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THE FLORA OF THE RIPLEY FORMATION

BY

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THE FLORA OF THE RIPLEY FORMATION

By Edward W. Berry

INTRODUCTION

In 1919 the Geological Survey published an extensive paper by me entitled "Upper Cretaceous floras of the eastern Gulf region in Tennessee, Mississippi, Alabama, and Georgia."[1] Despite this comprehensive title the work was primarily an account of the large flora found in the Tuscaloosa formation, the earliest Upper Cretaceous formation in that region. Between the date when the manuscript had been transmitted, in 1912, and the time of publication scattered collections from the Eutaw and Ripley formations had been made, and an account of these was included in the report. Although of considerable interest as the only known land plants of the Eutaw and Ripley, these plants were few and not especially well preserved, as I had not had the good fortune to encounter in these formations other than very carbonaceous leaf-bearing clays, with drifted and consequently more or less broken materials. It was realized that better-preserved and more representative material might be found in clay lenses in the upper embayment, but neither Stephenson nor I had been successful in locating such outcrops, and it was not until Wade's very detailed county studies for the Tennessee Geological Survey that this gap in the paleobotanic history of the Mississippi embayment was satisfactorily filled. All the forms known from the Ripley are included in the present contribution. The bulk of the materials have come from Henry and Carroll counties, in western Tennessee—a region that has also furnished the largest single florule of lower Eocene (Wilcox) age.

In the introduction to my account of the Upper Cretaceous floras of the eastern Gulf region I emphasized the reconnaissance nature of the field work and ventured to predict that more detailed work would result in the discovery of additional fossiliferous outcrops. The present contribution serves to fulfil this prediction in part and to supply the first detailed information regarding the flora of that part of the Upper Cretaceous section of which our ignorance was most profound. Both biologically and geologically this information is of the greatest importance, because it furnishes a measure of the rate of transition between the Cretaceous and Eocene floras, as well as data for correlation and distribution. Special acknowledgment is due to Bruce Wade for the industry and skill with which he has studied the Cretaceous of Tennessee and collected the material upon which the present paper is so largely based. The types are the property of the Johns Hopkins University, but they will be deposited in the United States National Museum as soon as the studies in hand are completed.

[1] U. S. Geol. Survey Prof. Paper 112, 1919.

GENERAL RELATIONS OF THE CRETACEOUS DEPOSITS

The region discussed in this paper includes that part of the Atlantic Coastal Plain lying south and west of the southern Appalachian province and east of Mississippi River. The area of outcrop of the Upper Cretaceous deposits borders the inland margin of the Coastal Plain, and the belt from which determinable plant fossils have been collected extends from the vicinity of the Kentucky boundary, in west-central Tennessee, southward and eastward to west-central Georgia.

Both Lower (?) and Upper Cretaceous deposits are represented in this area, but the former are much less extensive and varied than in the middle Atlantic slope, to the northeast, or in the western Gulf area, to the west, in Texas and Mexico. Supposed Lower Cretaceous sediments are present only in the extreme eastern part of the area, where the southwesterly extension of the Potomac group of the Middle Atlantic States has been considered to cross Georgia along the fall line as an irregular belt of unfossiliferous cross-bedded arkosic sandy clay and light-colored kaolin 5 to 30 miles wide and to extend westward into Alabama as a belt 4 to 8 miles wide that terminates in Elmore County. The question of the age of these beds is not yet settled. Recently Stephenson collected fossil plants from a locality within this belt at Old Fort Decatur on Tallapoosa River, which are of Upper Cretaceous age.[1a] This throws considerable doubt on outcrops in North Carolina, South Carolina, and Georgia, which on physical evidence have been considered to represent the Lower Cretaceous in this general region.

The Upper Cretaceous of the eastern Gulf region is subdivided into the Tuscaloosa formation, the Eutaw formation, the Selma chalk, and the Ripley formation, although these are not strictly chronologic units, as will be shown in the subsequent discussion.

The Tuscaloosa is the basal formation of the eastern Gulf Coastal Plain from Elmore County, Ala. (and probably farther east), to Tishomingo County, Miss., where it gradually thins and is transgressed by the partly overlying Eutaw formation, although it is represented by the remnants of coarse deposits which have been recognized across the Tennessee Valley as far as Kentucky and which consist of river deposits of somewhat later age than the delta deposits of west-central Alabama—the type region of the Tuscaloosa formation. At its eastern margin the Tuscaloosa doubtless impinges on the supposed Lower Cretaceous, but both the Tuscaloosa and the supposed Lower Cretaceous have been transgressed by the Eutaw and the details are obscured.

The Eutaw forms a belt of varying composition (sand, clay, and marl) extending from Taylor County, in western Georgia, to Benton County, in western Tennessee, and occurs in isolated remnants as far north as Trigg County, Ky. In Georgia and eastern Alabama it rests with marked unconformity on the supposed Lower Cretaceous. Throughout the rest of Alabama it overlies the Tuscaloosa without apparent unconformity. Beyond the Tuscaloosa region in Tennessee the Eutaw constitutes the basal formation of the Coastal Plain, resting on the rocks of the Paleozoic floor except where remnants of the Tuscaloosa are preserved.

The Eutaw formation has been divided into three members—a basal unnamed member, the Tombigbee sand member, and the Coffee sand member. I have shown in a previous paper[2] that the basal member in Alabama was probably wholly or partly the marine equivalent of the Tuscaloosa delta deposits. The Tombigbee sand member appears to be a true transgressive marine sand. In west-central Alabama the changes in drainage brought about clear-water marine conditions with chalky sediments, and these conditions were set up much earlier and persisted to a later time than either to the east or to the north. In Tennessee the Tombigbee sand merges into what has been called the Coffee sand member of the Eutaw, and in this region sandy sedimentation continued long after it had ceased in Alabama. Consequently the Coffee sand of Tennessee represents the time interval of approximately the lower half of the Selma chalk of east-central Mississippi and west-central Alabama. This general relation was inferred from the field relations during the reconnaissance made by Stephenson and me, was later confirmed by the faunal studies of Stephenson, and was still further established by the fossil plants subsequently discovered at Coffee Bluff and elsewhere in Tennessee.

The Selma chalk extends from east-central Alabama to Benton County, Tenn., resting throughout without apparent unconformity on the Eutaw. It is one of the most persistent lithologic units in the entire Coastal Plain and consists for the most part of massively bedded, usually lithified calcareous clay or argillaceous limestone. It was long known as the "Rotten limestone" and forms the so-called Black Prairie country. In the area of its maximum development along Tombigbee River in west-central Alabama it crops out in a broad belt and attains a thickness of at least 1,000 feet, extending to the extreme top of the Upper Cretaceous. It is a deposit laid down in moderately shallow water, as is

[1a] Berry, E. W., The age of the supposed Lower Cretaceous of Alabama: Washington Acad. Sci. Jour., vol. 13, pp. 433–435, figs. 1–6, Dec. 4, 1923.

[2] U. S. Geol. Survey Prof. Paper 112, p. 26, 1919.

shown by the abundance of fossil Ostreidae, and seems to owe its peculiar character to the absence of terrigenous materials. It is a lithologic and not a chronologic unit, the careful faunal studies of Stephenson having shown that it is partly the equivalent of the Eutaw and largely the equivalent of the Ripley. The various faunal lines have been traced successfully from the sand and clay of the Chattahoochee basin through the chalk to the sand and clay of northeastern Mississippi. The bearing of the Selma chalk on the Upper Cretaceous physiography is important, because the absence of run-off carrying terrigenous materials that made possible the formation of the chalk denotes a downwarping of the upper embayment and a shifting northward of the stream deltas that existed during Tuscaloosa time.

The deposits of the Ripley sea extend from Twiggs County, in central Georgia, to the head of the Mississippi embayment, in southern Illinois, and probably westward through the western Gulf region, although there is a wide interval in Missouri and Arkansas that was transgressed by Eocene deposits, large areas of which were subsequently removed by the action of Mississippi River during late Tertiary and Quaternary time.

These deposits of the Ripley sea do not constitute a single lithologic or formational unit, because in the eastern Gulf region those in the Chattahoochee basin are separated from those in northeastern Mississippi and the States farther north by the western Alabama area, in which the Selma chalk continues to the top of the Upper Cretaceous.

THE RIPLEY FORMATION

HISTORICAL SKETCH

The Ripley formation was named in 1860 by Hilgard[3] after the town of Ripley, in Tippah County, Miss., which is 3 miles southwest of the classic fossiliferous Ripley deposits exposed along Owl Creek. Until the studies by Stephenson, previously mentioned, the limits of the Ripley had been indefinite for more than half a century, any fossiliferous Upper Cretaceous sand having usually been considered Ripley. The history of the study of these deposits need not concern us further, the literature containing absolutely no reference to fossil plants except brief preliminary papers[4] and the description of Ripley plants in Professional Paper 112.

AREAL DISTRIBUTION

The beds to which the name Ripley formation has been applied crop out from Twiggs County, in central Georgia, to central Alabama, where they are interrupted by the synchronous deposits of the upper part of the Selma chalk. The Selma chalk forms the top of the Upper Cretaceous for most of the distance between central Alabama and Houston County, Miss. From that point to the head of the Mississippi embayment the Ripley deposits are continuous. In Georgia the outcrop is from 10 to 15 miles wide; in Alabama to the line where it passes into the chalk phase it is from 25 to 30 miles wide; and beyond the chalk in northeastern Mississippi it narrows to about 12 miles at the Mississippi-Tennessee boundary. It is about 6 miles wide at the Tennessee-Kentucky boundary and maintains that width across Kentucky and southern Illinois.

LITHOLOGIC CHARACTER

The Ripley materials are predominantly massively bedded dark-gray to greenish-black marine sands, more or less calcareous, micaceous, pyritiferous, glauconitic, and argillaceous, according to the conditions of sedimentation in different parts of the Ripley sea. They are usually fossiliferous, in some places enough so to constitute shell marls. Ledges of sandy limestone are developed locally. Some distance east of the Selma chalk, as in the Chattahoochee basin, the Ripley has been estimated (probably overestimated) to be about 1,000 feet thick, but it thins eastward in Georgia, where it becomes more definitely a deposit of littoral sands. It is also thinner in the upper embayment, having a reported thickness of 400 feet at Wickliffe, Ky.; 54 feet at Cairo, Ill.; and 204 feet at Paducah, Ky., as estimated from well records.

STRATIGRAPHIC RELATIONS

The Ripley formation rests without apparent unconformity on the somewhat similar

[3] Hilgard, E. W., Report on the geology and agriculture of Mississippi. pp. 62, 83–95. 1860.

[4] Berry, E. W. Contributions to the Mesozoic flora of the Atlantic Coastal Plain—VI, Georgia: Torrey Bot. Club Bull., vol. 37, pp. 503–511, 1910; XI, Tennessee: Idem, vol. 43, pp. 283–304, pl. 16, 1916.

sands of the upper part of the Eutaw in the Chattahoochee basin. Eastward in Georgia it lies unconformably on the supposed Lower Cretaceous. Westward across parts of Alabama and Mississippi it is developed above the chalk phase (Selma chalk), which, changing gradually northward into a clay, underlies it as far as the southern boundary of Kentucky. From this point to the head of the embayment it rests on the embayment floor of Paleozoic rocks. It is overlain throughout its extent by the unconformable deposits of the Eocene, although a limestone at the base of the Midway group (basal Eocene) at Owl Creek, Miss., which Lowe correlates with the Clayton limestone of Alabama, was included in the Ripley by Hilgard.

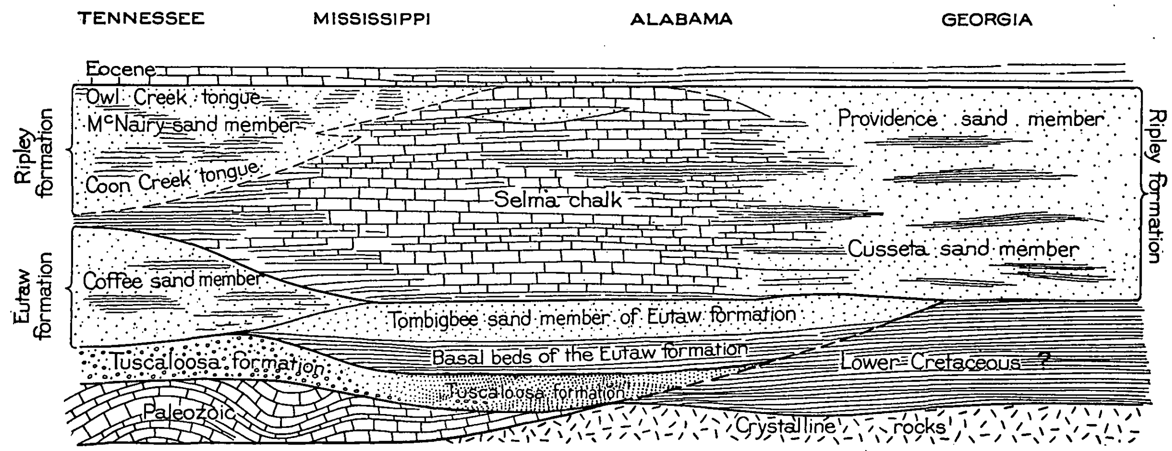


FIGURE 1.—Diagrammatic section of the Cretaceous from Tennessee to Georgia, showing the time relations of the different stratigraphic units and their relation to underlying and overlying formations

SUBDIVISIONS

Disregarding earlier interpretations we may note that in the Chattahoochee area and eastward in Georgia, Stephenson segregated the Ripley into three members—a lower named the Cusseta sand member, a middle unnamed member, and an upper or Providence sand member. The Cusseta sand member comprises 200 to 300 feet of irregularly bedded, mostly nonglauconitic sand with subordinate clay lenses of shallow marine origin, becoming thicker and more littoral in character toward the northeast as the more typically marine beds of the middle member pinch out. The Cusseta sand member contains a few fossil plants which indicate that it represents the whole or a part of the time interval of the Coffee sand member of the Eutaw formation in western Tennessee. The Providence sand member of the Ripley comprises irregularly bedded sand and clay of shallow marine and littoral origin which can be traced from Crenshaw County, Ala., to Twiggs County, Ga. Like the Cusseta sand it thickens toward the northeast, and it is indistinguishable from the Cusseta in the region where the middle member of the Ripley has disappeared. It continues to the top of the Cretaceous in that region.

The Ripley deposits of western Tennessee comprise irregularly bedded sand, clay, and marl which since the days of Safford (1864) have been referred to the Ripley formation. Stephenson, in 1914, proposed the name McNairy sand member for these beds. The detailed work of Wade has shown that the Ripley of the upper embayment was predominantly of marine origin and that several horizons can be discriminated. These from the oldest to the youngest are the Coon Creek, McNairy sand, and Owl Creek. The most extensive marine fauna yet found in the Ripley comes from Coon Creek, Tenn., and the second fauna in size and variety is that of Owl Creek, Miss., at the top of the formation. The intervening beds are less fossiliferous, but certain clay lenses that mark a horizon in the McNairy sand as limited by Wade contain an abundance of fossil plants and are interpreted as representing deposition in coastal lagoons.

The chronologic relations of the Upper Cretaceous formations of the eastern Gulf area as interpreted by me are shown diagrammatically in Figure 1.

THE RIPLEY FLORA

OCCURRENCE

Determinable fossil plants have been found at 13 different localities that are referred to the Ripley formation. Those in Alabama and Georgia were described in Professional Paper 112 (1919), already cited. Those discovered in western Tennessee are due almost entirely to the field work of Bruce Wade, and the localities, with the exception of the Big Cut in McNairy County, have not been visited by me; the stratigraphic description of these localities will be omitted from this report, as the Tennessee Geological Survey is publishing a series of county reports that will contain detailed discussions of these plant-bearing outcrops.

The localities in Alabama and Georgia furnish but few and on the whole not well-preserved fossil plants. They are separated by some 350 miles of coast line of the Ripley sea from the southernmost locality for Ripley plants in Tennessee, and this in turn is about 100 miles south of the highly fossiliferous localities in Henry and Carroll counties. At the other Tennessee localities the remains in character and condition of preservation are much like those of Alabama and Georgia. It is at the Perry place, in Henry County, and the Cooper pit, in Carroll County, that most of the information regarding the Ripley flora has been collected.

COMPOSITION, ORIGIN, AND EVOLUTION

Curiously enough each of the two localities just mentioned has yielded a total of 66 different species, and still more interesting is the fact that of this relatively large number there are only 15 species common to both, or slightly under 13 per cent of the total number of 117 species represented at the two localities. This difference of facies is not only a difference in species but in genera. For example, at the Perry place have been found species of the genera *Dioscorites*, *Geonomites*, *Protophyllocladus*, *Juglans*, *Salix*, *Liriodendron*, *Menispermites*, *Capparis*, *Acaciaphyllum*, *Caesalpinites*, *Dalbergia*, *Pachystima?*, *Rhamnus*, *Cissites*, and *Bumelia*, which are not found at the Cooper pit, and the Cooper pit has furnished representatives of the genera *Selaginella*, *Asplenium*, *Monheimia*, *Widdringtonites*, *Geinitzia*, *Potamogeton*, *Alismaphyllum*, *Dryophyllum*, *Fagus*, *Celtis*, *Cedrela*, *Acer*, *Dillenites*, *Cinnamomum*, *Nectandra*, *Myrcia*, *Eugenia*, *Cornophyllum*, *Chrysophyllum*, and *Acerates*, which have not been found at the Perry place.

Moreover, in the larger genera, such as *Myrica*, with 11 species, only one of these is common to the two localities; only two of the Leguminosae are common to both localities; of the seven species of *Celastrophyllum* but one is found at both outcrops; of the nine figs none are common to both; of the five species of *Apocynophyllum* none are common; of the three species of *Zizyphus* only one is common, and that one is rare at one locality and abundant at the other; and of the three species of *Ternstroemites* only one is found at both localities.

As these two localities have been shown by the mapping to represent practically the same horizon these marked differences in apparent facies can be due to but two causes—that is, they are to be accounted for solely as the result of accidents of preservation or discovery or as being inherent differences due to local differences in environmental conditions, at the time of growth. Possibly a combination of these two explanations is the correct solution. I am inclined, however, to think that in this as in many other fossil floras and faunas accidents of preservation and discovery are the major factors in producing the apparent differences, and this conclusion emphasizes anew the extreme danger of relying upon negative evidence, for did we not know otherwise we should doubt the contemporaneity of these two florules.

All the remaining localities where Ripley plants have been discovered have yielded too few species to afford satisfactory evidence for close correlation. The beds in Tennessee are known from their stratigraphic position to be of approximately identical age with those at the Perry place and Cooper pit. Those in Barbour County, Ala., are undoubtedly Ripley but whether younger or older than the Tennessee beds can not be determined. The two plant-bearing localities in Georgia which L. W. Stephenson has referred to the Cusseta sand member or lower Ripley of the Georgia area are of especial interest, because although neither locality has yielded more than half a dozen species these furnish conclusive evidence in support of the correlations proposed by Stephenson on stratigraphic and meager faunal evidence.

