Chapter 6 The Cretaceous palaeobotany of Great Britain

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Introduction

The Upper Cretaceous Series of Britain consists almost exclusively of the distinctive calcareous marine deposits known as 'Chalk', which contain no identifiable plant macrofossils. However, the Lower Cretaceous rocks of southern Britain consist of terrestrial or shallow marine elastic sequences that contain a good macrofloral record. It is best illustrated by the Wealden flora, although there are other localities along the south coast of England and on the Isle of Wight (see Luccombe Chine and Hanover Point GCR site reports). Similar floras are known from several parts of continental Europe (Belgium, France, Germany, Spain and Portugal) although some of these are not strictly contemporaneous.

History of research

The British Wealden flora has been studied intermittently since the early part of the 19th century. Mantell (1822) was the first to report that plant fossils occurred in Wealden deposits but the specimens were not described for another two years (Stokes and Webb, 1824). Later, Mantell (1833) himself figured and described plant fossils from the Tilgate Forest, and also referred to them in his synoptic paper on the palaeontology of Sussex (Mantell, 1835). Fitton (1836) described further remains from the Wealden rocks of south-east England, including the first reference to *Tempskya* stems. Other records were documented by Brown (1851), Topley (1875), Carruthers (1870a; in Dixon, 1878) and Peyton (1883). Bristow (1869) reported the presence of Wealden plants on the Isle of Wight.

The next major contribution was by Albert Seward (1894, 1895, 1913), who described most of the then-available specimens, principally in the collections of the British Museum (Natural History), and produced what was for many years the definitive account of this flora. However, as with his work on the Yorkshire Jurassic floras (see Chapter 3), a major weakness of his work was his failure to realize the important role that cuticle studies could play in improving the understanding of the plants.

A significant development was by R. Holden (1914), who prepared cuticles from bennettite foliage from the Wealden near Hastings and showed its importance in taxonomic work on these fossils. It was, however, many years before there were any further major developments in the study of the Weald floras. The recent growth in interest in them has arisen mainly from the activities of Ken Alvin, Joan Watson and their coworkers, who started to revise the flora during the 1960s using modern techniques, especially cuticle analysis. The results of this work have been published in numerous papers (e.g. Alvin, 1974, 1983; Alvin *et al.,* 1978, 1981, 1994; Watson, 1977, 1983; Watson *et* al., 1987, 1988; Skog, 1986). Watson has also been publishing monographs on various plant groups in the Wealden flora (Watson, 1969; Watson and Batten, 1990; Watson and Sincock, 1992). This work on the macrofossils has been complemented by analyses of the palynology of these deposits by Norman F. Hughes (e.g. Hughes, 1958, 1976; Hughes and Croxton, 1973) and David J. Batten (e.g. 1968, 1973, 1975, 1982, 1998), which have helped to widen the perspective of both the vegetation and the environment of southern England during much of the Early Cretaceous Epoch. Finally, Tim Oldam (1976) investigated the dispersed cuticles found in the Wealden plant debris beds.

Plant fossils tend to be rare in the Lower Greensand but have nevertheless attracted some attention because of their fine preservation. Mantell (1822) and Fitton (1836) made passing references to petrified wood from here, but the first macrofossil to be described in detail was a petrified conifer cone from Lyme Regis, *Pinostrobus oblongus* (Lindley and Hutton, 1834), later redescribed by Williamson (1887). Mantell (1833, 1835, 1851) made further references to wood in these deposits, and later (Mantell, 1844, 1846) described fossil cones. By 1854 Morris was able to list six fossil plant species from the Lower Greensand in his *Catalogue of British Fossils.* Mackie (1862) described the famous 'Dragon tree' from the Lower Greensand of Kent as a possible monocotyledon, although it was later shown by Marie Stopes (1911) to be a conifer. However, the most important contributions in the 19th century were by Carruthers (1866, 1867b, 1869, 1870a) who described several cones and stems from the Lower Greensand deposits of southern England. Berry (1911) included a list of 17 species from this succession in his summary of Lower Cretaceous floras.

