will be more difficult since the large agricultural and industrial areas north of Paris and in Belgium form barriers for dispersion.

Species that reach the southern border of their distribution area in the Netherlands and that are characteristic for permanent wet, often slightly acidic sites with rain water lenses, such as *Potentilla palustris, Eriophorum angustifolium, Myrica gale* and many *Carex* species are likely to disappear in the situation of a lasting increase in temperature because of higher temperatures and because of the disappearance of suited habitats.