The three species known from Byron, Ga., are *Dryopterites stephensoni*, *Araucaria jeffreyi*, and *Cunninghamites elegans*. The first is not found elsewhere, the second occurs in the Eutaw and Black Creek formations, and the third in the Black Creek, Magothy, and other, generally slightly older deposits. The beds at Byron appear to be older than any plant-bearing Ripley deposits in Tennessee and probably older than the Coffee sand member of the Eutaw formation, and also older than those at the Buena Vista locality in Georgia. Six species are recorded from Buena Vista. Two of these occur in the McNairy sand member of the Ripley formation. The other four are species characteristic of the Black Creek formation of the Carolinas and the Eutaw formation of Tennessee, Alabama, and Georgia; one of the four occurs in the Bingen sand of Arkansas, and two in the Magothy formation of Maryland. The beds at Buena Vista appear to be of the same age as part of the Eutaw of the Chattahoochee River region and of central Alabama, and as the Coffee sand of Tennessee. The Cusseta sand member of the Ripley formation in Georgia is thus older than any of the Ripley of Tennessee and is to be correlated with the lower half of the Selma chalk in the region of the greatest development of the chalk in west-central Alabama and east-central Mississippi, as is also the Coffee sand member of the Eutaw formation, and the Ripley of Tennessee corresponds with the upper half of the Selma chalk in the region of its maximum development and with the Providence sand member of the Ripley of Georgia. The localities in Henry and Carroll counties, Tenn., are well toward the head of the Cretaceous Mississippi embayment and over 20 miles north of the localities in Barbour County, Ala., or of the Ripley localities in Georgia. Moreover, it is becoming increasingly clear that a large body of Upper Cretaceous deposits originally laid down across Tennessee and Kentucky has disappeared during the formation of the Tennessee Valley, so that in Selma and Ripley time the shore line was some distance to the east of the present outcrop of these deposits and there was a considerable reentrant or bay extending eastward from the head of the late Cretaceous Mississippi Gulf.

These relatively slight geographic changes are not believed to be reflected in the facies of the flora, nor is it believed that the position of these deposits with relation to the Atlantic Ocean or their difference in latitude would have an appreciable effect upon their composition, for the corresponding floras extend over many degrees of latitude without appreciable changes, as is also true of the contemporaneous marine faunas. The few Ripley plants previously recorded were coriaceous, decay-resisting forms that might have been transported for considerable distances, but those from Henry and Carroll counties present every indication of having lived in the vicinity where they were found. Their state of preservation indicates this, as well as the abundance of small delicate and long, slender forms that would certainly be mutilated or destroyed by transportation. There could have been no wave action where these fine-grained clay lenses were deposited, so that the clay must owe its origin to the settling from suspension of mud, either in a sheltered lagoon along the coast or in a quiet estuary or bayou of a slow-moving stream. The exposed portion of the clay is not black and carbonaceous, but its thickness is inconsiderable and it lies immediately below the upper contact with the sand, so that nothing is known of the character of the lower clay.

The sands are coarse beach and barrier-beach sands, and the clay lenses tend to have their long axes approximately parallel to the old coast line. In general the relations are very similar to those which existed during lower Eocene time in this same region. This argillaceous portion of the Ripley is rather persistent, consisting of disconnected lenses of greater or less length, which extend from north to south for at least 50 miles across Henry and Carroll counties. Farther north in Henry County a bed of lignite more than 20 inches thick is exposed, but none is seen near the plant-bearing outcrops, nor is the base of the clay exposed. The basins in which the deposits were laid down may be pictured as a series of coastal lagoons stretching along the shore of the Ripley sea, from which they were partly or wholly cut off by barrier beaches.

Those that were less sheltered were filled with argillaceous sand such as occurs west of Camden and farther south, where most of the plant fragments were broken up and the more or less carbonaceous clays contain identifiable fragments of only the more resistant types. The lagoons represented by the Perry and Cooper localities were more sheltered and protected from wave action, at least for long intervals, during which the fine muds were deposited. That there were no considerable streams emptying into the Ripley sea in the Tennessee region is rendered very probable by the history of Tennessee River, to the east. The Tennessee appears to have been the master stream at that time, following much the same course that it does at present but farther east, its distributaries having migrated northward during Tuscaloosa time, as I have indicated in the discussion of Tuscaloosa history.[5] The Ripley mainland appears to have been well wooded. There is no evidence of distinctively palustrine conditions at the two principal plant localities, although elsewhere in deposits of this age such evidence is present. Several supposed aquatic plants are included in the collection, however, and the number of coastal types is considerable, as I have shown in the analysis of the flora.

DISTRIBUTION

The following systematically arranged table shows the distribution of the Ripley species at the several localities of this age from which identifiable plants have been collected:

[5] U. S. Geol. Survey Prof. Paper 112, 1919.

Distribution of the Ripley flora

	Tennessee									Alabama		Georgia	
	Perry place, Henry County	Cooper pit, Carroll County	Near Buena Vista, Carroll County	Near Mifflin, Chester County	13 miles northwest of Camden, Henry County	Near Camden, Benton County	Coon Creek, McNairy County	Near Selmer, McNairy County	Big Cut, McNairy County	Near Eufaula, Barbour County	Cowikee Creek, Barbour County	Near Buena Vista, Marion County	Near Byron, Houston County
Phylum LEPIDOPHYTA?													
Order LYCOPODIALES?													
Family SELAGINELLACEAE?													
Selaginella laciniata Lesquereux		×											
Phylum PTERIDOPHYTA													
Order FILICALES													
Asplenium calopteris (Debey and Ettingshausen) Heer		×											
Raphaelia neuropteroides Debey and Ettingshausen	×	×											
Raphaelia minuta Berry		×											
Monheimia aquisgranensis Debey and Ettingshausen		×											
Taeniopteris sp.	×	×											
Dryopterites stephensoni Berry													×
Phylum CONIFEROPHYTA													
Protophyllocladus lobatus Berry	×												
Widdringtonites reichii (Ettingshausen) Heer		×	×										
Moriconia cyclotoxon Debey and Ettingshausen	×	×											
Moriconia americana Berry	×												
Geinitzia formosa Heer		×											
Cunninghamites elegans (Corda) Endlicher													×
Araucaria bladenensis Berry												×	
Araucaria jeffreyi Berry													×
Dammara acicularis Knowlton			×										

Distribution of the Ripley flora—Continued

	Tennessee									Alabama		Georgia	
	Perry place, Henry County	Cooper pit, Carroll County	Near Buena Vista, Carroll County	Near Mifflin, Chester County	13 miles northwest of Camden, Henry County	Near Camden, Benton County	Coon Creek, McNairy County	Near Selmer, McNairy County	Big Cut, McNairy County	Near Eufaula, Barbour County	Cowikee Creek, Barbour County	Near Buena Vista, Marion County	Near Byron, Houston County
Phylum ANGIOSPERMOPHYTA													
Class MONOCOTYLEDONAE													
Order NAIADALES													
Family NAIADACEAE													
Potamogeton ripleyensis Berry		×											
Alismaphyllum cretaceum Berry		×											
Order LILIALES													
Family DIOSCOREACEAE													
Dioscorites cretaceus Berry	×												
Doryanthites cretacea Berry												×	
Order ARECALES													
Family ARECACEAE													
Geonomites schimperi Lesquereux	×			×			×						
Sabalites sp						×		×					
Class DICOTYLEDONAE													
Series CHORIPETALAE													
Order JUGLANDALES													
Family JUGLANDACEAE													
Juglans similis Knowlton	×												
Juglans tennesseensis Berry	×												
Juglans wadii Berry	×												
Order MYRICALES													
Family MYRICACEAE													
Myrica wadii Berry	×												
Myrica wadii minor Berry	×												
Myrica ripleyensis Berry					×			×					
Myrica cooperensis Berry		×											
Myrica johnstrupi (Heer) Berry		×											
Myrica minor Berry	×												
Myrica ornata Berry		×											
Myrica torreyi Lesquereux		×											
Myrica torreyi obtusata Berry		×											
Myrica brittoniana Berry	×												
Myrica brittoniana obtusata Berry	×												
Order SALICALES													
Family SALICACEAE													
Salix gardneri Knowlton?	×												

Distribution of the Ripley flora—Continued

	Tennessee									Alabama		Georgia	
	Perry place, Henry County	Cooper pit, Carroll County	Near Buena Vista, Carroll County	Near Mifflin, Chester County	13 miles northwest of Camden, Henry County	Near Camden, Benton County	Coon Creek, McNairy County	Near Selmer, McNairy County	Big Cut, McNairy County	Near Eufaula, Barbour County	Cowikee Creek, Barbour County	Near Buena Vista, Marion County	Near Byron, Houston County
Order FAGALES													
Family FAGACEAE													
Dryophyllum gracile Debey		×						×	×				
Dryophyllum protofagus Berry		×											
Fagus ripleyensis Berry		×											
Order URTICALES													
Family ULMACEAE													
Celtis cretacea Berry		×											
Family MORACEAE													
Artocarpus cretacea Berry	×	×											
Ficus ripleyana Berry		×											
Ficus krausiana Heer		×											
Ficus obtusa-sessilia Berry	×												
Ficus crassipes (Heer) Heer	×												
Ficus celtifolius Berry		×											
Ficus leei Knowlton		×											
Ficus cooperensis Berry		×											
Ficus georgiana Berry	×											×	
Ficus carrollensis Berry		×											
Order PLATANALES													
Family PLATANACEAE													
Platanus ripleyensis Berry										×			
Platanus sp											×		
Order RANALES													
Family MAGNOLIACEAE													
Liriodendron laramiense Ward	×												
Magnolia capellinii Heer								×					
Family MENISPERMACEAE													
Menispermites variabilis Berry	×												
Order PAPAVERALES													
Family CAPPARIDACEAE													
Capparis proeocenica Berry	×												
Order ROSALES													
Family MIMOSACEAE													
Acaciaphyllites cretaceum Berry	×												
Mimosites cooperensis Berry	×	×		×									

Distribution of the Ripley flora—Continued

	Tennessee									Alabama		Georgia	
	Perry place, Henry County	Cooper pit, Carroll County	Near Buena Vista, Carroll County	Near Mifflin, Chester County	13 miles northwest of Camden, Henry County	Near Camden, Benton County	Coon Creek, McNairy County	Near Selmer, McNairy County	Big Cut, McNairy County	Near Eufaula, Barbour County	Cowikee Creek, Barbour County	Near Buena Vista, Marion County	Near Byron, Houston County
Family CAESALPINIACEAE													
Caesalpinites perryensis Berry	×												
Caesalpinites ripleyensis Berry	×												
Bauhinia ripleyensis Berry								×			×		
Family PAPILIONACEAE													
Dalbergia cretacea Berry	×												
Dalbergia perryana Berry	×												
Dalbergia prewilcoxiana Berry	×												
LEGUMINOSAE (position uncertain)													
Leguminosites canavalioides Berry	×	×											
Leguminosites perryensis Berry	×												
Leguminosites carrollensis Berry		×											
Gleditsiophyllum preovatum Berry	×												
Gleditsiophyllum proeocenicum Berry	×												
Gleditsiophyllum aristatum Berry		×											
Order GERANIALES													
Family MELIACEAE													
Cedrela prewilcoxiana Berry		×											
Family EUPHORBIACEAE													
Euphorbiophyllum petiolatum Berry	×	×		×								×	
Euphorbiophyllum tennesseensis Berry	×												
Euphorbiophyllum cretaceum Berry	×												
Euphorbiophyllum antiquum Saporta and Marion		×											
Manihotites georgiana Berry								×				×	
Order SAPINDALES													
Family CELASTRACEAE													
Celastrophyllum carolinensis Berry		×											
Celastrophyllum ripleyanum Berry	×	×											
Celastrophyllum minimum Berry	×												
Celastrophyllum cassinoides Berry	×												
Celastrophyllum perryi Berry	×												
Celastrophyllum variabilis Berry	×												
Pachystima? cretacea Berry	×												
Family ACERACEAE													
Acer cretaceum Berry		×											
Order RHAMNALES													
Family RHAMNACEAE													
Rhamnus ripleyensis Berry	×												
Zizyphus laurifolius Berry		×											
Zizyphus ripleyensis Berry	×	×											
Zizyphus perryi Berry	×												

Distribution of the Ripley flora—Continued

	Tennessee									Alabama		Georgia	
	Perry place, Henry County	Cooper pit, Carroll County	Near Buena Vista, Carroll County	Near Mifflin, Chester County	13 miles northwest of Camden, Henry County	Near Camden, Benton County	Coon Creek, McNairy County	Near Selmer, McNairy County	Big Cut, McNairy County	Near Eufaula, Barbour County	Cowikee Creek, Barbour County	Near Buena Vista, Marion County	Near Byron, Houston County
Family VITACEAE													
Cissites crispus Velenovsky								×					
Cissites panduratus Knowlton	×												
Order MALVALES													
Family TILIACEAE													
Grewiopsis ripleyensis Berry		×											
Grewiopsis inequilateralis Berry	×	×											
Family STERCULIACEAE													
Sterculia snowii tennesseensis Berry								×					
Order PARIETALES													
Family DILLENIACEAE													
Dillenites cretaceus Berry		×											
Family TERNSTROEMIACEAE													
Ternstroemites ripleyensis Berry	×												
Ternstroemites tennesseensis Berry		×											
Ternstroemites cretaceus Berry	×	×											
Order THYMELEALES													
Family LAURACEAE													
Cinnamomum newberryi Berry			×	×				×					
Cinnamomum newberryi lanceolatum Berry		×											
Cinnamomum newberryi minimum Berry		×											
Cinnamomum newberryi ellipticum Berry		×											
Cinnamomum praespectabile Berry		×											
Nectandra prolifica Berry		×											
Malapoenna horrellensis Berry								×	×				
Laurus atanensis Berry	×	×											
Laurus asiminoides Berry	×												
Laurus ripleyensis Berry	×												
Laurus coloradensis Knowlton	×												
Laurophyllum ripleyensis Berry	×	×											
Order MYRTALES													
Family MYRTACEAE													
Myrcia havanensis Berry		×			×			×	×				
Myrcia dubia Berry		×											
Eugenia? anceps Berry		×						×					
Myrtophyllum angustum (Velenovsky) Berry	×	×	×	×								×	
Order UMBELLALES													
Family ARALIACEAE													
Aralia wellingtoniana minor Berry	×												
Aralia problematica Berry	×	×											

Distribution of the Ripley flora—Continued

	Tennessee									Alabama		Georgia	
	Perry place, Henry County	Cooper pit, Carroll County	Near Buena Vista, Carroll County	Near Mifflin, Chester County	13 miles northwest of Camden, Henry County	Near Camden, Benton County	Coon Creek, McNairy County	Near Selmer, McNairy County	Big Cut, McNairy County	Near Eufaula, Barbour County	Cowikee Creek, Barbour County	Near Buena Vista, Marion County	Near Byron, Houston County
Family CORNACEAE?													
Cornophyllum minimum Berry		X											
Series GAMOPETALAE													
Order ERICALES?													
Family ERICACEAE?													
Andromeda anceps Berry	X												
Order EBENALES													
Family SAPOTACEAE													
Chrysophyllum parvum Berry		X											
Bumelia prewilcoxiana Berry	X												
Bumelia ripleyana Berry	X												
Order GENTIANALES													
Family ASCLEPIADACEAE													
Acerates cretacea Berry		X											
Family APOCYNACEAE													
Apocynophyllum giganteum Berry		X											
Apocynophyllum perryensis Berry	X												
Apocynophyllum sumterensis (Berry) Berry		X									X		
Apocynophyllum ripleyensis Berry		X											
Apocynophyllum alatum Berry	X												
Position uncertain													
Calycites ripleyensis Berry	X												
Phyllites hydrilloides Berry	X												
Phyllites hydrocharitoides Berry		X											
Phyllites ripleyensis Berry		X											
Carpolithus perryensis Berry	X												
Carpolithus ripleyensis Berry							X						
Carpolithus carrollensis Berry		X											
Halymenites major Lesquereux								X					

The Ripley flora as at present known comprises 135 species, including the doubtfully organic remains named *Halymenites*. Most of these species are represented by well-preserved and ample material and are hence well characterized; fragmentary remains of still other forms in the collection have been ignored. Undoubtedly more extensive collecting would greatly increase the number of species, and this is also to be expected should similar highly fossiliferous clay lenses be uncovered in the future. Of the 135 species 86, or more than 60 per cent, are new to science, and these include the genera *Dioscorites*, *Celtis*, *Capparis*, *Cedrela*, *Dillenites*, and *Chrysophyllum*, hitherto unknown in deposits older than the Eocene.

The total number of genera is 71, and these are segregated into 40 families representing 28 orders. The supposed alga (*Halymenites*) and the form referred to the genus *Selaginella* are of doubtful botanic affinity. The collection contains very fragmentary remains of six different species of ferns. These are all small and of more or less doubtful botanical identity, but they are of importance for purposes of correlation, as nearly all are found in other areas, especially in Greenland and Europe. There are nine species of gymnosperms, but several of these are of somewhat doubtful value in indicating age, and traces of plants of this affinity are extremely rare in western Tennessee. The monocotyledons also number nine species, including a fan palm and a feather palm that is referred to the genus *Geonomites* and is of a type that is prominent in the lower Eocene of the Raton Mesa region. Several of the monocotyledons appear to represent aquatic or semiaquatic species. Thus, there is a well-marked *Potamogeton* and the mud-flat type *Alismaphyllum.* In addition the forms named *Phyllites hydrilloides* and *Phyllites hydrocharitoides* appear to represent aquatics. The former shows great resemblance to *Hydrilla*, of the family Hydrocharitaceae, a genus supposed to be monotypic in the existing flora and widely distributed throughout the Old World. The latter appears to represent an Upper Cretaceous type of this same family, comparable in its habit with the existing genus *Vallisneria.*

The dicotyledons of the Ripley flora number 105, of which 95 belong to the more primitive or choripetalous series, and only 10 represent the more specialized Gamopetalae. Among the Choripetalae the anemophilous forms, regarded as primitive by some botanists and reduced by others, number 19. The largest alliance is the Rosales, with 14 species, all of which belong to the Leguminosae. As two of these species are definitely referred to the Mimosaceae, three to the Caesalpiniaceae, and three to the Papilionaceae, and as six can not be certainly referred to any one family of Leguminosae, none of these families can be considered larger than the others and all are less abundantly represented than some other families present in the Ripley flora. The second largest family is the Lauraceae, with 12 species, but the recognition of minute differences in the genera *Cinnamomum* and *Laurus* tends to overemphasize their relative importance in the Ripley flora. The family Myricaceae is third in size, with 11 species, all of which belong to the genus *Myrica*, which shows an extraordinary differentiation at this time. The next most abundantly represented family is the Moraceae, with ten species, nine of which are referred to *Ficus* and the tenth to a striking new form of *Artocarpus.* None of the species of *Ficus* are individually abundant in the collections. Then follows the family Celastraceae, with seven species. The family Apocynaceae has five species, all of which are referred to the genus *Apocynophyllum.* The Euphorbiaceae, Rhamnaceae, and Myrtaceae have four species each, and the Juglandaceae, Fagaceae, Ternstroemaceae, and Sapotaceae have three species each. The remaining families have only one or two species each. The largest single genera are *Myrica*, with 11 species, Ficus, with 9, and *Celastrophyllum*, with 6. If the type represented by *Celastrophyllum* were considered with the forms that I refer to *Ternstroemites*, which were formerly referred to *Celastrophyllum*, they would constitute the most abundant type in both differentiation and individual abundance.