The fossil wood from the Lower Greensand was first described in detail by Barber (1898) and then in a number of papers by Stopes (1911, 1912). Her work culminated in the catalogue of the Lower Greensand plant fossils in the then British Museum (Natural History), which to this day remains the definitive account of these floras (Stopes, 1913, 1915). In 1918, she described a bennettite cone from the Lower Greensand, and another from the Gault of Folkestone. However, her now-famous book on birth control, *Married Love,* was also published in 1918, and this effectively marked the end of her palaeobotanical work (Andrews, 1980). Since then, little work has been done on the palaeobotany of the Lower Greensand, although a study on the wood is currently being finalized by Mark Crawley, formerly of the Natural History Museum, London.

Palaeogeographical setting

The palaeogeography of the Early Cretaceous world is summarized in (Figure 6.1). Most of the land was still joined together in the supercontinent of Pangea, although the beginnings of some of today's oceans, such as the North Atlantic, were apparent. One of the most notable features of the Early Cretaceous Epoch was that arid and semi-arid conditions had not only spread through most of the low latitudes but also into some parts of the middle latitudes of both the Northern and Southern hemispheres. Britain was in middle latitudes at the time and the climate was hot to very warm. Rainfall varied and sometimes there were periods of severe drought, especially in the Wessex Basin (Allen, 1998).

As in the Jurassic Period, the Early Cretaceous Epoch was a time of 'greenhouse' conditions, with a relatively low climatic gradient between the equator and the poles. This led to relatively low levels of vegetational provincialism over the globe. The plant macrofossil record of the equatorial zone is generally very poor. Palynological studies have suggested that a restricted vegetation prevailed, comprising mainly cheirolepidiacean conifers and matoniacean ferns (Doyle *et al.,* 1982). Three floristic zones have been recognized (Meyen, 1987; Vakhrameev, 1991): the Notal Palaeoarea in southern middle and high latitudes (Australia, India, southern Africa); the Europe (or Eurosinian) Palaeoarea in northern middle latitudes (USA, much of Europe and China); and the Siberia Palaeoarea in northern high latitudes (Siberia, north-east Canada). According to this scheme the British floras clearly belong to the Europe Palaeoarea.

During the first part of the Cretaceous Period (Berriasian to Hauterivian), central southern and south-eastern England was part of an area of coastal mudflats with lagoons and sandy rivers (Figure 6.2) (Allen, 1976, 1981). This supported the varied vegetation that forms the classic Wealden floras of south-east England. The fossils reveal important environmental information. A few plants are relatively well known in terms of growth habit, internal structure and reproductive biology The vast majority of species are, however, less well known, with many being represented by one or only a small number of fragments. Unless they show special morphological or structural characteristics, they are of little value for environmental interpretations. The most reliable characters, according to Watson and Alvin (1996), are as follows:

1. Charcoal, which is accepted as a reliable indicator of wildfire that most probably started by lightning strike.
2. Xeromorphy, whose significance is far from clear. Xeromorphic characters, including thick-walled epidermis and hypodermis, thick and shiny cuticles, epicuticular wax, papillae and trichomes, salt glands, sunken stomata, small leaves and photosynthetic stems, are all found in Wealden plants. They can indicate either dry conditions or physiological adaptations for water uptake, transportation or loss. They are prevalent in the gymnosperms and especially in the conifers. However, all conifers living today have xeromorphic characters regardless of the climate in which they live, so not much can be read into their abundance in the Wealden.
3. Growth rings, which indicate seasonal environments; these are usually alternations of warm and cold or wet and dry. Ring patterns observed in Wealden woods are most probably the result of alternating wet and dry conditions.

Batten (1975, 1998), Allen (1976) and Watson and Alvin (1996) have given summaries of the Wealden flora and interpreted the environments in which its various components grew. Allen (1976) interpreted the lower Hastings Beds as coastal mudplains with lagoons, sandy watercourses and coalescent alluvial fans that were subject to wet and dry seasons. Batten (1968, 1973, 1975, 1982) used palynological and palynofacies data including, with co-workers (Batten and Eaton, 1980; Batten and Lister, 1988a,b), the distribution of dinoflagellate cysts to interpret the depositional environments and composition of the vegetation. His results largely agree with Allen's interpretation of the lowland area based principally on sedimentological studies. He suggested that a mixed pteridophyte–gymnosperm flora covered the lowland and that the constantly changing environment may have resulted in shifting sediment and soils or even stopped soil development. This would have limited or prevented tree growth and restricted some of the longer-lived plants, such as bennettites and conifers, to more stable inland environments. Watson and Sincock (1992) and Watson and Alvin (1996) agreed with this interpretation, believing there to be bennettitaleans, cycads, perhaps some conifers and ferns in a number of distinct communities requiring different microclimate and edaphic conditions.

Later in the Early Cretaceous Epoch, there is evidence of rising sea levels, the deposits overly ing the Wealden (Greensands and Gault) being fully marine transgression. This eventually culminated at the beginning of the Cenomanian with the deposition of the Chalk, which coincides with an almost total break in the macrofloral record in Britain until the Palaeocene Epoch.

Stratigraphical background

The Lower Cretaceous rocks of the Weald Sub-Basin have been traditionally divided into the Wealden, Lower Greensand, Gault and Upper Greensand 'Series' (e.g. Rawson *et al.,* 1978). The Wealden succession is divided into the Hastings Group and the Weald Clay Formation, the former comprising several formations (Figure 6.3), the latter being composed of Lower and Upper divisions. Much of the material described by the earliest workers (e.g. Mantell, 1822; Stokes and Webb, 1824) originated from inland exposures in quarries in the Wadhurst and Tunbridge Wells formations, which are Valanginian in age (e.g. Watson and Sincock, 1992). However, the coastal exposures, including all those covered in this volume, are in the underlying Ashdown Formation and thus somewhat older (late Berriasian–early Valanginian).

The rather different successions that are exposed on the Isle of Wight are divided into the Wessex and Vectis Formations, Lower Greensand Group, and Gault and Upper Greensand Formations (Figure 6.3). The famous 'pine raft' at Hanover Point is in the upper Wessex Formation and thus post-dates the palaeobotanical sites of the Weald Sub-Basin. The stratigraphically highest flora, from Luccombe Chine, is in the Lower Greensand and Aptian in age.

Early Cretaceous vegetation

Although the plant groups present in the Wealden floras are broadly the same as those seen in the Yorkshire Jurassic succession (see Chapter 3), the proportions are somewhat different. They are particularly rich in horsetails, ferns, bennettites and conifers. The commonest ferns belong to the Matoniaceae, although there are also the remains of the enigmatic tree fern *Tempskya,* unknown in Yorkshire. The conifers are dominated by representatives of the Cheirolepidiaceae. The bennettites include both the Williamsoniaceae and Bennettitaceae; the latter is not known for certain from Yorkshire. Cycads, caytonias, corystosperms and ginkgos are all relatively rare as macrofossils by comparison with occurrences in Yorkshire (Vakhrameev, 1991). Reconstructions of a range of plants found preserved in the Wealden are shown in (Figure 6.5).

Angiosperms are known to have already evolved by the Early Cretaceous Epoch (Sun *et al.,* 1998). If early angiosperm representatives were adapted to life in upland and/or arid conditions, as has been suggested by some authors, this could account for the fact that they do not appear to have made a major impact on the mudflats of southern England during deposition of the Wealden succession. Hill (1996) has described just one possible example (*Bevhalstia*) from the Wealden Clay, although its systematic position is somewhat in doubt (Figure 6.4).