Among the 105 species of dicotyledons of the Ripley flora 68 have entire margins. This is 64.7 per cent of the known forms. The ratio of entire leaves to the whole flora of woody dicotyledons has been shown by Bailey and Sinnott [6] to have a fairly constant relation to climatic conditions and altitude. According to the figures compiled by these authors, over 70 per cent of the woody dicotyledons of subtropical and tropical lowland floras have entire leaves. Their published percentages range from 71 per cent in the flora of Hongkong to 86 per cent in the flora of the Malay States. Comparisons of fossil with existing floras are always handicapped by the incompleteness of the fossil record, although, on the other hand, the vast majority of fossil forms are arborescent, so that the problem is simplified to that extent. As the Ripley flora is obviously a lowland coastal flora, the question of altitude is eliminated. It would thus appear that the percentage of entire leaves in the Ripley plants accords well with the conclusions derived from

[6] Bailey, I. W., and Sinnott, E. W., Science, new ser., vol. 41, pp. 832–833, 1915.

the general facies of the flora that the climate was probably warm temperate and rather uniform and the precipitation abundant.

The approximate outline of eastern North America during Ripley time is well shown in the accompanying sketch map (fig. 2). The North Atlantic, as recorded in the deposits along the west coast of Greenland, extended northward in the Davis Strait region between Greenland and Baffin Land. The extent of this arm of the sea is conjectural, as its sediments have been discovered nowhere except in west Greenland. They were laid down in extremely shallow water, and presumably the gulf did not extend northward much beyond the latitude of Disco Island, or else it was of a very transitory nature, as there seems to have been a free land path of migration between Greenland and the Atlantic coast of North America.

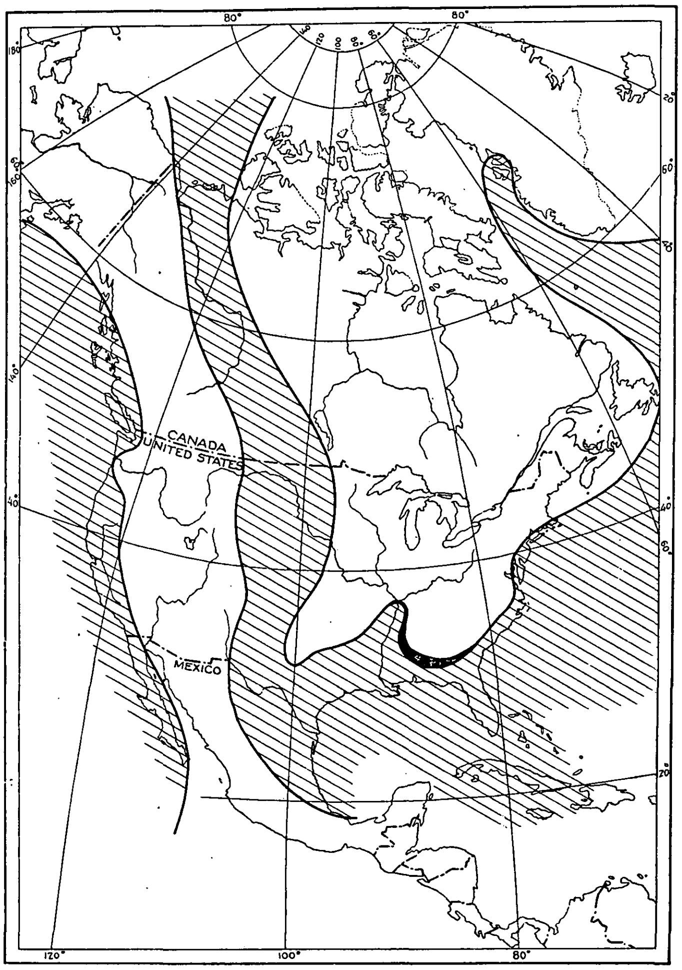


FIGURE 2.—Map of North America showing the area of outcrop of the Ripley formation (solid black) and the generalized relations of land (white areas) and sea (ruled areas) during Ripley time

From Cape Cod southward the shallow sea that covered the continental shelf overlapped the margin of the Piedmont Plateau, and a broad arm reached up the Mississippi Valley as far as Illinois. The middle of the continent was a region of shifting shore lines and shallow seas which completely separated eastern and western North America. Eastern North America was also separated from Central and South America by a profound expanse of sea.

That the late Lower and earlier Upper Cretaceous floras of North America represent, in a broad way, a single botanic province is shown by the lack of dissimilarity between the Albian, Cenomanian, and possibly Turonian floras of the East and the West. There are naturally elements in each not found in the other, but these are to be attributed to the imperfection of the record or explained as reflections of minor local facies. The time represented in the midcontinental region by the major portion of the Colorado and Montana groups, however, was a time of independent evolution in both the East and the West. The West was broadly connected with the great land mass of Asia, and this fact might seem to furnish the setting for a greater resemblance to the flora of Europe than could be shown by the flora of eastern North America. This does not appear to have been the case, however, and it would seem that there was still a shorter and readily traversed path from the east across the Arctic and north Atlantic, and this paleogeographic conception would be equally true if we regarded the two regions as receiving the bulk of their plant population from a somewhat earlier Greenland center of radiation.

It is interesting to see in this Ripley flora a characteristic local facies, and this is especially emphasized, as might have been expected, by the dicotyledons. Nearly all the ferns and all the conifers have an outside distribution, as befits their more ancient lineage and earlier radiation, but of the angiosperms only 33 forms, or about 28 per cent, have been found in other areas. This is still more striking than appears from the bare statement, for if Greenland is excluded as near the probable place of origin of the Upper Cretaceous floras or at least the ancient home of those of eastern North America, it seems that only six of the angiosperms are common to distant regions, such as Europe. These six are *Dryophyllum gracile*, *Ficus krausiana*, *Magnolia capellini*, *Euphorbiophyllum antiquum*, *Cissites crispus*, and *Myrtophyllum angustum*.

The Ripley flora shows a marked relationship to that of the antecedent Eutaw formation of this same region, to the Black Creek flora of the Carolinas, and to the Magothy flora of New Jersey and Maryland. As the known floras of the Eutaw and Black Creek are small and fragmentary this resemblance is all the more remarkable. Thus 16 of the Ripley species are common to the Eutaw, 19 to the Black Creek, and 15 to the Magothy. The older Tuscaloosa flora of the eastern Gulf area has but six species that continue on into the Ripley, and these are all widely distributed types, common to either Greenland or Europe. It would thus appear that the Ripley flora consists of some few forms existing in this region since Tuscaloosa time, with many new elements that were added by immigration or evolution in the interval between the Tuscaloosa and Ripley.

In so far as the present records permit a conclusion, the Ripley flora may be regarded as the culmination of the earlier Cretaceous floras of eastern North America. Certain of its species are Ripley species only because of the somewhat inconsistent usage of the formational name Ripley by the Geological Survey. Thus *Araucaria bladenensis* and *Araucaria jeffreyi*, which are so highly characteristic of the Black Creek and Eutaw formations, are recorded from the Ripley formation of Georgia. They have never been found in the true Ripley of Alabama, Mississippi, or Tennessee, and as I have shown elsewhere in this paper the Cusseta sand of the Ripley of Georgia is of the same age as the Coffee sand of the Eutaw of Tennessee.

The Ripley flora includes a considerable number of forms that are common to the Patoot beds of Greenland. Thus eight of the Patoot species are found in the Ripley, and the general facies is more similar than the number of identical species would indicate. There are also eight species common to the Vermejo flora of Colorado and New Mexico, of which all but one are dicotyledons and several, such as the abundant *Cissites panduratus*, have been found nowhere else. This would serve to confirm Knowlton's contention that the Vermejo is older than Laramie, as the only Ripley species recorded from the Laramie is *Myrica torreyi*, which also occurs in post-Laramie deposits in the West. Five species are found in beds in the West that are referred to the Montana group, four in the Mesaverde formation, two in the Fox Hills, and five in the Fruitland formation.

ANALYSIS OF OTHER UPPER CRETACEOUS FLORAS

GENERAL CONSIDERATIONS

Comparisons with European Upper Cretaceous floras show that five Ripley species are recorded from beds on that continent classed as Cenomanian, two from beds classed as Turonian, three from beds classed as Emscherian, and six from beds that are either Santonian or Campanian. The Ripley flora contains noticeable elements common to that of the sands of Aix-la-Chapelle (Aachen), Germany. How many it is not possible to determine, for large collections made around Aix-la-Chapelle by Debey were never studied, and only the ferns have received adequate treatment. The plants from the plastic clays of Baume (St. Vaast), France, described by Coemans, and found also at La Louvière, Belgium, are probably of the same age. There has been considerable discussion and difference of opinion regarding the age of the sands of Aix-la-Chapelle. These sands contain a sparse shallow-water marine fauna with *Exogyra*, *Trigonia*, *Eriphyla*, *Inoceramus*, and lenses of clay containing fossil plants. The sands are overlain by a highly fossiliferous glauconitic sand—the *Actinocamax quadratus* zone of the Campanian. This relationship would seem to indicate that the underlying plant-bearing beds represent the littoral and continental deposits of the Santonian or at most can not be older than the lower Emscherian Coniacian substage. Despite this, Haug refers these sands to the Turonian. They are siliceous and cross-bedded and in part represent coastal dune sands, so that they might conceivably be considerably older than the overlying strictly marine sediments. The question is important, because I regard the Ripley as of about the same age, but perhaps it can not be settled in the present state of our knowledge. I am disposed, however, to regard them as representing the Santonian substage, or upper Emscherian.

The known Ripley flora contains no forms that are common to the abundant Wilcox or lower Eocene flora of the Mississippi embayment region, the only forms doubtfully recorded from the Eocene in other regions being *Geonomites schimperi* and the wholly worthless *Halymenites major*. Despite this lack of identical species, which might be expected, the Ripley flora does contain a number of types that became differentiated subsequently and are characteristic elements of the lower Eocene flora in southeastern North America. These are all angiosperms, the genera and species of the pteridophytes and some of the coniferophytes having become extinct and some genera of the coniferophytes having been restricted to other regions before the dawn of the Eocene. Eocene prenuncial characters are seen in the Ripley *Geonomites*, *Dryophyllum*, *Celtis*, *Artocarpus*, *Capparis*, *Dalbergia*, *Gleditsiophyllum*, *Cedrela*, *Dillenites*, *Ternstroemites*, *Nectandra*, *Cinnamomum*, species retained in the form genus *Laurus*, *Myrcia*, *Chrysophyllum*, *Bumelia*, and *Apocynophyllum*. Many of these are coastal types that might be expected to persist in an only slightly changed environment, but the same is true as regards the habitat of most of the earlier Upper Cretaceous floras of the Atlantic Coastal Plain, so that these differences in the Ripley flora as compared with antecedent floras may truly be regarded as of chronologic value. Detailed comparisons with the extensive Wilcox flora (Eocene) show many striking differences. In the Wilcox the old Mesozoic coniferophyte elements are all gone, and numerous genera of angiosperms found in the Ripley, commonly considered as temperate forest types, such as *Salix*, *Fagus*, *Celtis*, *Liriodendron*, *Platanus*, *Acer*, *Cornophyllum*, and *Andromeda*, were apparently lacking along the Eocene coast of the Mississippi Gulf, although present in the Rocky Mountain and Great Plains region at that time. This would seem to indicate some climatic difference between Ripley and Wilcox conditions, and in that event the Ripley would be more distinctly temperate than the Wilcox.

The most extensive, best-preserved, and earliest studied Upper Cretaceous floras, both in this country and abroad, have been those in the continental deposits immediately preceding the transgression of the Upper Cretaceous sea, or in the initial deposits of that sea—such, for example, as the Dakota sandstone of Kansas and Nebraska, the Raritan clays of New Jersey, the Perucer beds of Bohemia, or the Niederschoena deposits of Saxony. In all the sections the plant evidence rapidly diminishes in both variety and quality from bottom to top. A knowledge of the Ripley flora not only serves to offset this condition and furnish a basis for more precisely evaluating the passing of Cretaceous time but it introduces us to many of the smaller and more delicate forms, such as almost invariably fail of preservation in coarse deposits.

Examples of the relative paucity of the later Cretaceous floras of the Atlantic Coastal Plain are furnished by noting that the Tuscaloosa, Raritan, and Magothy floras comprise about 150 species each, whereas in my report on the Upper Cretaceous floras of the world,[7] I listed but nine species from the Ripley formation in Georgia, two from beds of that age in Alabama, and three from Tennessee. A foreign parallel may be taken from the Bohemian area. Here the Perucer beds (Cenomanian) have furnished 184 species, the Turonian 47, and the Chlomeker (Emscherian) but 32.

It may be noted that of the genera identified in the Ripley flora 35, or 51 per cent, are extinct. Most of these, which are angiospermous, are form genera and therefore not as precise as might be wished, although obviously some, such as *Ternstroemites*, represent the stock from which the Tertiary and existing genera were differentiated, and it is noteworthy that 16 of the genera have not been recognized in post-Cretaceous deposits. The following are the extinct genera of the Ripley flora:

Halymenites.	Caesalpinites.
Raphaelia.	Gleditsiophyllum.
Dryopterites.	Leguminosites.
Monheimia.	Euphorbiophyllum.
Taeniopteris.	Manihotites.
Protophyllocladus.	Cissites.
Widdringtonites.	Grewiopsis.
Cunninghamites.	Dillenites.
Moriconia.	Ternstroemites.
Geinitzia.	Laurophyllum.
Alismaphyllum.	Myrtophyllum.
Doryanthites.	Cornophyllum.
Dioscorites.	Acerates.
Geonomites.	Apocynophyllum.
Dryophyllum.	Calycites.
Menispermites.	Carpolithus.
Acaciophyllites.	Phyllites.
Mimosites.	

That students in general have underestimated the contrast between Upper Cretaceous and Eocene floras is, I think, obvious. It is the fashion to picture the incoming of the Angiosperms in Upper Cretaceous time as a sudden and overwhelming event, which in Cenomanian time transformed the Mesozoic floras of ferns, cycadophytes, and conifers into an essentially Cenozoic flora of broad-leafed modern forests. At the beginning of Lower Cretaceous time the floras, as might be predicted a priori, were essentially of Jurassic type. Only gradually did they become typically Cretaceous, and those elements that give them a Cretaceous facies lingered in gradually diminishing numbers to the end of Upper Cretaceous time. Floras as early as the Albian show a variety of dicotyledons, including many still existing genera, but the numerical representation of dicotyledons in the rocks tends to be illusory, and a large number of the Cretaceous dicotyledons are more or less synthetic types, if one is justified in drawing such conclusions from the evidence of foliage alone. The lower Eocene introduces us to floras that are of a decidedly different facies and that distinctly show a great Cenozoic modernization, despite the difficulty of reflecting this change in the current nomenclature of paleobotany.

Moreover, when it comes to details the change is profound. If the Ripley flora is compared with the Wilcox flora of the same general region the two are seen to be almost totally unlike, though living under similar environmental conditions. Both are lowland coastal floras, both are warm temperate in type, and yet they have no common species. A tyro would immediately recognize the one as Cretaceous and the other as Tertiary. The Cretaceous cycadophytes and conifers have disappeared in the interval between the two; the flowering plants are distinctly better differentiated and more modern.

That these Eocene floras as well as the Upper Cretaceous dicotyledons had ancestors is no more pertinent than the fact that the Eocene mammals had ancestors. In fact, the comparison is not inept, because the evolution of the flowering plants was, I believe, the major factor that made possible the evolution of the mammals.

The other Upper Cretaceous floras in various parts of the world that may profitably be compared with the Ripley flora are shown on the accompanying sketch map (fig. 3). Some of these are of great importance, such as those of Montana age in the western interior region of North America, or of especial interest because of their geographic position, such as that of the Patoot beds of Greenland. Others are worthy of comment because they are of approximately the same age—as, for example, the

[7] Maryland Geol. Survey, Upper Cretaceous, 1916.

plants of the Izumi series of Japan, of southeastern France, of the Alpine Gosau beds, and of the Aix-la-Chapelle sands—even though as to these floras our information is still very incomplete.

EUTAW FLORA

The first comparison that naturally suggests itself is a comparison with the flora of the Eutaw formation, whose deposition immediately preceded that of the Ripley formation in this area. The Eutaw flora is still incompletely known. The Eutaw sediments in so far as they might preserve land plants successfully are either marine clays or littoral, prevailingly sandy deposits. The clays contain only decay-resisting forms such as *Araucaria* twigs and coriaceous dicotyledons, and the sands contain similar forms that successfully withstood the triturating action of the troubled waters, as no clay lenses with any extensive representation of the plants that grew along the Eutaw shores have yet been discovered.

The known Eutaw flora, which has been collected chiefly from the Chattahoochee Valley, in Georgia; near Havana, in Hale County, Ala.; and near Beacon, in Decatur County, and at Coffee Bluff, in Tennessee, consists of but 46 species. It includes no ferns, 34 angiosperms, and 11 gymnosperms. Among the gymnosperms are the genera *Androvettia*, *Brachyphyllum*, *Cephalotaxospermum*, *Cupressinoxylon*, *Sequoia*, and *Tumion*, which are unknown in the Ripley, as well as the twigs and scales of Araucaria, which, although recorded from the Ripley, come from deposits of the same age as the Eutaw in other regions, as I have already explained. These are preserved in the Eutaw because of their resistance to maceration, but they should be present also in the Ripley if they had not become extinct. Similarly among the dicotyledons the prevailing forms found in the Eutaw are coriaceous types such as *Andromeda*, *Cinnamomum*, *Ficus*, *Magnolia*, *Myrcia*, *Manihotites*, *and Sabalites*.

In the following list of the known Eutaw species those marked * are also present in the Ripley flora. Of the 46 Eutaw species 16 continue into the Ripley, but the following genera of the Eutaw have not been recognized in the Ripley: *Androvettia*, *Brachyphyllum*, *Cephalotaxospermum*, *Cupressinoxylon*, *Dewalquea*, *Diospyros*, *Paliurus*, *Pterospermites*, *Sequoia*, and *Tumion*.