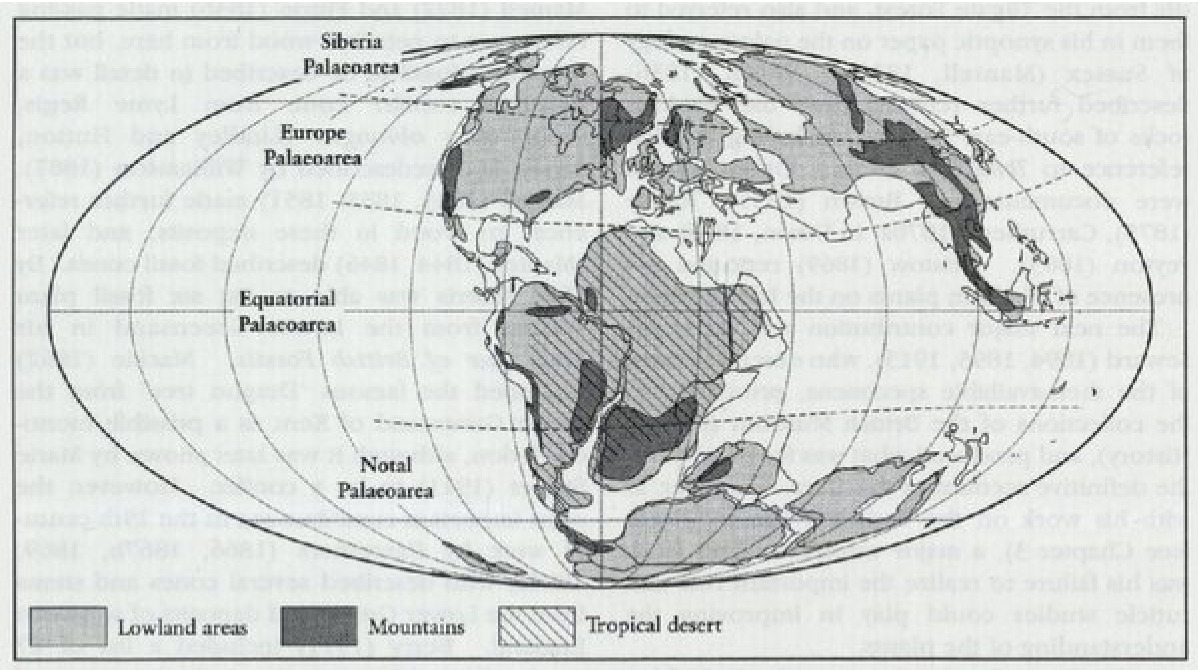
Cretaceous palaeobotanical sites in Britain

The most important Cretaceous palaeobotanical sites in Britain are in the Ashdown Formation of the Weald Sub-Basin (Figure 6.3). The flora is large, varied and well preserved in mudplain deposits that indicate deposition close to the position of growth. Today, the only site still yielding material is at Covehurst, a coastal exposure to the east of Hastings. This was, therefore, selected as the GCR site. Comparable, although less diverse, floras have been reported in the past from higher horizons (Wadhurst and Tunbridge Wells formations) but most of these inland workings are no longer exposed.

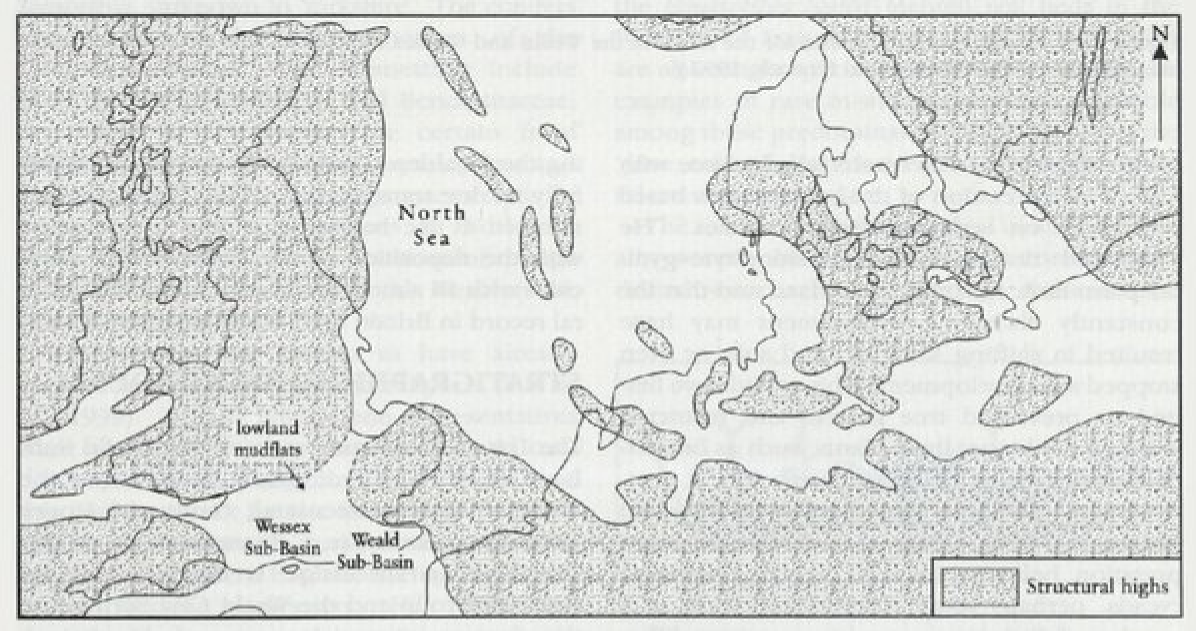
There are numerous other sites in the Ashdown Formation and in the Wessex Formation of the Wessex Sub-Basin that have yielded plant macrofossils. These yield floras that vary considerably in both content and range of diversity. Some are dominated by a single species, such as the '*Pseudofrenelopsis* bed' (Wessex Formation) (Alvin *et al.,* 1981) and the *Weichselia* bed' (Vectis Formation) (Alvin, 1974), both near Hanover Point on the Isle of Wight. *Lycopodites hannahensis* Harris in the Lower Tunbridge Wells Sand Formation (Ardingly Sandstone Member) at Philpots Quarry, West Hoathly, Sussex (Harris, 1976) and the *Equisetites lyellii* Mantell soil beds in the Wealden of Sussex (Watson and Batten, 1990) are also single-species assemblages but they are examples of rare in-situ preservation. Notable among these predominantly single species is the 'pine raft' of Hanover Point, which has been selected as a GCR site.

The marine Lower Greensand contains generally poorer macrofloras mostly consisting of drifted wood remains, although these can be anatomically well preserved. The remains found at Luccombe Chine on the Isle of Wight in particular stand out as being important and justify this part of the coastal exposure being selected for the GCR.