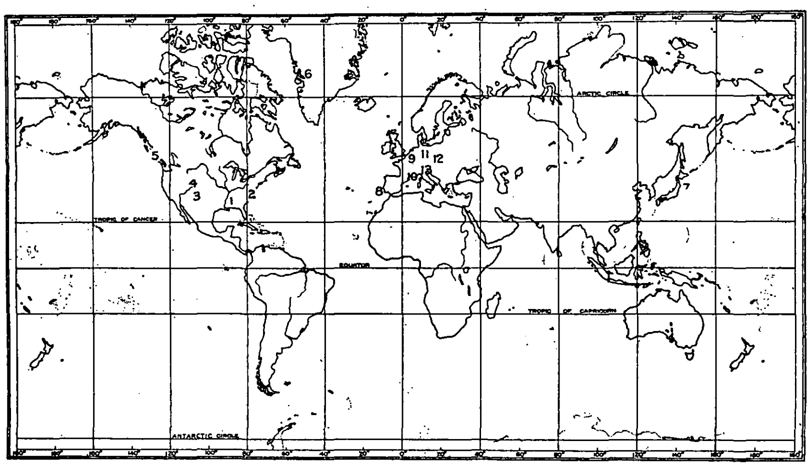


FIGURE 3.—Sketch map of the world showing the location of fossil floras that have been compared with the Ripley flora. 1, Ripley; 2, Black Creek and Magothy; 3, Vermejo; 4, Montana group; 5, Vancouver; 6, Patoot; 7, Izumi series; 8, Portugal; 9, Aix-la-Chapelle; 10, Marseille, Fuveau, and Toulon; 11, Sub-Hercynian and Westphalian; 12, Chlomeker beds of Bohemia and Silesia; 13, Gosau beds

Andromeda cretacea Lesquereux? (Ga.)
Andromeda novaecaesareae Hollick. (Tenn.)
Andromeda parlatorii Heer. (Ala.)
Andromeda wardiana Lesquereux. (Ga., Tenn.)
Androvettia elegans Berry. (Ga.)
Aralia eutawensis Berry. (Ga.)
*Araucaria bladenensis Berry. (Ga.)
*Araucaria jeffreyi Berry. (Ga.)
Bauhinia alabamensis Berry. (Ala.)
Bauhinia cretacea Newberry. (Ga.)
Brachyphyllum macrocarpum formosum Berry. (Ga.)
Cephalotaxospermum carolinianum Berry. (Ala.)

Cinnamomum heerii Lesquereux? (Ga., Tenn.)
*Cinnamomum newberryi Berry. (Ga.)
Cupressinoxylon sp. Berry. (Tenn.)
Dewalquea smithii Berry. (Tenn.)
Diospyros primaeva Heer. (Tenn.)
*Doryanthites cretacea Berry. (Ala.)
*Myrtophyllum angusta Velenovsky. (Ga.)
*Ficus crassipes (Heer) Heer. (Ga., Tenn.)
*Ficus krausiana Heer. (Ga., Tenn.)
Ficus ovatifolia Berry. (Ga., Tenn.)
*Geonomites schimperi Lesquereux. (Tenn.)
*Halymenites major Lesquereux. (Tenn.)
Juglans arctica Heer. (Ga.)
Laurophyllum elegans Hollick. (Tenn.)
Laurus plutonia Heer. (Ala.)
Magnolia boulayana Lesquereux. (Ala., Ga.)
*Magnolia capellinii Heer. (Ga.)
*Malapoenna horrellensis Berry. (Ga., Tenn.)
*Manihotites georgiana Berry. (Ga., Tenn.)
*Menispermites variabilis Berry. (Ga.)
*Myrcia havanensis Berry. (Ala., Tenn.)
Paliurus upatoiensis Berry. (Ga.)
Phragmites pratti Berry. (Ga., Tenn.)
Phyllites asplenioides Berry.
Pterospermites carolinensis Berry. (Tenn.)
Sabalites carolinensis Berry. (Tenn.)
Salix eutawensis Berry. (Ga., Tenn.)
Salix flexuosa Newberry. (Ga.)
Salix lesquereuxii Berry. (Ga.)
Sequoia ambigua Heer. (Ala.)
Sequoia reichenbachi (Geinitz) Heer. (Ala., Ga.)
*Ternstroemites ripleyensis Berry. (Tenn.)
Tumion carolinianum Berry? (Ga.)
*Zizyphus laurifolius Berry. (Ga.)

Ripley plants that have been found also at pre-Eutaw horizons and are therefore legitimately considered as probable unknown members of the Eutaw flora are

Widdringtonites reichii Ettingshausen (Heer).
Moriconia cyclotoxon Debey and Ettingshausen.
Moriconia americana Berry.
Myrica brittoniana Berry.
Leguminosites canavalioides Berry.

BLACK CREEK FLORA

The second flora of interest in this connection is the Black Creek flora of the Carolinas. This is of approximately the same age as that of the Eutaw and contributes the following elements to the Ripley flora that have not yet been discovered in the Eutaw:

Protophyllocladus lobatus Berry.
Moriconia americana Berry.
Cunninghamites elegans (Corda) Endlicher.
Myrica brittoniana Berry.
Ficus celtifolius Berry.
Celastrophyllum carolinensis Berry.
Pachystima? cretacea Berry.
Laurus atanensis Berry.
Apocynophyllum sumterensis (Berry) Berry.

These also should probably be regarded as forms which in all probability were present in the Eutaw flora but were not preserved or have not been discovered.

MAGOTHY FLORA

The Magothy flora, which is found from Marthas Vineyard to Maryland, is much larger than either the Black Creek or the Eutaw flora. The beds in which it occurs are more remote from the Ripley area geographically and also in part definitely older. It is of especial interest because in the northern Atlantic Coastal Plain the fossil plants are found in large part in the Magothy formation, which is transgressed by the Matawan formation—a marine glauconitic deposit that has yielded only two or three fossil plants—whereas in the Carolinas and the Gulf region alternation of conditions or near-shore phases of the marine formations have furnished a considerable number of fossil plants of the same general facies throughout a much greater thickness of sediments.

The Magothy flora, as at present known, consists of 195 species, many of which represent surviving Cenomanian types. A large number of these survive from the underlying Raritan formation. In 1914 I made the statement[8] that there were no known Cenomanian floras in North America, unless the Raritan flora of the East and the Washita flora of the West represented that stage of the European section, and that the post-Raritan and pre-Ripley floras of the East and the Dakota sandstone flora of the West were of Turonian age. Nothing that has come to light since this statement was written has cast any doubt upon its correctness. On the contrary, additional information serves to strengthen the opinion, and I would even be inclined to include the upper Raritan flora in the Turonian category, although the New Jersey Geological Survey still maps the Raritan formation as Lower Cretaceous. Fifteen species of the Magothy flora are found in the Ripley. None of these, however, are especially abundant or characteristic

[8] Berry, E. W., The Upper Cretaceous and Eocene floras of South Carolina and Georgia: U. S. Geol. Survey Prof. Paper 84, p. 71, 1914.

of the Magothy with the exception of certain long-lived forms like *Widdringtonites reichii*, *Cunninghamites elegans*, *Ficus krausiana*, *Ficus crassipes*, *Magnolia capellini*, and *Cinnamomum newberryi*. Elements of the Magothy that apparently became extinct before Ripley time are the numerous species of *Andromeda*, *Gleichenia*, *Hymenaea*, *Laurus*, *Liriodendron*, *Magnolia*, *Myrsine*, *Pinus*, *Podozamites*, *Quercus*, *Salix*, *Sassafras*, *Sequoia*, *Sterculia*, *Williamsonia*, and *Zizyphus*.

PATOOT FLORA

Interest in the Cretaceous Arctic floras has always been very great and is enhanced by the theoretic possibility of their representing the original center of radiation of the Upper Cretaceous angiosperms. The stratigraphy of western Greenland has rested almost entirely on the paleobotanic work of Heer, who segregated the somewhat similar lithologic series exposed there into three units—the Kome, Atane, and Patoot beds, entirely upon the evidence of their contained floras. Subsequent exploration has shown that the limits of these units are exceedingly doubtful and that although the main bodies of these three floras are distinct, the boundaries of the units are largely arbitrary. There can be no doubt that the Kome flora is Lower Cretaceous or that the Atane flora belongs in the early half of the Upper Cretaceous. The Patoot flora, which occupies a stratigraphic position between the Atane flora and that of the overlying Tertiary—Heer's Arctic Miocene—is the one that is of most interest in the present connection.

The Patoot beds of western Greenland appear to be purely a paleobotanic unit, if they really merit the term unit, because lithologically they can not be differentiated from the older Atane beds or the younger Tertiary deposits. The Patoot flora is a relatively large one, comprising about 125 species. Of this number 77 are dicotyledons, of which 7 are referred to *Quercus* and only 2 to *Myrica*, although some of the supposed oaks are certainly Myricas. Species of *Myrica*, *Cinnamomum*, and *Laurus* are identical with Ripley forms, and, in addition, the following dicotyledonous genera are represented in both floras: *Acer*, *Acerates*, *Aralia*, *Carpolithus*, *Celastrophyllum*, *Cissites*, *Ficus*, *Juglans*, *Leguminosites*, *Platanus*, *Rhamnus*, and *Zizyphus*. The Monocotyledonae number 5, and one of these—a *Potamogeton*—is close to a Ripley species.

There are 20 species of ferns in the Patoot flora, and among them species of *Raphaelia* and *Asplenium* are common to the Ripley. The conifers number 18 species and include the genera *Cyparissidium*, *Dammara*, *Cunninghamites*, *Geinitzia*, *Glyptostrobus*, *Inolepis*, *Moriconia*, *Pinus*, *Sequoia*, *Taxites*, and *Widdringtonites*. Five different species of *Sequoia* are recognized. Five of the coniferophyte genera occur in the Ripley, and the species of *Cunninghamites*, *Moriconia*, and *Widdringtonites* from the two regions are identical.

There is little in the Patoot flora to mark its occurrence 2,400 miles farther away from the Equator than the Ripley flora. A slight difference might perhaps be predicated from the absence of palms or *Artocarpus* and the abundance of conifers in the Patoot flora supplemented by the presence in the Ripley flora of such genera as *Dioscorites*, *Capparis*, *Dalbergia*, *Ternstroemites*, *Bumelia*, *Cedrela*, *Dillenites*, and *Chrysophyllum*, which are supposed to indicate a warm habitat and which are not represented at Patoot.

There has been some difference of opinion regarding the age of the Patoot flora. The associated invertebrates were classed as Senonian by De Loriol, and White and Schuchert incline to the belief that what Heer called the Patoot beds are transitional both stratigraphically and paleontologically from Cretaceous to early Tertiary. The few invertebrates of either the Atane or the Patoot beds are of slight significance, as Stanton has stated, and therefore the conclusion that these beds are somewhat near the age of the Pierre and Fox Hills of our Western States is without any satisfactory evidence, although possibly true. The flora, as perhaps overdifferentiated by Heer, appears to have a reasonable degree of homogeneity and distinctness of facies, although it contains a large number (34) of forms that are common to the Atane beds.

The flora contains 20 Dakota species, 22 Raritan species, 19 Magothy species, 8 Tuscaloosa species, and 4 Black Creek species. There are 11 species common to the Perucer beds of Bohemia and Moravia, 6 to Niederschoena, 7 to the European Turonian, 3 to Aix-la-Chapelle (Aachen) and 3 to the Westphalian Cretaceous (Campanian). Four have been identified in the Montian of Europe.

The large number of Atane species present, as well as the numerous Dakota, Raritan, and Magothy species, preclude considering the flora as young as, for example, the Laramie. It is singular, if the Patoot flora is younger than the Emscherian, that it should have so much more in common with the Cenomanian and Turonian floras than with the extensive Lower (Campanian) and Upper (Maestrichtian) Aturian floras so extensively developed in northern Germany. On the other hand, the four Montian species are not without significance. It is possible that several horizons of the Upper Cretaceous are represented in the Patoot, although this seems doubtful.

An interesting feature of similarity between the Patoot and Ripley floras is the abundance of dicotyledonous leaves with toothed margins—a feature which, according to the statistics compiled by Bailey and Sinnott, is indicative of nontropical conditions.

VERMEJO FLORA

The Vermejo flora of southeastern Colorado and northeastern New Mexico as recently monographed by Knowlton[9] comprises 108 forms—1 fungus, 5 algae, 14 ferns, 9 conifers, 5 monocotyledons, 60 dicotyledons, and 14 forms that were not specifically identified. It contains 17 species of *Ficus*, of which only one is common to the Ripley. Other prominent elements are 8 species of *Viburnum* and 5 species of *Salix*. Ferns are more numerous and varied than in the Ripley. Genera found in the Vermejo but not represented in the Ripley include *Abietites*, *Acrostichum*, *Amelanchier*, *Anemia*, *Brachyphyllum*, *Canna*, *Colutea*, *Credneria*, *Diospyros*, *Fraxinus*, *Gleichenia*, *Hedera*, *Osmunda*, *Palaeoaster*, *Phaseolites*, *Polystichum*, *Pteris*, *Pterospermites*, *Quercus*, *Sequoia*, *Viburnum*, and *Woodwardia*. The two floras have eight identical species, and doubtless there were many small or delicate forms in Vermejo time that failed of preservation or detection in the relatively coarse material in which the plant fossils occur and that would increase the number of identical forms. Probably some of the small forms and leguminous leaflets represented in the Ripley flora are due to the fact that the Ripley was a coastal flora, but aside from this environmental factor my experience indicates that in general lithified sediments are less productive in well-preserved remains or small forms than fine clays like those of the Ripley in northern Tennessee.

[9] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, pp. 242–283, 1917.

VANCOUVER ISLAND

From the Upper Cretaceous of Vancouver Island (Nanaimo, Port McNeill, Baynes Sound) and the probable extension of these beds on Protection and Newcastle islands the late Sir William Dawson recorded a considerable flora of about 80 species. These included 10 ferns, 2 cycads, 6 coniferophytes, 3 monocotyledons, two of which are fan palms, and 58 dicotyledons. Two ginkgoes are recorded, as well as six species of Ficus, and six species are referred to *Quercus*.

This flora appears to have little in common with the Ripley flora and seems to include some discordant elements, but this may be due to the lack of precision in the identification and illustration of the material.

COLORADO GROUP

The flora of the Colorado group of the western interior is, unfortunately, too imperfectly known to afford profitable comparisons. It comprises 24 species described by Knowlton from the Frontier formation of Wyoming, 2 species of fungi from the Graneros formation of Nebraska, and 18 species described by Dawson from the Mill Creek formation of British Columbia, whose age is in doubt and may be somewhat older. The Ripley flora contains no species common to these florules, nor do these in fact show any especial similarities to the pre-Ripley floras of the Atlantic Coastal Plain, so that one is forced to conclude that the similarities between the Dakota flora of the West and the Raritan, Tuscaloosa, and Magothy floras of the East were not continued through Colorado time.

MONTANA GROUP

With the florules of the Montana group the Ripley has more in common. Thus the Mesaverde formation contains 5 species common to the Ripley, the Vermejo formation contains 8, the Judith River formation 2, the Trinidad sandstone 1, the Fruitland formation 5, the Kirtland formation 1, and the Fox Hills 2.

The so-called Laramie flora as it stands in the literature is composite, and until the recent publication of the revision of these floras by Knowlton,[10] students have had difficulty in making correct evaluations. The revised list of plants from the Laramie formation of the Denver Basin as given by Knowlton[11] shows only a single species, *Myrica torreyi*, common to the Ripley. This species is a variable one that may really be composite, and in any event it does not detract from the obvious weight of the evidence, which shows that the Ripley and Laramie floras are extremely dissimilar. These differences are so great and of such a character that they indicate not regional variation but difference in age. Thus the Laramie flora contains a variety of forms prenuncial of Eocene floras, such as *Anemia*, *Anona*, *Aristolochia*, *Artocarpus*, *Ceanothus*, *Cercis*, and *Dombeyopsis*. The many species of *Ficus*, *Juglans*, *Laurus*, *Phyllites*, *Rhamnus*, *Salix*, and *Zizyphus* are all different from those of the Ripley. I conclude that the Ripley flora is of pre-Laramie age and that the Laramie of the West is represented in the Atlantic Coastal Plain by the interval between the Cretaceous and the Eocene. This conclusion, it seems to me, is as secure as it is possible to make interpretations of the past, and it is of especial interest because those who make correlation tables from the literature rather than from the study of former life have frequently correlated the Ripley with the Laramie.

JAPAN

Comparisons between the Ripley flora and those of other continents naturally are of less value than comparisons with floras of the same land mass, and this is especially true of comparisons with the floras of higher stages of the Cretaceous, because most of the foreign work has been either not done at all or else is very old and sadly in need of revision. For the first of these reasons it is not possible to compare the Ripley flora with the fossil plants of the Izumi series of Japan. The Izumi sandstones, so named from the mountain range of that name along the west coast, and beds of similar age (Upper Cretaceous) are widespread throughout Japan, in places overlying the Ryoseki series. They contain a fauna of which *Trigonia pocilliformis* Yokoyama is the most characteristic species. Fossil plants have been reported from a number of localities and are said to include *Sequoia*, *Populus*, *Salix*, *Quercus*, *Fagus*, *Platanus*, *Cinnamomum*, *Arundo*, and other genera. More detailed information regarding this exceedingly interesting flora is greatly to be desired.

PORTUGAL

Similarly in Portugal a considerable flora from beds of Senonian (probably Emscherian) age has been noticed by DeLima, but no details beyond tentative generic identifications are available. Among these the genera common to the Ripley are *Cinnamomum*, *Dammara*, *Sabalites*, *Laurus*, *Magnolia*, *Myrica*, and *Zizyphus*. Additional information regarding this flora is also greatly to be desired, as the earlier Portuguese floras of the Albian and Cenomanian and still older Cretaceous show such a striking parallelism with those of our Atlantic Coastal Plain.

GERMANY

A full account of what is known of the flora of the sands of Aix-la-Chapelle and near-by regions across the border of Rhenish Prussia was published in 1916.[12] The age of this flora is somewhat uncertain, but it is of note in that it contains six species common to the Ripley—three ferns, two conifers, and a dicotyledon—and three of these are also common to the Patoot beds of western Greenland.

A considerable number of fossil plants have been described from the Harz region (sub-Hercynian) and Westphalia in Germany, but their resemblances to those of the Ripley are on the whole not especially close. Fossil plants are not uncommon in the Emscherian of the Saxon-Bohemian border region (Chlomeker beds). In addition to more or less worthless remains, 32 species, mostly well characterized, have been described, and these

[10] Knowlton, F. H., The Laramie flora of the Denver Basin: U. S. Geol. Survey Prof. Paper 130, 1922.
[11] Idem, pp. 95–96.
[12] Berry, E. W., Maryland Geol. Survey, Upper Cretaceous, pp. 266–271, 1916.

include two, *Cissites crispus* and *Myrtophillum angustum*, that are common to the Ripley.

GOSAU FLORA

The Gosau beds of the Tyrol and eastern Alps contain fossil plants at a number of localities, as at St. Wolfgang, Wiener-Neustadt Brandenberg, and Grünbach. These are of interest because the Gosau beds, in part at least, are the equivalent of the Ripley. The published list of species is small and shows no especial affinities with Ripley forms, but much undescribed material from Grünbach is reported by Krasser to include a number of Ripley genera.

FRANCE

Plant-bearing deposits at a number of localities in southeastern France—namely, the Turonian near Marseille (Var), the Emscherian of Beausset, near Toulon (Var), and the Aturian lignites of Fuveau (Bouches-du-Rhône)—are of interest in the present connection, though here again the floras have not been adequately described. The chief similarities to the Ripley are to be found in the Turonian, which contains two identical species, *Euphorbiophyllum antiquum* and *Widdringtonites reichii*, and a number that are similar—for example, in *Araucaria*, *Artocarpus*, *Dryophyllum*, *Menispermites*, and *Myrica*. This resemblance does not indicate identity in age, as the known Turonian floras of Europe are more closely allied to the Eutaw and Black Creek floras of North America, but it is of importance in preventing the assignment of a too young age to the Ripley.