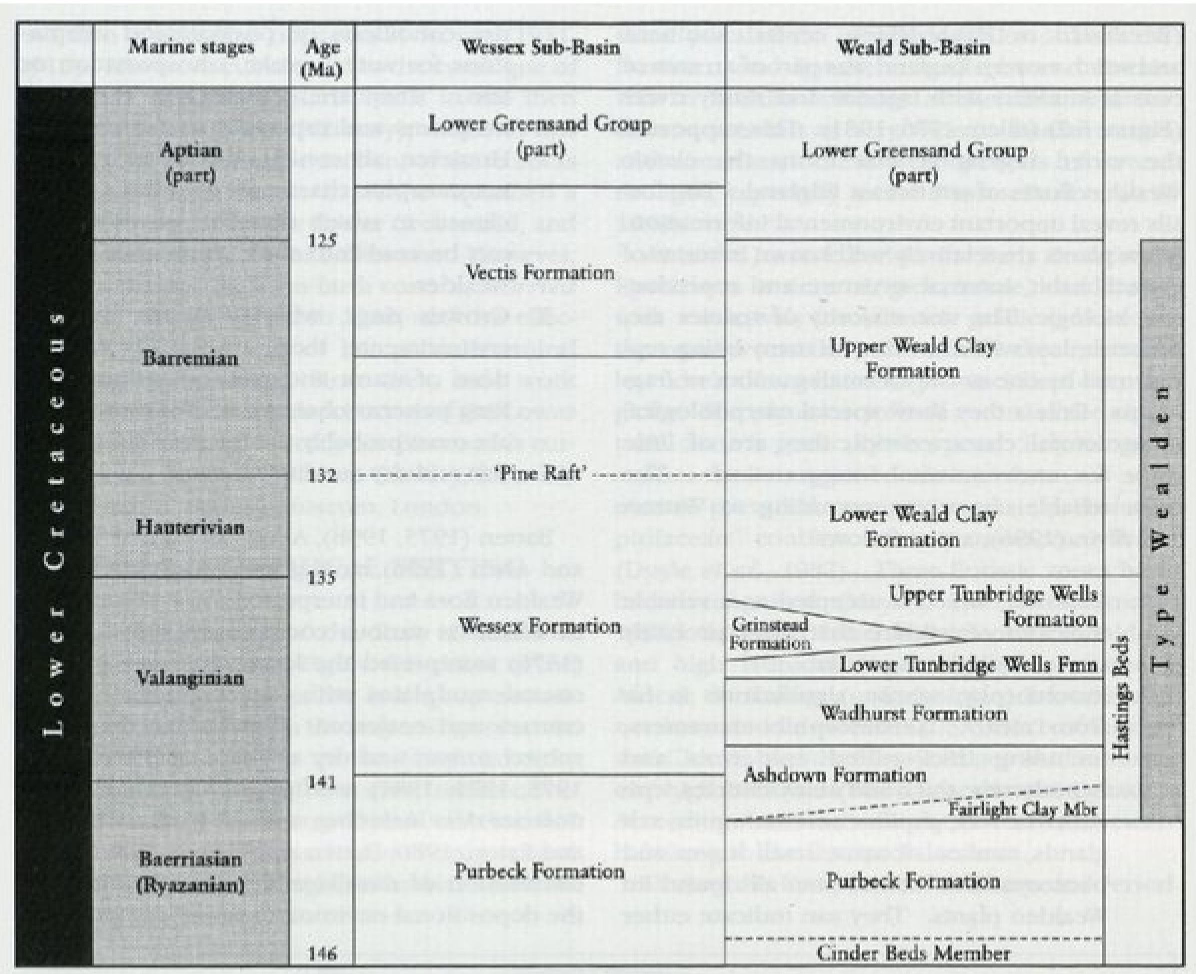
References



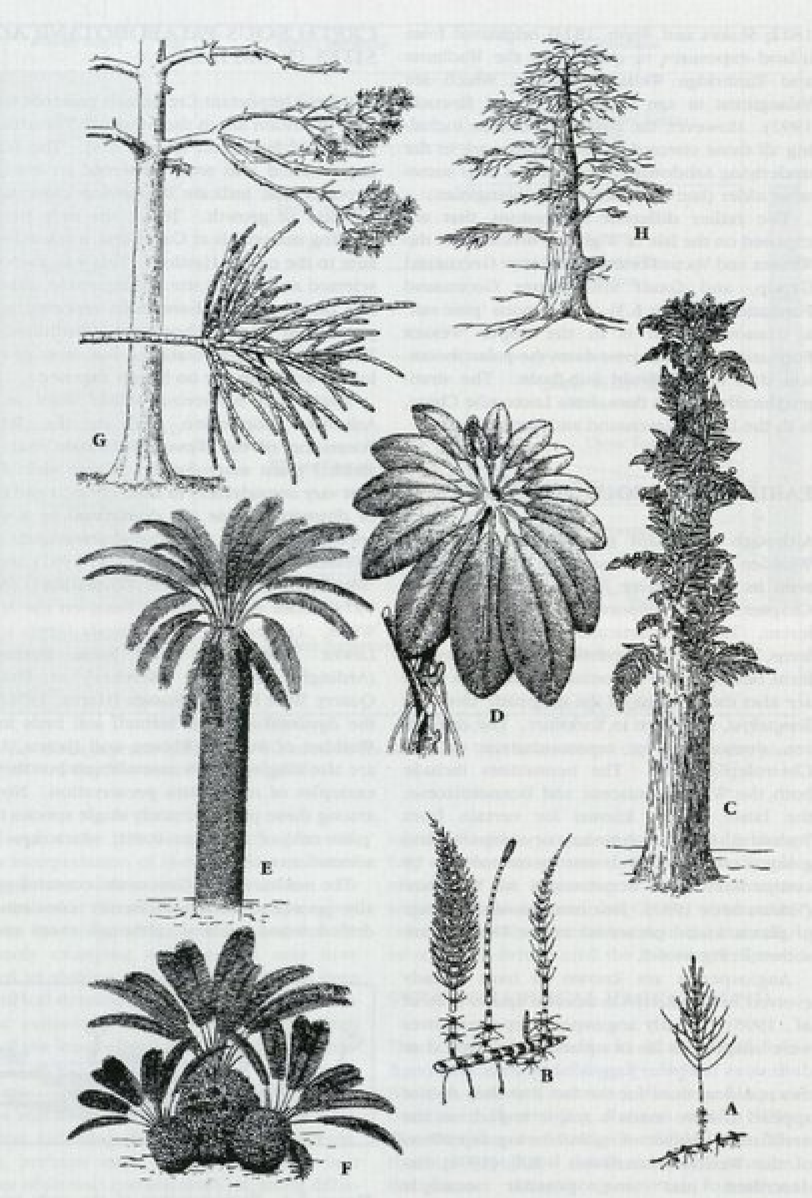
(Figure 6.1) Palaeogeography of the Early Cretaceous world, showing main areas of land and mountains (based on Smith et at,1994). Also shown are the main palaeofloristic areas (based on Meyen, 1987 and Vakhrameev (1991).