With the European floras referred to the Montian stage the Ripley flora has nothing in common.

BEARING ON CORRELATION

Long-distance correlations are obviously uncertain, particularly if they are intercontinental, and although experience has shown that the march of evolution of the Upper Cretaceous floras was remarkably parallel in North America and Europe, the absence of reliable data at present from the European region renders precise comparisons out of the question. After a careful consideration of the evidence available I am of the opinion that the Ripley flora is of Emscherian age, although it might be as young as the Campanian substage of the Aturian. I am strongly of the opinion that it is not as young as the Maestrichtian or upper substage of the Aturian. As regards our western Cretaceous section the Ripley flora indicates contemporaneity with the Montana group. More precise correlation is not possible at the present time.

The appended table shows the members of the Ripley flora that have an outside distribution, with the occurrence and range of each. It serves as a basis and graphic summary of the preceding discussion.

Ripley plants found in other formations

	Eutaw formation	Black Creek formation	Magothy formation	Tuscaloosa formation	Raritan formation	Woodbine sand	Bingen sand	Dakota sandstone	Benton formation	Kirtland shale	Fruitland formation	Fox Hills sandstone	Mesaverde formation	Vermejo formation	Montana group	Laramie formation	Post-Laramie deposits	Eocene	Cenomanian	Turonian	Emscherian	Santonian or Campanian
Selaginella laciniata															×							
Asplenium calopteris																						×
Raphaelia neuropteroides																						×
Monheimia aquisgranensis																						×
Protophyllocladus lobatus		×	×																			
Widdringtonites reichii			×	×	×			?											×			
Moriconia cyclotoxon			×		×																	×
Moriconia americana		×	×																			
Geinitzia formosa			×	×	×						×		×	×	×							×
Araucaria bladenensis	×	×	×																			
Araucaria jeffreyi	×	×																				
Cunninghamites elegans		×	×		×										×				×		×	
Dammara acicularis															×							
Doryanthites cretacea	×	×	×																			
Geonomites schimperi	×																	?				
Juglans similis														×								
Myrica johnstrupi																						
Myrica torreyi											×	×	×	×		×	×					
Myrica brittoniana		×	×																			
Salix gardneri														×								
Dryophyllum gracile																					×	×
Ficus krausiana	×	×	×	×															×	×		
Ficus crassipes	×	×	×	×			×	×														
Ficus celtifolius		×																				
Ficus leei										×	×			×								
Liriodendron laramiense													×									
Magnolia capellini	×	×	×	×				×											×			
Menispermites variabilis	×																					
Leguminosites canavalioides			×																			
Euphorbiophyllum antiquum																				×		
Manihotites georgiana	×	×					×															
Celastrophyllum carolinensis		×																				
Pachystima? cretacea		×																				
Cissites crispus																					×	
Cissites panduratus														×								
Zizyphus laurifolius	×																					
Ternstroemites ripleyensis	×																					
Cinnamomum newberryi	×	×	×	×	×	?		×														
Malapoenna horrellensis	×	×																				
Laurus atanensis		×	×					?														
Laurus asiminoides													×		×							
Laurus coloradensis											×			×								
Laurophyllum ripleyensis											×											
Myrcia havanensis	×																					
Myrtophyllum angustum	×	×																	×			
Apocynophyllum sumterensis		×																				
Halymenites major	×								×			×	×	×			×	×				

SYSTEMATIC DESCRIPTIONS

Phylum LEPIDOPHYTA?

Order LYCOPODIALES?

Family SELAGINELLACEAE?

Genus SELAGINELLA Beauvois?

Selaginella laciniata Lesquereux

Selaginella laciniata Lesquereux, U. S. Geol. and Geog. Survey Terr. Bull., vol. 1, p. 378, 1875; U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1874, p. 297, 1876; idem for 1876, p. 499, 1878; Tertiary flora, p. 47, pl. 64, figs. 12, 12a, 1878.

Knowlton, F. H., U. S. Geol. Survey Bull. 163, p. 24, pl. 3, figs. 5–8, 1900.

This species is described as follows by Knowlton:

> Branches regularly, pinnately arranged at right angles to the main rachis; leaves (?) close, two-ranked, deeply laciniate; laciniae linear, slightly inflated toward the point, either simple from the base or dichotomous.

This species was described by Lesquereux from material collected by the Hayden Survey at Point of Rocks, Wyo. Subsequently Knowlton obtained more complete material from this same locality, which is referred to the Montana group. Both of these authors clearly recognize the uncertain botanic relationship of these fossils, seeking comparisons with algae and various Lycopodiales. Identical but less complete material is not uncommon in the Ripley formation of western Tennessee. It appears to me to represent a vascular plant, but I am unable to reach any positive conclusions on this point and therefore retain it under the name originally given by Lesquereux, as it constitutes a factor in the geologic correlation of the Upper Cretaceous of the Atlantic Coastal Plain and that of the western interior. At the same time it should be emphasized that the reference of this form to the genus *Selaginella* is entirely problematic and in my judgment entirely without foundation.

Occurrence: McNairy sand member of the Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Phylum PTERIDOPHYTA

Order FILICALES

Genus ASPLENIUM Linné

Asplenium calopteris (Debey and Ettingshausen) Heer

Plate I, figures 9, 10

Benizia calopteris Debey and Ettingshausen, K. Akad. Wiss. Wien Denkschr., Band 17, p. 216 (36), pl. 5, figs. 13–17, 1859.

Asplenium calopteris Heer, Flora fossilis arctica, vol. 7, p. 5, pl. 48, figs. 5a, 6a, 6b, 7, 8, 1883.

This species was characterized as follows by Debey and Ettingshausen:

> Fronde sterili bi-v. tripinnata, pinnis inferioribus patentissimis, summis subarrectis, strictis v. subflexuosis, regulariter alternis, lineari-lanceolatis, 1–3 centim. circiter longis, decrescenti pinnatis; pinnulis sessilibus, discretis v. basi connatis, patentibus v. subarrectis, ovato-rotundatis v. ovato-oblongis, integerrimis, apice rotundatis, subalternis, confertis, 2–4 millim. longis, 1½–2 millim. latis, summis pinnatifido-lobatis, terminali minima sinuato-rotundata vix discreta; fronde fertili pinnulis vel lobis latioribus, bullatodilatatis inaequalibus steriles magnitudine superantibus; soris ovalibus vel subrotundis, minimis [?].

This species was described from specimens obtained in the Upper Cretaceous of Aix-la-Chapelle (Aachen) in Rhenish Prussia and was subsequently identified by Heer in material from the Patoot beds of western Greenland. Both identifications were based upon more complete material than that found in the Ripley formation of Tennessee. The Ripley material shows tiny leathery rounded connate pinnules, exactly like some of those figured by Debey and Ettingshausen and by Heer. In some specimens the branches from the midvein are simple, but as a rule they are once forked. A wide band along the rachis and branches following the midvein, and the basal subsidiary veins on the distal side show a thick mass of coaly material that suggests some forms of asplenoid fructifications. Microscopic preparations fail to show any traces of structure or spores, and this peculiar appearance may merely represent the enlarged proximal portion of the veins and an exceedingly large and flattened rachis.

Small fragments lacking fructifications are especially liable to be confused with *Gleichenia*, but these and the foliar habit are strikingly different.

Occurrence: McNairy sand member of the Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Genus RAPHAELIA Debey and Ettingshausen

Raphaelia neuropteroides Debey and Ettingshausen

Plate I, figure 8

Raphaelia neuropteroides Debey and Ettingshausen, K. Akad. Wiss. Wien Denkschr., Band 17, p. 220 (40), pl. 4, figs. 23–28; pl. 5, figs. 18–20, 1859.

Heer, Flora fossilis arctica, vol. 7, p. 6, pl. 60, figs. 3, 3b, 1883.

The sponsors for this species described it in the following terms:

R. fronde bi-v. tripinnato-pinnatifida; rhachibus strictis v. apice subflexuosis, subteretibus; pinnis appositis v. subappositis, patentibus v. arrecto-patentibus, remotis, strictus v. saepius arcuatis, subflexuosisque; pinnulis suboppositis v. alternis, superioribus sessilibus v. subsessilibus v. liberis v. pinnatifido-lobatis, inferioribus petiolatis, e basi cordata v. subcordata ovatis v. ovato-oblongis, integerrimus v. saepius sinuatis v. sinuato-lobatis v. pinnatipartitis ad pinnarum ordinem novum tendentibus, apice obtusis; nervo medio apicem versus tenuissimo flexuoso; nervis secundariis tenuibus, plus minus profunde iteratimque furcatis, summis simplicibus.

The material from the Ripley that is referred to this species is scanty but shows fragments of thin pinnatifid pinnae exactly like those from the Patoot beds of Greenland which Heer referred to this species. Comparison with Debey and Ettingshausen's figures of type material from the sands of Aix-la-Chapelle is less satisfactory, as their material was very fragmentary and they included in this species a considerable variety of forms, some with a neuropteroid base, as the above-quoted diagnosis indicates. Whether the original species is composite can not be determined.

The Greenland and Tennessee materials are also very similar to specimens from the Bohemian Cretaceous which Bayer [13] described as *Gymnogramme bohemica*.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, and Cooper pit, near Hollow Rock, Carroll County, Tenn.

[13] Bayer, Edwin, Einige neue Pflanzen der Perucer Kreideschichten in Böhmen, p. 45, text fig. 14, pl. 2, fig. 2, 1899. Frič, Anton, and Bayer, Edwin, Naturwiss. Landesdurchforschung Böhmen Archiv, Band 11, p. 70, text fig. 6, 1901.

Raphaelia minuta Berry, n. sp.

Plate I, figures 5–7

Fronds small and lax, probably bipinnate. Rachis feeble, winged. Pinnae ovate, variable, 6 to 8 millimeters in length, divided into three to seven pinnule-like divisions of irregular ovoid form, the proximal ones sublobate, the distal ones usually becoming narrower and simpler but sometimes remaining united to form a sphenoid sublobate apical segment. Veins thin, dichotomous, flabellate. Separating sinuses narrow. Midvein conspicuously winged. Texture thin but not meriting the term membranaceous. No traces of fructification.

This species appears to be entirely distinct from previously described forms. It is based upon a small amount of material, without clearly defined generic characters, so that it has seemed proper to refer it to the form genus *Raphaelia*, proposed by Debey and Ettingshausen in 1859 for fern remains from the Upper Cretaceous sands of Aix-la-Chapelle. Its minuteness and lax character are somewhat suggestive of some of the Hymenophyllaceae, as, for example, *Hymenophyllum australe* Willdenow, but in my judgment it is not a filmy fern. It might also be compared with a variety of existing ferns in the genera *Cystopteris*, *Pleurosorus*, *Woodsia*, and *Asplenium*, as well as in other and unrelated genera. In the absence of fruiting characters there is little profit in extended comparisons based merely on form. In some respects it seems most suggestive of a variety of both fossil and modern forms that have been referred to *Asplenium*, and I do not doubt that it is an Upper Cretaceous member of the family Polypodiaceae and probably of the tribe Asplenieae, which appear to have been abundant and varied during Upper Cretaceous time and many species of which are represented by fruiting material. The most similar fossil form, identical except for its greater regularity of outline, is *Asplenium tenellum* Knowlton,[14] which comes from the Montana group of the West.

Occurrence: McNairy sand member of the Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

[14] Knowlton, F. H., Flora of the Montana formation: U. S. Geol. Survey Bull. 163, p. 19, pl. 3, figs. 1, 2, 1900.

Genus MONHEIMIA Debey and Ettingshausen

Monheimia aquisgranensis Debey and Ettingshausen

Plate I, figures 1, 2

Monheimia aquisgranensis Debey and Ettingshausen, Die urweltlichen acrobryen Kreidegebirges Aachen: K. Akad. Wiss. Wien Denkschr., Band 17, p. 211 (31), pl. 4, figs. 3–10, 1859.

The following is the original description of this species:

M. fronde bipinnatipartita vel pinnatisecta, laciniis arrecto-patentibus vel arrectis, alternis, remotis, decurrentibus, lineari oblongis, anguste frondosis, 1–3 millim. circiter longis, 1½–5 millim. latis, apice acuminatis, integerrimis; rhachibus costisque longe flexuosis, tenuibus, glabris, subteretibus; soris in summitatibus laciniarum copiosis, maximam frondis angustae laminam tegentibus, a costa mediana remotioribus subhaemisphaericis.

Although it is true that Debey and Ettingshausen describe sori which they take to indicate a polypodiaceous affinity, and no traces of sori are seen in the Tennessee material, they were inclined to see and idealize fructifications in poorly preserved material from Aix-la-Chapelle and in other material where such features were nonexistent, as for example in the gymnosperm *Moriconia*, so that in the absence of actual specimens one may well doubt the accuracy of both descriptions and figures.

The Tennessee material is scanty, and I have no opinion to offer regarding its botanic affinity. It would be without interest were it not for the significance attached to the appearance on both sides of the Atlantic at about the same time of a variety of identical plant fossils, of which this is a peculiar example, that have not been detected in the antecedent rocks of either region. The present species also shows similarities to the figures of another from Aix-la-Chapelle which Debey and Ettingshausen call *Zonopteris goepperti*, but as that form is based exclusively on what is said to be fertile material and is described as having a crenate margin, the American material is considered to be that of *Monheimia*. It may well be questioned if a number of specific and generic distinctions in the classic paper by these authors are not more finely drawn than the facts warrant.

In the Tennessee material referred to *Monheimia* the venation is well preserved and consists of relatively stout veins that are invariably forked. There may be a single fork, as in the region of the sinus, but normally a vein detaches itself from the midvein at a very acute angle, ascending for some distance and after giving rise to two branches turning sharply outward and proceeding to the margin in a course parallel with that of the two branches. The lamina is not strictly linear but expands slightly distad.

Occurrence: McNairy sand member of the Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Genus TAENIOPTERIS Brongniart

Taeniopteris sp.

Plate I, figures 3, 4

In the collection from the Cooper pit, near Hollow Rock, there are several fragments of the lamina of a linear frond, pinna, or pinnule, which are readily recognizable and yet too incomplete for adequate diagnosis. They are of a coriaceous texture and range from 1 to 1.6 centimeters in width, with a fairly prominent midvein, which is not more prominent on either the upper or lower surfaces. The laterals are stout, largely immersed in the leaf substance; they diverge from the lateral margins of the midvein at wide angles, forking once almost immediately, and proceed in parallel courses to the margins. Weathering of the thick substance of the lamina often gives the appearance of a crenate margin, but I have satisfied myself that the margins are entire.

The question of the generic reference is one on which opinions will differ. Knowlton [15] has referred similar but somewhat larger fragments from the Montana group of Wyoming to *Asplenium*, but it seems better to refer the present material to *Taeniopteris*, which is after all a form genus without any especial significance regarding botanic relationship.

By Brongniart's definition [16] the present fragments belong in *Taeniopteris*. Heer [17] described a *Taeniopteris deperdita* from the Upper Cretaceous of Greenland, but this was based on an uncertain fragment which is at

[15] Knowlton, F. H., Flora of the Montana formation: U. S. Geol. Survey Bull. 163, p. 20, pl. 3, fig. 11, 1900.

[16] Brongniart, A. T., Prodrome d'une histoire des végétaux fossiles, p. 61, 1828.

[17] Heer, Oswald, Flora fossilis arctica, vol. 7, p. 8, pl. 48, fig. 14, 1883.

least specifically different from the Tennessee specimens. These are not dissimilar to *Marattia cretacea* from the Upper Cretaceous of Bohemia, described by Velenovsky.[18] There is also some resemblance to an entire-margined *Nilsonia*, as, for example, *Nilsonia bohemica*, from the Upper Cretaceous of Bohemia, described by Velenovsky,[19] but this resemblance is purely superficial, as *Nilsonia* has simple veins and the lamina at the top of the rachis.

Occurrence: McNairy sand member of the Ripley formation, Perry place, Henry County, and Cooper pit, near Hollow Rock, Carroll County, Tenn.

Family POLYPODIACEAE

Genus DRYOPTERITES Berry

Dryopterites stephensoni Berry

Dryopterites stephensoni Berry, U. S. Geol. Survey Prof. Paper 84, p. 103, pl. 17, figs. 1, 2, 1914.

This species is fully described in the publication cited above, and it has not been discovered outside of the type locality.

Occurrence: Cusseta sand member of Ripley formation, cut on Central of Georgia Railway 1½ miles northeast of Byron, Houston County, Ga.

Phylum CONIFEROPHYTA

Order CONIFERALES

Genus PROTOPHYLLOCLADUS Berry

Protophyllocladus lobatus Berry

Thinnfeldia n. sp. Berry, Johns Hopkins Univ. Circ., new ser., No. 7, 1907, p. 81.

Protophyllocladus lobatus Berry, Torrey Bot. Club Bull., vol. 38, 1911, p. 403; U. S. Geol. Survey Prof. Paper 84, p. 17. pl. 2, figs. 9–13, 1914.

The present record is based on a few fragments in the Ripley formation of Tennessee. The species was originally described from rather complete material from the Middendorf arkose member of the Black Creek formation in South Carolina. Following is a quotation of the original description:

Leaves (phylloclads) of large size, lanceolate or oval in general outline, either entire with crenate margins, rounded apex, and narrowly cuneate base or compound through the development of opposite lateral lobes. Axial vascular strand very stout below, becoming very thin and finally disappearing by repeated branching apically. When the leaves are lobate, subordinate opposite vascular strands form the axis of the lobes, and these also are generally but not invariably lost before reaching the tips of the lobes by giving off innumerable secondary branches. Margins in all specimens are rather remotely undulate-crenate, and the tips are all rounded. Secondaries numerous and thin, diverging from the main axis of the phylloclad or the axis of the lobes at very acute angles, curving outward, some simple but many dichotomously forked, and a few several times forked. Lobes when present are separated by cuneate, narrowly rounded sinuses which terminate some distance from the main axis. The largest specimen, which is still incomplete both at the apex and at the base, measures 8 centimeters in length and 5 centimeters from tip to tip of the lower lobes, the entire upper portion measuring about 1.5 centimeters in width.

These remains are superficially like fern fronds, especially in specimens which are compound, and were it not for the presence in the Cretaceous of other *Phyllocladus*-like remains with a demonstrated gymnospermous structure (for example, *Androvettia*) their reference to this genus would seem hazardous. The entire specimens are strikingly like some of the forms of *Protophyllocladus subintegrifolius* (Lesquereux) Berry, of the Raritan and Magothy formations, or like *Protophyllocladus polymorphus* (Lesquereux) Berry, from higher western American horizons, and even the compound specimens have an unlobed apical portion of comparable length which is also similar in appearance to the two species just mentioned. The compound forms are superficially like *Thinnfeldia rhomboidalis* Ettingshausen,[20] the type of the genus *Thinnfeldia*, whose systematic position has been the occasion of so much controversy and which has been variously regarded as a fern, as a cycad, and as a conifer. The present species shows important differences, however, aside from being much younger, and it is confidently believed to be unrelated to the various older Mesozoic species of *Thinnfeldia* which have been described.

It may also be compared with various forms from the Upper Cretaceous of Dalmatia discussed at great length by Kerner,[21] who refers them to the genus *Pachypteris*, which he regards as cycadaceous in nature.

The present species is believed to be closest to *Protophyllocladus subintegrifolius*, a species which is abundant in the Atane beds of Greenland, the Dakota sandstone of Kansas and Nebraska, the Raritan formation of New Jersey, and the Magothy formation from Marthas Vineyard to New Jersey, and which commonly assumes a sublobate form. This is especially shown in unreported collections made by the writer in the Magothy formation of New Jersey.

[18] Velenovsky, Josef, Farne der böhmischen Kreideformation, p. 9, pl. 1, fig. 13, 1888.

[19] Velenovsky, Josef, Gymnospermen der böhmischen Kreideformation, p. 11, pl. 2, figs. 25–28, 1885.

[20] Ettingshausen, C. von, K.-k. geol. Reichsanstalt Abh., vol. 1, pt. 3, No. 3, p. 2, pl. 1, figs. 4–7, 1852.

[21] Kerner, F. von, K.-k. geol. Reichsanstalt Jahrb., vol. 45, p. 39, 1896.

No new light is shed upon the habit or systematic position of the genus by the meager amount of material in the collection from Tennessee.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Genus WIDDRINGTONITES Endlicher

Widdringtonites reichii (Ettingshausen) Heer[22]

Frenelites reichii Ettingshausen, Kreideflora von Niederschoena, p. 12 (246), pl. 1, figs. 10a–10c, 1867.

Widdringtonites reichii Heer, Flora fossilis arctica, vol. 6, Abt. 2, p. 51, pl. 28, fig. 5, 1882.

Berry, Maryland Geol. Survey, Upper Cretaceous, p. 793, pl. 55, fig. 1, 1916.

Medium-sized branches with more or less crowded, slender, elongated fastigiate twigs, bearing reduced ovate-subulate leaves, spirally arranged. Both microsporangiate and megasporangiate cones have been found. The cones are small oval bodies 5 to 12 millimeters long by 3 to 7 millimeters in diameter, usually poorly preserved, said by Ettingshausen to be axillary in position but evidently often terminal, as evinced by some of the Raritan material and by some of the better-preserved cones from the Cenomanian of Bohemia and Moravia. The latter material clearly shows that the cones consisted of four scales. This would ally it either with the subgenus *Widdringtonia* of the genus *Callitris* Ventenat, to which Eichler in his treatment of the living species in Engler and Prantl (1887) refers Endlicher's genus, or to the subgenus *Eucallitris* Brongniart, which also is characterized by four cone scales. *Eucallitris* has a single living species of northern Africa, and *Widdringtonia* has three or four species of southern Africa and Madagascar. The propriety of Eichler's classification may well be questioned, and in any event paleobotanists must necessarily prefer the older segregation of *Frenela* and *Widdringtonia* and their respective form genera.

There seems to be little doubt that the present species should be referred to *Widdringtonia*, as Velenovsky and Krasser have done. but as the term *Widdringtonites* is equally indicative of its true affinity, little is to be gained by making the proposed change.

This species, which is not rare in the Ripley formation of western Tennessee, is probably the most common conifer of the Raritan formation. It was described originally by Ettingshausen from the Cenomanian of Niederschoena, in Saxony, as a species of *Frenelites*. When Heer discovered it in the Greenland material, where it has been collected from both the Atane and the Patoot beds, he transferred it to the present genus. It has subsequently been reported from the Cenomanian of Bohemia and Moravia, from the Magothy formation at numerous localities, and from the southern New England islands. It has also been reported from the Tuscaloosa formation of Alabama, where it is abundant at a number of localities, and is apparently represented in the Dakota sandstone by the remains which Lesquereux referred to *Glyptostrobus*.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, a quarter of a mile west of Buena Vista, Carroll County, Tenn.

Genus MORICONIA Debey and Ettingshausen

[K. Akad. Wiss. Wien Denkschr., Band 17, p. 239, 1859]

Leafy twigs, apparently deciduous in habit, bifacial, phylloclad-like, made up of decussate 4-ranked leaves, those on the flat faces rounded, those folded at the margins pointed, the whole resulting in a strictly geometric pattern. No traces of fructifications known.

The type of the genus was described in 1859 by Debey and Ettingshausen in their account of the ferns from the sands of Aix-la-Chapelle. They considered *Moriconia* a fern, as did Heer the first specimens collected from Greenland, and there is no doubt that specimens in which the outlines of the leaves are indistinct are very fernlike in appearance. Saporta pointed out the coniferophyte nature of this genus in 1868, comparing it with *Libocedrus* and *Thuiopsis*,[23] and most subsequent authors, including Schenk, Newberry, and Lange, have referred the genus to the Cupressinaceae. Two species have been recognized, although the differences between them are slight. Heretofore these two forms have never been found associated, and this fact

[22] The extensive synonymy of this species has been given in several recent publications and need not be repeated.

[23] Saporta, Gaston de, Soc. géol. France Mém., 2d ser., vol. 8, p. 301, 1868.

largely influenced their separation. Now, however, both forms are known to occur at the same horizon in the Ripley formation of Tennessee—at a single locality in the McNairy sand member. There seems to be little doubt that these two expressions of *Moriconia* habit represent the same or closely related species and that the differences are due to the relative age or position of the twigs. They certainly do not represent either chronologic or geographic variations. At the same time the two forms are strikingly unlike in appearance, and after mature consideration it seems best to emphasize this difference in appearance by different names, as it seems probable that the larger mutants are progressing in the direction of the genus *Androvettia*.

Moriconia cyclotoxon Debey and Ettingshausen

Plate III, figures 1, 2

Moriconia cyclotoxon Debey and Ettingshausen, K. Akad. Wiss. Wien Denkschr., Band 17, p. 59, pl. 7, figs. 23–27, 1859.
Heer, Flora fossils arctica, vol. 6, Abt. 2, p. 49, pl. 33, figs. 1–9b, 1882; idem, vol. 7, p. 11, pl. 53, fig. 10, 1883.
Lange, Deutsche geol. Gesell. Zeitschr., Band 42, p. 665, pl. 33, fig. 4, 1890.
Schenk, Palaeophytology, p. 318, fig. 220, 1890.
Newberry, U. S. Geol. Survey Mon. 26, p. 55, pl. 10, figs. 11–22, 1896.
Hollick, New York Acad. Sci. Annals, vol. 11, p. 57, pl. 3, fig. 10; p. 418, pl. 37, fig. 8, 1898; U. S. Geol. Survey Mon. 50, p. 46, pl. 3, figs. 16, 17, 1907.
Berry, New Jersey Geol. Survey Bull. 3, p. 86, pl. 8, figs. 3–6, 1911.
Pecopteris kudlisetensis Heer, Flora fossilis arctica, vol. 3, Abt. 2, p. 97, pl. 26, fig. 18, 1874.

Twigs of somewhat varying size and proportions, consisting of a thick central axis, bearing two strictly opposite rows of more or less reduced or extended, abruptly pointed lateral twigs, the whole covered with closely appressed decussate leaves, those on the faces short and evenly rounded, those terminating at the margins slightly longer and pointed. Substance not at all thickened, as in the genus *Brachyphyllum*, but thin, although not as thin as in the allied species *Moriconia americana*.

The material from the Ripley formation of Tennessee shows long, slender forms like the larger one figured, in which the narrow lateral twigs are only about 2 millimeters in width and 10 to 12 millimeters in length, proximad with seven cycles of leaves. They decrease somewhat in length upward and then increase considerably, so that distad they have a length of 17 millimeters and show about 12 cycles of leaves. A detached fragment of this form from the locality in Henry County, also figured, has similar narrow lateral twigs, but these are about 3 centimeters in length with 17 or 18 cycles of leaves. In all the material the leaf covering of the main axis, though present in juvenile forms, is less markedly developed than in *M. americana* and tends to become obliterated both by age and by fossilization, so that it is rarely preserved in detail as in that species, although its character is well shown in some of the specimens from the Raritan formation of New Jersey figured by Newberry.

The species was described originally from specimens obtained in the sands of Aix-la-Chapelle (Aachen), and its superficial resemblance to a fern, especially when poorly preserved, led Debey to insist always on its fern nature. Similarly the first specimens discovered by Heer in the Greenland Upper Cretaceous were described as a species of *Pecopteris*. There can be no doubt, however, of its gymnospermous nature.

Subsequently the species was recorded from the Saxon Cretaceous (Turonian?), from the Atane beds (Cenomanian) and Patoot beds (Turonian or Emscherian) of Greenland, from the Raritan formation (Cenomanian) of New Jersey and Staten Island, and from the Magothy formation (Turonian) of Block Island. It has not been found elsewhere in our Atlantic Coastal Plain until its recent discovery in the Ripley formation of western Tennessee, in beds which I regard as probably Emscherian in age. There has been considerable difference of opinion regarding the equivalents in the western United States and in Europe of the Coastal Plain Upper Cretaceous formations, invertebrate paleontologists leaning to the view that they were younger than the paleobotanic evidence seemed to admit.

From its bearing upon the place of origin and Upper Cretaceous dispersal of floras the determination of the oldest horizon at which *Moriconia cyclotoxon* has been found is a matter of considerable interest. This, it seems to me, is in the Atane beds of western Greenland. These beds were fully discussed by Heer, who considered them the equivalent of the Cenomanian of Europe. The few poorly preserved invertebrates associated with the plants are stated by White and Schuchert [24] to indicate strongly an equivalence with the Pierre and Fox Hills of the western United States and with the Senonian of Europe. This is not the place for an analysis of this statement, but it would seem that a decided paleozoologic opinion might well await the discovery of a representative fauna, and that meanwhile the evidence of a flora of 182 fossil plants, 36 of which are common to undisputed Cenomanian localities in Europe (Bohemia, Moravia, and Saxony), might be considered as having some bearing on the question. Although dogmatism is to be deprecated, I can not conceive that the general relations of these floras permit their being considered younger than Turonian, and in any event the present species of *Moriconia* fully confirms the generally accepted notion of a northern origin and southward migration of these earlier Upper Cretaceous floras.

As yet no traces of *Moriconia* have been found in the abundant plant beds of the Upper Cretaceous of the western interior of North America nor in the upper Cretaceous of eastern Asia, recently differentiated on Sakhalin Island by Kryshtofovich. The specimens from the Atane beds figured by Heer in 1882 show considerable variation, particularly the very great extension of some of the lateral twigs shown in his Plate XXXIII, Figure 4, where they are twice as long as the balance of the laterals on the same branch. His Figure 2 on the same plate shows a form of branching not observed in the rest of the *Moriconia* material and remotely suggests a comparison with the supposed staminate aments of *Androvettia.* It is true that as drawn by Heer this small lateral cluster has the same form and arrangement of parts as the normal *Moriconia* twig, but Heer was notoriously careless about detail and in illustrating poorly preserved material often supplied the deficiency of the specimen, and in this case he might well have assumed the presence of the central axis and regularly decussate leaves, whereas this branch may really have been like those of *Androvettia* that have been considered to represent staminate sporophylls.

[24] White, David, and Schuchert, Charles, Cretaceous series of the west coast of Greenland: Geol. Soc. America Bull., vol. 9, p. 366, 1898.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, and Cooper pit, near Hollow Rock, Carroll County, Tenn.

Moriconia americana Berry

Plate III, figures 3, 4

Moriconia americana Berry, Torrey Bot. Club Bull., vol. 37, pp. 20, 186, 1910; U. S. Geol. Survey Prof. Paper 84, p. 26, pl. 7, figs. 1–4, 1914; Maryland Geol. Survey, Upper Cretaceous, p. 802, pl. 56, fig. 1, 1916.

Moriconia cyclotoxon Berry, New York Bot. Garden Bull., vol. 3, p. 65, pl. 43, fig. 4; pl. 48, figs. 1–4, 1903 [not Debey and Ettingshausen]; Torrey Bot. Club Bull., vol. 31, p. 70, 1904, vol. 33, pp. 165–167, 1906.

Leafy twigs, consisting of a main axis and short, reduced, lateral branches of decussate leaves. Along the main axis on each flat face of the branch these leaves are relatively and closely appressed, with a narrow base and a broad semicircular apex. The corresponding lateral pairs of leaves are thin and pointed and transversely compressed. In the axis of each of these marginal leaves is a reduced branch flattened in the same plane as the main branch, so that the whole arrangement is strictly opposite and distichous. These reduced lateral branches have leaves of the same character and arrangement as those of the main branch. The bifacial leaves are, however, somewhat smaller and blunter, and the marginal leaves are broader and less acute. They become rapidly smaller distad, it usually requiring not more than five or six pairs to complete the blunt lateral reduced twigs. The main vascular axis is stout, but that of the lateral twigs is thinner and much less prominent. The leaves fail to show any veins. The texture was apparently coriaceous but obviously thin in most of the specimens. The Tennessee material shows evidence of a slight thickening along the keel toward the apex of the lateral leaves and along the truncated margin of the bifacial leaves. The leaves are concrescent, and the lowermost lateral of each subordinate twig has disappeared on the distal side, its position being occupied by the long and narrow marginal of the main axis. The great majority of specimens have extremely reduced lateral twigs, but in the specimen of this species from the Magothy formation of New Jersey these laterals are extended and reach a length of 3 centimeters and a width of 9 millimeters and consist of eight or nine pairs of leaves.

Moriconia americana is known only from the Atlantic Coastal Plain, having been found previously in the Magothy formation of New Jersey, Delaware, and Maryland; the Black Creek formation of North Carolina; and the Middendorf arkose member of the Black Creek formation of South Carolina. The occurrence in the Ripley formation of Tennessee greatly extends its range, both geographic and geologic, and indicates its probable occurrence in the intervening region between South Carolina and Tennessee, as well as in the intermediate Eutaw formation, but it has not yet been found at this horizon or in these regions. *Moriconia*, especially *M. americana*, is strikingly like the genus *Androvettia* in vegetative habit. Three species are known in *Androvettia*, of which one has furnished structural material and two show what is either a curious dimorphism or strobilar habit. It would require but a further reduction of the lateral twigs of *Moriconia americana* and the resulting obliteration of leaf outlines to reach a form like that of *Androvettia elegans* Berry, and from this type by continued reduction we arrive at *A. statenensis* Hollick and Jeffrey and finally reach *A. carolinensis* Berry, which is the most reduced and phylloclad-like of the whole series.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Genus GEINITZIA Endlicher

Geinitzia formosa Heer[25]

Geinitzia formosa Heer, Zur Kreideflora von Quedlinburg: Schweizer. paleont. Gesell. Neue Denkschr., Band 24, p. 6, pl. 1, fig. 9; pl. 2, 1871.
Newberry, U. S. Geol. Survey Mon. 26, p. 51, pl. 9, fig. 9, 1896.
Hollick, New York Acad. Sci. Trans., vol. 16, p. 129, pl. 12, figs. 1, 2, 1897.
Knowlton, U. S. Geol. Survey Bull. 163, p. 28, pl. 5, figs. 1, 2, 1900; U. S. Geol. Survey Prof. Paper 98, p. 333, pl. 85, fig. 3, 1916; U. S. Geol. Survey Prof. Paper 101, p. 251, pl. 31, figs. 1–3, 1918.
Berry, New York Bot. Garden Bull., vol. 3, p. 57, 1903; Torrey Bot. Club Bull., vol. 31, p. 68, pl. 4, figs. 2, 3, 1904; New Jersey Geol. Survey Bull. 3, p. 97, 1911; Maryland Geol. Survey, Upper Cretaceous, p. 801, pl. 54, fig. 6, 1916; U. S. Geol. Survey Prof. Paper 112, p. 61, 1919.
Geinitzia sp. Newberry, New York Lyc. Nat. Hist. Proc., vol. 2, p. 10, 1873.
Sequoia reichenbachi Lange (in part), Deutsche geol. Gesell. Zeitschr., Band 42, p. 770, 1890.
Stanton and Knowlton, Geol. Soc. America Bull., vol. 8, p. 137, 1897.
Sequoia gracillima Newberry, U. S. Geol. Survey Mon. 26, pl. 9, figs. 1–3, 1896 [cones only].
Berry, New York Bot. Garden Bull., vol. 3, pl. 48, figs. 21, 22, 1903; Torrey Bot. Club Bull., vol. 31, p. 69, pl. 2, 1904; Am. Geologist, vol. 34, pl. 15, 1904; Torrey Bot. Club Bull., vol. 32, p. 44, 1905; idem, vol. 33, p. 165, 1906; New Jersey State Geologist Ann. Rept. for 1905, p. 139, 1906.
Geinitzia gracillima Jeffrey, Bot. Gaz., vol. 51, pp. 21–27, pl. 8, 1911.

Heer's description is quoted below.

Strobile ovato-cylindrici, squamis rachi validae spiraliter insertis, apice peltatis, disco conavo, margine crenato, toroso; semina sub quavis squama quatuor (?), squamarum stipite crasso inserta, striata. Ramulis elongatis, virgatis, foliis omnino tectis, foliis subfalcatis, angustis, apice valde attenuatis, uninerviis, ramis adultis pulvinis rhombeis obtectis.

The American occurrences of cones of this species have been commonly referred to *Sequoia gracillima* Newberry, a composite made up of *Geinitzia* cones and *Widdringtonites* foliage. These cones are exceedingly abundant in the Magothy formation at Cliffwood Bluff, N. J., where those that are more or less pyritized are washed out of the clays by storms and high tides. The cones preserved as flattened lignitic inclusions are somewhat different in appearance, and it is believed that material of this species in that condition of preservation was the basis for the Raritan forms that were identified as *Microzamia gibba* (Reuss) Corda by Newberry.[26] A single cone is contained in the Magothy collections made along the Chesapeake & Delaware Canal in Delaware.

The foliage, which resembles somewhat that of *Sequoia reichenbachi* (Geinitz) Heer, as well as that of *Cunninghamites squamosus* Heer, shows rather thick twigs with slender curved needle leaves interspersed with small

[25] This species is said to be represented by *Carpolithes hemlocinus* of Schlotheim. See also Otto, Ernst von, Additamente zur Flora des Quadergebirges in der Gegend um Dresden und Dippoldiswalde, pt. 1, pl. 5, figs. 1–3, 5, 6, 1852.

[26] U. S. Geol. Survey Mon. 26, p. 45, pl. 12, figs. 6, 7, 1896. See also Berry, E. W., New Jersey Geol. Survey Bull. 3, p. 78, 1911.

scalelike leaves. This foliage is unquestionably distinguished with difficulty from that of *Sequoia reichenbachi* (Geinitz) Heer, and it is very likely that some of the records of the latter, which are so extensive, both geographically and geologically, include occurrences of *Geinitzia*. An extensive review of the literature would be necessary to determine this point, and even this might prove fruitless. In general the twigs of the *Sequoia* are more slender with stouter leaves all of one kind, whereas in *Geinitzia* the twigs are stouter and the leaves are longer and more falcate and are interspersed with small scalelike leaves. Except for the last feature these criteria are of uncertain value and lead to much confusion. The cones are, of course, very readily distinguishable, but except for their presence at the type locality and their prodigious abundance in the Magothy formation around Raritan Bay they are not represented with the foliar remains, so that all these identifications are hence open to more or less doubt.