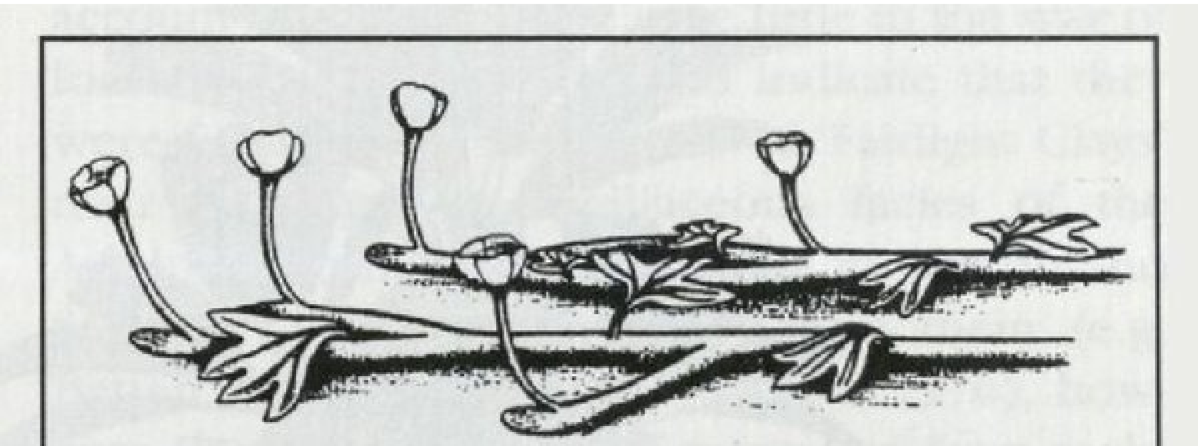
(Figure 6.2) Palaeogeography of north-western Europe during the Berriasian Age, showing areas of lowlands where the Wealden' deposits typically developed. Scale: 1 cm = c. 100 km (After Batten, 1996.)



(Figure 6.3) Stratigraphical schemes for the strata in the Weald and Wessex Sub-Basins that have yielded plant macrofossils. (After Watson and Sincock, 1992.)



(Figure 6.5) Reconstructions of typical plants found in the Wealden floras of southern England. (A) Equisetum burcbardtii, c. × 0.1, (B) Equlsetites lyellii, c. × 0.1, (C) Tempskya, c. 6 m tall, (D) Weichselia reticultata, c. × 0.08, (E) Monanthesia, c. 2 m tall, (F) Cycadeoidea, c. × 0.05, (G) Pseudofrenelopsis parceramosa, a tall forest tree (II) Cupressinocladus valdensis, also a tall forest tree. (From Watson and Alvin, 1996.)



(Figure 6.4) Reconstruction of the early possible angiosperm Bevhalstia, described by Hill (1996) from the English Wealden. (Redrawn from an original by Annette Townsend.)