For the foregoing reasons any extended comment on the distribution of *Geinitzia formosa* is not warranted. The type material came from the Senonian of Saxony, and there is no doubt that it is represented in the Magothy formation of the Atlantic Coastal Plain. Purely foliar records include the sands of Aix-la-Chapelle, the Montana group in Wyoming, the Vermejo formation in Colorado, and the Fruitland formation in New Mexico. It would seem singular that there are no Greenland records of *Geinitzia*, because Greenland almost invariably constitutes one of the three regions furnishing records of Cretaceous forms common to North America and Europe. This is readily explained, however, by the probable assumption that some of the numerous foliar remains from Greenland which Heer referred to one or another of his numerous species of *Sequoia* actually represent *Geinitzia*. In the absence of specimens it is not worth while to base any conclusions on figures of these species.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Genus CUNNINGHAMITES Presl

Cunninghamites elegans (Corda) Endlicher

Cunninghamites elegans (Corda) Endlicher, Synopsis coniferarum, p. 270, 1847.

Newberry, U. S. Geol. Survey Mon. 26, p. 48, pl. 5, figs. 1–7, 1896.

Hollick, New York Bot. Garden Bull., vol. 2, p. 402, pl. 41, fig. 11, 1902.

Berry, New York Bot. Garden Bull., vol. 3, p. 64, 1903; Torrey Bot. Club Bull., vol. 31, p. 70, pl. 3, figs. 7, 8, 1904; New Jersey Geol. Survey Ann. Rept. for 1905, p. 138, 1906.

Knowlton, U. S. Geol. Survey Bull. 257, p. 135, pl. 15, fig. 1, 1905.

Hollick, U. S. Geol. Survey Mon. 50, p. 41, pl. 3, fig. 1, 1906.

Berry, Torrey Bot. Club Bull., vol. 37, pp. 186, 505, pl. 20, figs. 1–4, 1910; U. S. Geol. Survey Prof. Paper 84, pp. 24, 106, 1914; Prof. Paper 112, 1919.

This widespread species has not been found in the Ripley except in the Cusseta sand member near Byron, Ga., which, as I have shown, is the chronologic equivalent of the Coffee sand member of the Eutaw formation. It is essentially a somewhat older species, but as it has been recorded in the Judith River beds of Montana there is no known reason why it should not range up into the true Ripley in the Atlantic Coastal Plain.

Occurrence: Ripley formation, Cusseta sand member, near Byron, Houston County, Ga.

Genus ARAUCARIA Jussieu

Araucaria bladenensis Berry

Araucaria bladenensis Berry, Torrey Bot. Club Bull., vol. 35, p. 255, pls. 12–14, figs. 1–3, 1908; (?) vol. 38, p. 405, 1911; U. S. Geol. Survey Prof. Paper 112, p. 61, pls. 9, 10, 1919.

This species is fully described in the publications cited above. It is exceedingly common in and characteristic of the Black Creek formation in North Carolina. In South Carolina it is found in the extension of these beds. It is present in the lower part of the Eutaw formation and in later Cretaceous deposits in western Georgia and along Chattahoochee River. Careful search has failed to discover this species in the fossiliferous plant beds of western Alabama of Tuscaloosa age, but it is present in great abundance at the very base of the Eutaw deposits in Hale County. Recent collections have shown it to be present in the Magothy formation in Maryland. Singularly enough, it is not found among the abundant display of Ripley plants in western Tennessee, a fact which suggests that it does not range above the Eutaw and that the Cusseta sand of Georgia should be correlated with the Eutaw rather than with the Ripley formation.

Occurrence: Eutaw formation (basal beds), 2 miles south of Havana, Hale County, Ala.; Chimney Bluff, Chattahoochee County, Ga. Ripley formation (Cusseta sand member), Buena Vista, Marion County, Ga.

Araucaria jeffreyi Berry

Araucaria jeffreyi Berry, Torrey Bot. Club Bull., vol. 35, p. 258, pl. 16, 1908; U. S. Geol. Survey Prof. Paper 84, p. 105, 1914.

These cone scales were completely described in the papers cited and need not be discussed here.

Occurrence: Eutaw formation, Chimney Bluff, Chattahoochee County, Ga. Ripley formation (Cusseta sand member), near Byron, Houston County, Ga.

Genus DAMMARA Lamarck

Dammara acicularis Knowlton

Plate XXII, figure 8.

Dammara acicularis Knowlton, U. S. Geol. Survey Bull. 257, p. 134, pl. 15, figs. 2–5, 1905; Canada Geol. Survey Summary Rept. for 1915, p. 205.

This species, which was described from specimens collected from the Judith River formation of Montana and which has also been recorded from the Belly River formation of western Canada, is represented by a single specimen in the Ripley. It was described by Knowlton as follows:

> Cone scales broad and very thick at apex, narrowed below into a broad, thick basal portion; apex broadly rounded, provided in the center with a long, slender, acute, apparently depressed awn; body of scale with several (8 to 10) strong apparently concentric ribs [resin canals], which are pressed close together and pass down the narrowed basal portion as thin striae.

This species is abundant in the Judith River beds, and Knowlton regards the awn as a distinctive character. Similar awns are, however, occasionally present on the earlier Upper Cretaceous forms described under other specific names—for example, *Dammara borealis* Heer—so that specific characters other than those of size, shape, and stratigraphic position are not available.

Remains of these organs were described and figured by Hitchcock in his account of the organic remains found at Gay Head, Marthas Vineyard, as long ago as 1841. He did not name them but remarked: "It seems to me very obvious that these remains must be the seed vessels of some coniferous plants." In 1882 Heer found similar forms in the material from the west coast of Greenland and named and described three very similar forms and definitely recognized their relation to *Dammara*. Subsequently they have been recorded from the European Cenomanian by Velenovsky, Krasser, and Beyer, from the Raritan formation of New Jersey by Newberry, and from Long Island and Staten Island by Hollick. They are abundant in the middle part of the Raritan at Woodbridge, N. J., and occur in the upper part of the Raritan (at the same horizon as the beds at South Amboy, N. J.) immediately across Arthur Kill on Staten Island.

I have found these scales in the Matawan formation of Maryland, in the Black Creek formation of North Carolina, and in the Tuscaloosa formation of Alabama. They have not been detected in the Cretaceous deposits of South Carolina or Georgia.

Similar remains have been considered by Heer, White, Krasser, and others as representing the fruits of the *Eucalyptus*, but it seems obvious that their relations are definitely with the araucarian conifers.

Occurrence: McNairy sand member of Ripley formation, a quarter of a mile west of Buena Vista, Carroll County, Tenn.

Phylum ANGIOSPERMOPHYTA

Class MONOCOTYLEDONAE

Order NAIADALES

Family NAIADACEAE

Genus POTAMOGETON Linné

Potamogeton ripleyensis Berry, n. sp.

Plate III, figure 5; Plate XXIII, figures 1–3

Leaves small, oblanceolate, with a pointed apex and a narrowed apetiolate base. Texture thin. Length 5.1 centimeters; maximum width, above the middle, 1.2 centimeters. Venation acrodrome; veins numerous, thin, parallel, rarely forking, immersed. Cross veinlets present.

This new species, superficially suggestive of *Podozamites* or some cycadean pinnule, is of a thin texture and lax venation entirely conforming to *Potamogeton*. Conclusively identified Cretaceous remains of this genus are rare, the only other Cretaceous species known to me being *Potamogeton cretaceus* Heer [27] and *Potamogeton middendorfensis* Berry,[28] both of which are very similar to the Ripley species. Both are sessile or subsessile. The former is more symmetrically lanceolate, somewhat larger, and relatively broader, with coarser and much fewer veins. It comes from the approximately synchronous horizon of the Patoot beds in western Greenland. The latter is shorter and relatively wider, with a broadly rounded tip, and comes from the Middendorf arkose member of the Black Creek formation, in South Carolina, a slightly older horizon.

Although the Ripley species is better preserved, the essential differences are slight, and if a single botanic species may be regarded as varying within the limits of the two it is quite possible that *Potamogeton middendorfensis* and *Potamogeton ripleyensis* may represent the variants of a single botanic species. When fossil leaves from slightly different horizons show recognizable differences and intermediate forms are absent from the geologic record, good practice requires that they shall be considered distinct species.

Between 30 and 40 fossil species have been referred to this genus, none of which appear to be identical with the present form. They range in age from the Arctic Emscherian through the Eocene, Oligocene, Miocene, and Pliocene to the Pleistocene—in fact, several still existing species are recorded from the Pleistocene, both in this country and abroad.

The modern species number more than 60 and occur both in the Tropics and more abundantly in the Temperate Zone. The species generally have a wide range, and many are cosmopolitan, a single species commonly extending over a great many degrees of latitude—for example, *Potamogeton perfoliatus* Linné extends over more than 20 degrees of latitude in America, from Newfoundland and British Columbia to Florida and California, and also occurs in Europe and Asia. It is an interesting fact that all the wide-ranging species extend into both comparatively high and low latitudes, whereas species of more restricted range, such as *Potamogeton floridanus* Small and *Potamogeton curtissii* Morong, of Florida, are commonly confined to warmer regions. This condition may be taken to indicate either that species confined to low latitudes in the existing flora, or their immediate ancestors in more ancient floras, had originally a much wider range than now, or that the modern wide-ranging species have greatly extended their range in recent times. I incline to accept the latter supposition, although it is well known that the majority of aquatics, both animal and plant, are little influenced even by rather wide differences in latitude.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Genus ALISMAPHYLLUM Berry

Alismaphyllum cretaceum Berry, n. sp.

Plate III, figure 6

Leaves ovate-auriculate, approaching or incipiently sagittate in general outline, with entire margins, pointed tip, and slightly decurrent base. Length about 4.5 centimeters; maximum width, in the basal half of the leaf, about 2.8 centimeters. Petiole stout, curved, about 6 millimeters in length, midrib rather broad but flat. The apparent breadth of both the petiole and the midrib seems to be due to the flattening during fossilization of a not very resistant structure. The secondary venation is obscure in all the four specimens of this species in the collection; the most that can be made out are one or two veins diverging from the midrib at an acute angle at or near its base and pursuing an upward and apparently acrodrome course parallel with the leaf margins.

In so far as its characters are discernible this species should be referred to the family Alismaceae. Rather than give it a too decisive generic position I have referred it to the genus *Alismaphyllum*, which was proposed by

[27] Heer, Oswald, Flora fossilis arctica, vol. 7, p. 19, pl. 55, figs. 23, 24, 1883.

[28] Berry, E. W., U. S. Geol. Survey Prof. Paper 84, p. 27, pl. 4, fig. 6, 1914.

me [29] for leaves from the latest Lower Cretaceous (Patapsco formation) of Virginia. Generic names for fossil forms supposed to belong to this family are plentiful; thus *Alismacites* Saporta [30] contains a doubtful Lower Cretaceous form from Portugal, a second from the Dakota sandstone, which is totally different from this Ripley species, and two or three Oligocene and Miocene species of Europe. *Alismaphyllites* was proposed by Knowlton [31] in 1918 for a form from the lower Eocene (Raton formation) of southeastern Colorado. The genus *Alisma* has had referred to it a doubtful form from the Upper Cretaceous (Atane beds) of western Greenland and several Tertiary species, as well as still existing forms occurring in the Pleistocene.

The family contains about 75 existing species segregated into about a dozen genera, all of which are small aquatic or marsh plants widely distributed and found on all the continents. Their latitudinal range is great and seems to depend less upon climatic than on edaphic factors.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Order LILIALES

Family DIOSCOREACEAE

Genus DIOSCORITES Saporta

[Annales sci. nat., Bot., vol. 17, p. 196, 1862. Type *Dioscorites resurgens* Saporta from the Oligocene of southeastern France.]

Dioscorites cretaceus Berry, n. sp.

Plate III, figure 7

Leaves small, ovate, widest in the basal half of the leaf. Apex narrowly rounded. Base broadly rounded. Margins entire, very slightly undulate. Substance thin but firm. Midrib slightly stouter than the lateral primaries, of which there are three on each side, rather evenly spaced and acrodrome. They are connected by oblique nervilles, ascending from within outward and rarely forking.

[29] Berry, E. W., Maryland Geol. Survey, Lower Cretaceous, p. 452, 1911.

[30] Saporta, Gaston de, Annales sci. nat., Bot., 4th ser., vol. 17, p. 228, 1862.

[31] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 286, 1918.

This characteristic little leaf, unfortunately known only from the single specimen figured, is an indubitable member of the Dioscoreaceae and is seemingly one of the most modern elements in the Ripley flora, but this is due, I believe, to the scarcity of this family in the fossil record throughout the Tertiary rather than to its late evolution, as the present species tends clearly to indicate.

Fossil forms referable to the family Dioscoreaceae are almost unknown. Lesquereux, it is true, described *Dioscorea? cretacea*,[32] from the Dakota sandstone of Kansas, but this form is entirely valueless as evidence for the presence of the family in the Upper Cretaceous. The present species, however, furnishes conclusive proof of the presence of this family toward the end of Cretaceous time. It is very similar to existing species of the genus *Rajania* Linné and also to several of the existing species of *Dioscorea* Linné. It is less like *Smilax*, the only other monocotyledonous type with which comparisons were instituted. *Rajania* has several existing species of the Antillean region. *Dioscorea* is a large modern genus with more than 200 species in the warmer parts of both hemispheres, some of which extend long distances into the Temperate zones.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Genus DORYANTHITES Berry

Doryanthites cretacea Berry

Doryanthites cretacea Berry, Torrey Bot. Club Bull., vol. 38, p. 406, 1911; U. S. Geol. Survey Prof. Paper 112, p. 70, pl. 13, fig. 1, 1919.

Leaves as preserved linear, presumably lanceolate above and sheathing below, 4.5 to 6 centimeters in width and preserved without any diminution in width for a length of 50 centimeters. Texture very coriaceous. Margins entire. Veins simple and parallel, immersed, considerably less than 1 millimeter apart. Leaves alike on both surfaces. In the hollows between the veins occur rows of small stomata with the guard cells all oriented in a direction parallel with the veins and equally numerous on both surfaces of the leaf. Leaf surface under the microscope appearing finely striated parallel with the veins.

[32] Lesquereux, Leo, Cretaceous flora, p. 56, pl. 28, fig. 10, 1874.

Occurrence: Eutaw formation (basal part), 2 miles south of Havana, Hale County, Ala. Coffee sand member of Eutaw formation, 1 mile north of Beacon, Decatur County, Tenn. Ripley formation (Cusseta sand member). Buena Vista, Marion County, Ga.

Order ARECALES

Family ARECACEAE

Genus GEONOMITES Visiani

Geonomites schimperi Lesquereux

Plate II

Geonomites schimperi Lesquereux, Tertiary flora, p. 116, pl. 10, fig. 1, 1878.

This species was described as follows by Lesquereux:

Frond large; rays flat, obtusely carinate, half-sheathing or decurrent to a narrow rachis, obscurely nerved; primary veins thick or inflated; intermediate nerves few, three or four.

The specimen represents a portion of an evidently long and large leaf. The rachis is narrow, not more than 4 millimeters thick at the lowest part of the specimen, very slowly decreasing in size, as at the top of the specimen, which is 22 centimeters long, it still measures 3 millimeters. It appears half round and striate but is distinct only at a few places, the rays apparently covering it by their decurrent or half-sheathing base. The rays are scarcely narrowed at the base, enlarging a little above it, and connected by their borders, thence decreasing upward, soon disjointed, and thus palmato-pinnate; they average in width 2.5 centimeters a little above the rachis. The rays are marked in the middle by a deep midrib and are thus subcarinate; they show on both sides of it ten to fourteen inflated primary veins, with few intermediate veinlets, only two to four discernible, and even these rarely, after abrasion of the epidermis. The substance of the fronds is thin, membranaceous, of a dull-red color, a character which may be casual.

Palm leaves are notoriously without clearly defined specific features, especially as represented by the broken remains characteristic of most museum specimens, hence the determination of this species rests largely upon the process of eliminating other previously described species of *Geonomites* which show the distinguishing characters that appear to be specific. As preserved in the Ripley clays the remains indicate leaves of large size. The accompanying illustration was redrawn from a sketch made from a specimen in place by E. S. Perry in October, 1919, combined with the many fragments collected by Dr. Wade. This specimen had a length of 60 centimeters and a width of 45 centimeters and represented a leaf at least 100 centimeters in length, if not much longer, and over 50 centimeters in width. The rays vary greatly in width and are generally united, becoming free marginally and toward the tip of the leaf.

As has been previously pointed out, the genus *Geonomites*, which receives its name from its resemblance to the existing genus *Geonoma* of Willdenow, is more properly considered to represent the undifferentiated ancestry or the generically indistinguishable fossil representatives of the tribe Geonomeae. This tribe includes at least ten genera, three of which, all monotypic, are natives of western Africa. The remaining genera, containing 98 per cent of the known species, are widely distributed in tropical and subtropical America. Most of these seven genera are small, containing from one to five existing species each. The only large genus of the tribe is *Geonoma*, which comprises between 80 and 100 existing species that extend from the Antilles and southern Mexico through Central America, along the eastern base of the Andes to Bolivia, and along the east coast of South America to Rio de Janeiro. Their center of distribution at the present time is in the basin of the Amazon. They are prevailingly small stemless or short-stemmed palms and are undoubtedly of American origin. The fossil representatives of the Geonomeae comprise several Eocene and Oligocene forms of both North America and Europe that have been referred to the genus *Manicaria* of Gaertner, three forms referred to *Geonoma*, and six forms referred to *Geonomites*.

The present Ripley fossil represents the oldest known occurrence not only of the genus but of the tribe Geonomeae and the only certain pre-Eocene occurrence. The type of *Geonomites schimperi* came from a somewhat indefinite locality in Yellowstone Park and has doubtfully been referred to the "Laramie" of that region, which is now assigned to Mesaverde. If this age determination is substantiated the Ripley occurrence is probably of about the same age. The species has also been recorded from beds of uncertain age in Contra Costa County, Calif., but this record may well be doubted, for it is not substantiated by either figures or preserved specimens. In addition to the present Cretaceous species either *Geonoma* or *Geonomites*, or both, are recorded from the early Eocene of Colorado (Raton and Denver formations), Wyoming, New Mexico, and Texas. On the other hand, the earliest known European form, the type of the genus, comes from the lower Lutetian of Italy. A second species, referred to *Geonoma* by its describer, comes from the Oligocene of Italy, and a third, likewise referred to *Geonoma*, comes from the lower Miocene of Switzerland.

Although the geologic record is incomplete, it would seem to indicate a tropical origin for the tribe, in later Upper Cretaceous time, a spread northward far into western North America during the early Eocene, and an invasion of southern Europe, possibly extending to tropical Africa, during the middle Eocene or slightly later. An opinion as to whether the tribe migrated to the Eastern Hemisphere across the Tropics or in higher latitudes is not warranted in the present state of our knowledge.

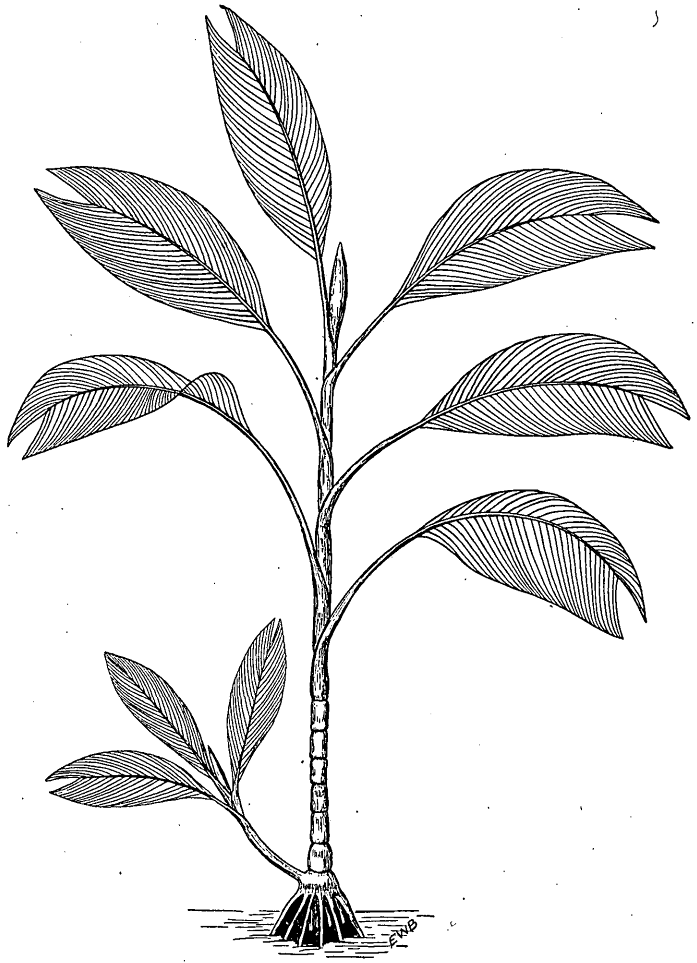


FIGURE 4.—Restoration of *Geonomites visianii* Berry, one-eighteenth natural size

Geonomites has not yet been found in the extensive Eocene floras from the shores of the Mississippi embayment which I have described, but in view of its presence in that region toward the end of Upper Cretaceous time it should eventually be found in the early Eocene of that region.

The accompanying attempt at a restoration of the basal Eocene *Geonomites visianii* Berry,[33] of western Texas (fig. 4), not only will answer for *Geonomites schimperi*, which differs in general aspect merely by the splitting apart of the rays distad, but it also serves to indicate the general habit of the numerous existing species of *Geonoma*. Somewhat questionable fragments of *Geonomites schimperi* occur in the shell marl at Coon Creek.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County; 2½ miles south of Mifflin, Chester County, Coon Creek, McNairy County, Tenn.

Genus SABALITES Saporta

Sabalites sp. Berry

Sabalites sp. Berry, U. S. Geol. Survey Prof. Paper 112, p. 72, pl. 11, fig. 1, 1919.

Fragments of leaves of a large fan palm are present in the basal Ripley formation of Benton and McNairy counties, Tenn. They indicate large flabellate leaves, with numerous rays 1.5 to 2 centimeters broad having an ill-defined midrib and close-set parallel lateral veins. The texture is coriaceous.

The material is very fragmentary, one of the best specimens being that figured, which is altogether insufficient for specific diagnosis. It is in my judgment distinct from the so-called *Sabalites grayanus* Lesquereux, of the Montana group of the West, from *Sabalites magothiensis* Berry of the Magothy formation of the northern Atlantic coast, or from *Sabalites carolinensis* Berry of the Middendorf arkose member of the Black Creek formation of South Carolina.

Occurrence: Ripley formation (McNairy sand member), half a mile from Camden, Benton County; 2½ miles southwest of Selmer, McNairy County, Tenn.

[33] Berry, E. W., U. S. Geol. Survey Prof. Paper 125, p. 5, pl. 2, 1919.

Class DICOTYLEDONAE

Series CHORIPETALAE

Order JUGLANDALES

Family JUGLANDACEAE

Genus JUGLANS Linné

Juglans similis Knowlton

Juglans similis Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 255, pl. 36, fig. 2, 1917.

This species, which is represented by several specimens in the Ripley formation, is described as follows by Knowlton:

> Leaflets membranaceous in texture, ovate-lanceolate in outline, abruptly wedge-shaped at base, prolonged above into an acuminate apex; margin entire; midrib thin, straight; secondaries ten or twelve pairs, thin, alternate, slightly curved upward, camptodrome, and curving just within the border to join the one next above; finer nervation obsolete.
>
> This fine little species is well represented by the example figured. This is narrowly ovate-lanceolate in shape, being about 7.5 centimeters in length and 3.25 centimeters in width in the middle. The nervation is well shown in the figure.
>
> This species is of the type of certain of the leaflets often referred to *Juglans rugosa* Lesquereux but differs from it in having a more narrowly lanceolate shape, larger acuminate apex, and thinner nervation at a slightly more acute angle of divergence.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Juglans tennesseensis Berry, n. sp.

Plate III, figure 8

Leaflets broadly ovate, widest below the middle, rounding upward to a pointed tip and downward to a rounded base. Margins entire, slightly flexuous. Texture thin but subcoriaceous. Length about 11 centimeters; maximum width 4 to 5 centimeters. No petiolule preserved. Midrib stout, very prominent on the lower surface of the leaflets. Secondaries stout and prominent on the lower surface; about ten pairs diverge from the midrib at varying angles and somewhat irregular intervals; occasionally an odd one is forked near the base; all are camptodrome close to the margins. Tertiaries well marked.

This species, which has something of the form of *Juglans arctica* Heer, is relatively broader, more nearly equilateral, and with a coarser venation. It is decisively differentiated from the narrow *Juglans wadii* Berry, with which it is associated, and is also less common. It might be considered to represent the terminal leaflets of the species of which *Juglans wadii* represents the lateral leaflets, but this does not seem probable because of the different facies of the two.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Juglans wadii Berry, n. sp.

Plate IV, figures 1–3

Leaflets of variable size, somewhat inequilateral, petiolulate, lanceolate, with bases and tips similarly acuminate. Margins entire. Texture subcoriaceous. Petiolule stout, variable in length, in one of the larger leaflets 1.5 centimeters long. Midrib very stout, prominent on both surfaces but more so on the lower surface. Secondaries stout, numerous, regularly spaced, camptodrome. Areolation finely reticulate, mostly obsolete. Length from 7 to 12 centimeters; maximum width, in the middle part of the leaf, from 2.3 to 2.6 centimeters. Thus the larger leaflets are relatively narrower and more elongated than the smaller leaflets.

This species, which is fairly common in the Ripley, is not especially close to previously described forms, of which several are known from the Upper Cretaceous. The smaller leaves are rather suggestive of lower Eocene forms referred to the allied genus Engelhardtia, but in the absence of the characteristic winged fruits of that genus such a determination can not be substantiated, nor is the species certainly a *Juglans*, although it appears to be a member of the Juglandaceae. The absence of corroborative evidence in the form of fruits of the Cretaceous leaves referred to this family renders their generic position uncertain, and it is quite possible that these forms represent a more primitive stock from which the early Eocene winged fruit and nut bearing trees representing different lines of descent were evolved.

The species is named for the collector, Dr. Bruce Wade.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Order MYRICALES

Family MYRICACEAE

Genus MYRICA Linné

Myrica wadii Berry, n. sp.

Plate IV, figures 4, 5

Leaves of variable size and marginal characters, elongate linear-lanceolate, with a narrowly cuneate base and an extremely attenuated tip. Typical forms average about 17 centimeters in length by 1.2 centimeters in maximum width, which is below the middle. Some forms are relatively shorter and broader, with a wider cuneate base. One such has a length of 10 centimeters and a maximum width of 1.5 centimeters. Texture coriaceous. Margins entire for a short distance proximad, above which they show remotely and somewhat irregularly spaced prominent serrate teeth separated by wide, flatly rounded inequilateral sinuses. The teeth become more remote and less prominent distad, and the narrow tip may have entire margins for a greater or less distance. Petiole short and stout, especially proximad, about 1 centimeter in length. Midrib stout and prominent on the lower surface of the leaf, usually curved. Secondaries medium stout, prevailingly straight and craspedodrome, diverging from the midrib at open angles in the proximal part of the leaf and at progressively more acute angles in passing toward the tip. In the intervals between these craspedodrome secondaries are similar subparallel branches from the midrib, whose deflected marginal portions arch close to the margins, forming a sort of marginal hem. The tertiaries are percurrent.

The present species, which is named in honor of the collector, Dr. Bruce Wade, is not especially close to any modern species of *Myrica* and is clearly distinct from previously described fossil species. It does not merit a comparison with any of these except perhaps the associated *Myrica ripleyensis* Berry, which is shorter and broader and has more numerous *Comptonia*-like teeth, which become more numerous instead of fewer toward the tip of the leaf. Forms of similar age referred to *Myrica torreyi* Lesquereux are readily distinguishable.

These remains are clearly those of a simple leaf and do not represent leaflets of a compound leaf like *Dewalquea*, the leaflets of some species of which they greatly resemble—for example, those from the lower Senonian of Germany figured by Hosius and Von der Marck.[34] I was at first disposed to refer this Ripley form to the proteaceous genus *Banksia* and to regard it as ancestral to *Banksia saffordi* (Lesquereux) Berry,[35] of the Wilcox Eocene. It differs from that species, however, in characters such as areolation and apical attenuation, in which respect it is more like *Myrica*. It is still possible that the two should be affiliated, and in that event I would be compelled to regard the later form as a *Myrica* rather than a *Banksia*. The Tertiary records of *Banksia* and other genera of the Proteaceae have been hotly disputed by some botanists, and it is true that in *Banksia* the modern leaves are abruptly pointed. At the same time some of the Tertiary forms referred to the Proteaceae have been conclusively shown to be authentic and are corroborated by fruiting specimens. This being true, there is no inherent reason for drawing the line at any of the genera except perhaps those that can be definitely shown to be late Tertiary evolutions confined to the Australian region. The problem, then, of differentiating *Myrica* and *Comptonia* from *Banksia* and *Dryandra* becomes extremely difficult if not altogether impossible.

There is certainly an astonishing variety of *Myrica*-like leaves in the Ripley flora, and the variations shown are of a character and degree that preclude considering the bulk of them as variants of a single botanic species.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Myrica wadii minor Berry, n. var.

Plate IV, figures 6–8

Leaves slender, linear-lanceolate, somewhat smaller and relatively shorter than *Myrica wadii* and also somewhat more coriaceous. Tip attenuated. Base narrowly cuneate. Length about 13 centimeters; maximum width about 1 centimeter. Margins entire proximad, above which they are beset with small remote serrate teeth, directed upward and separated by scarcely marked flat sinuses. Petiole missing. Midrib stout, prominent on the under side of the leaf. Secondaries thin, largely immersed in the leaf substance, diverging from the midrib at rather wide angles, curved and regularly camptodrome some distance inside the margin, sending short tertiary branches to the marginal teeth. In this respect the variety shows a constant difference from *Myrica wadii*, as it does also in the very much reduced and more closely spaced marginal teeth. In some small forms of the variety the teeth are relatively twice as numerous as in the larger forms.

Very many species of *Myrica* leaves range from entire to toothed forms, with the consequent change from camptodrome to craspedodrome venation, and it would require merely the straightening out of the secondaries with the enlargement of the teeth and the reduction of the old camptodrome tips of the secondaries to derive *Myrica wadii* from such a form as the variety *minor*. It is less abundant than the type.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Myrica ripleyensis Berry

Myrica ripleyensis Berry, Torrey Bot. Club Bull., vol. 43, p. 288, 1916; U. S. Geol. Survey Prof. Paper 112, p. 74, pl. 11, fig. 2, 1919.

Leaves of medium size, linear-lanceolate, with a gradually narrowed and acuminate tip and a cuneate base. Length about 13 centimeters; maximum width, in the middle part of the leaf, about 1.75 centimeters. Margins conspicuously serrate-toothed, the teeth somewhat irregular in size and disposition; distad they are reduced and close-set. They increase in size proximad until in the median and basal part of the leaf they are large and triangular, the intervening sharp sinuses reaching nearly to the midrib and closely simulating those of our recent *Comptonia* in character. Texture coriaceous. Petiole not preserved, presumably short and stout. Midrib stout, flexuous. Secondaries numerous, diverging from the midrib at wide angles (about 70°), every third or fourth one straighter than the rest and running to a marginal tooth, the intervening ones somewhat more curved and camptodrome.

[34] Palaeontographica, Band 26, p. 48, pl. 32, figs. 111–113; pl. 33, fig. 109; pl. 34, fig. 110, 1880.

[35] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 208, pl. 36, figs. 5, 6, 1916.

This species is exceedingly well marked and is entirely distinct from previously described forms. It resembles closely some of the leaves of our existing *Camptonia peregrina* (Linné) Coulter. It is also much like some of the European Tertiary forms, about which so much controversy raged in times past as to whether they were myricaceous or proteaceous.[36] For example, some of the forms of *Comptonia vindobonensis* (Ettingshausen) Berry are similar to the present species. A somewhat similar form from the Bohemian Cretaceous is described by Velenovsky[37] as *Dryandra cretacea*, and another from the Cretaceous of Transylvania by Unger[38] as *Comptonites antiquus*. These are both generically distinct from the present species, as shown by their characteristic habit. *Myrica ripleyensis* is not especially close to any of the other Ripley species of *Myrica*, *M. wadii* being more elongated and slenderer, with conspicuously different marginal characters.

Occurrence: Ripley formation (McNairy sand member), Camden-Paris road, 13 miles northwest of Camden, Henry County, Tenn.; 2½ miles southwest of Selmer, McNairy County, Tenn.

Myrica cooperensis Berry, n. sp.

Plate VI, figure 1

Leaves oblong-lanceolate, of medium size, with an acuminate apex and a narrowly cuneate base, the margins irregularly toothed or lobed and the texture coriaceous. Length, about 9 centimeters; maximum width, at a point where the marginal teeth may become lobate, about 2 centimeters. The characteristic features of these species is furnished by the peculiar and variable character of the margins, which range from remote outward-directed teeth separated by nearly equilateral rounded sinuses to variants in which one or more of the teeth are directed upward or finally produced as ascending narrow conical pointed lobes. Thus in the specimen figured, which is a synthesis of many fragments, the distal teeth on each side are aquiline conical lobes, on the left side two outward-directed teeth are separated by wide openly rounded sinuses, and the proximal and slightly more produced tooth is produced as an ascending conical lobe; on the right side the penultimate tooth is but slightly developed and directed outward, the next below is a conical ascending lobe, below which is a normal outward-directed tooth, followed by a proximal and slightly more produced tooth. The petiole is stout and about 5 millimeters in length; the midrib is stout, slightly flexuous, and prominent on the lower surface of the leaf. The secondaries are thin; usually a craspedodrome secondary proceeds from the midrib at varying angles to the tips of the teeth or lobes; the remainder, which are numerous, are camptodrome, or unite at large angles with an inframarginal vein or hem, which is apparently the modification of a more regular camptodrome venation due to the formation of the marginal sinuses. The ultimate areolation can not be made out.

The species is not uncommon but fragmentary, and small fragments suggest small lobate leaves of *Quercus*, although the venation is not that of *Quercus* but suggestive of *Myrica* or some member of the Proteaceae—for example, *Lomatia*. General considerations, it seems to me, rule out the latter possibility, so that I am constrained to adopt *Myrica*, in spite of the abundance and diversity of *Myrica* types that this flora is thus made to exhibit. There is little likelihood of confusing the present unique type either with its associates in the Ripley flora or with other American forms. On the other hand, in both size and peculiar marginal lobing, it is somewhat like a form from the Senonian of Germany described by Hosius and Von der Marck[39] as *Quercus hieraciifolia*. As the name used by Hosius and Von der Marck is one in the literature commonly attributed to Debey, it is probable that somewhat similar forms occur in the Cretaceous of Aix-la-Chapelle.

The value of careful descriptions and precise figuring of fossil leaves is well illustrated by the unsatisfactory objects described by Hosius and Von der Marck. I should like to call the

[36] See Berry, E. W., Living and fossil species of *Comptonia:* Am. Naturalist, vol. 40, pp. 485–520, pls. 1–4, 1906.

[37] Velenovsky, Josef, Die Flora der böhmischen Kreideformation, pt. 2, p. 1, pl. 1, figs. 1–5, 1883.

[38] Unger, Franz, Ueber einige fossile Pflanzenreste aus Siebenbürgen und Ungarn: K. Akad. Wiss. Wien Sitzungsber., Band 51, pt. 1, p. 2, pl. 1, fig. 1, 1865.

[39] Palaeontographica, Band 26, p. 42, pl. 31, figs. 85–88, 1880

Ripley species *Myrica hieraciifolia* but am prevented by the possibility that the German form may have to be transferred to *Myrica*. The desirability of more precise comparison has a bearing upon correlation. Moreover, there are a much larger number of botanists interested in the origin and distribution of the oaks. Formerly almost any lobate leaf was referred to *Quercus*, often upon scanty evidence. One would not find fault with the older workers if they had left figures accurate enough for a judgment. If, as seems probable, *Quercus* and *Castanea* are derived from *Dryophyllum*, the lobate forms older than *Dryophyllum* are open to suspicion, and with scientific descriptions and figures it would be possible to get some idea of the lines of evolution.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Myrica johnstrupi (Heer) Berry

Quercus johnstrupi Heer, Flora fossilis arctica, vol. 7, p. 24, pl. 56, figs. 7–12a, 1883 [not Newberry, 1896].

Knowlton, in Stanton and Martin, Geol. Soc. America Bull., vol. 16, p. 408, 1905.

Leaves lanceolate to ovate, with a bluntly pointed apex and a broadly cuneate and slightly decurrent base. Texture subcoriaceous. Length from 3 centimeters to 7 millimeters; maximum width, at or below the middle, from 1.25 to 2.5 centimeters. Margins with somewhat variously developed coarsely dentate teeth, which are generally more prominent in the larger leaves. Petiole stout, of undetermined length. Midrib stout, prominent on the under surface of the leaf. Secondaries thin but prominent, six to eight subopposite to alternate pairs diverging from the midrib at angles of about 45°, pursuing a rather straight subparallel ascending course, and terminating at apices of the marginal teeth, hence craspedodrome. Tertiaries thin, percurrent, usually obsolete by immersion.

This species is abundant in the Patoot beds of Greenland and was well illustrated by Heer. It has been recorded from the Upper Cretaceous of Chignik Bay, Alaska, but this material has not yet been described or figured. It is sparingly represented by characteristic specimens in the Ripley of Tennessee. It was recorded by Newberry from the Raritan formation of New Jersey, but this record was based on an erroneous identification. Heer referred the type material to the genus *Quercus*, but it lacks any positive diagnostic features of that genus and is on the other hand identical in essential characters with numerous species of *Myrica*. The tendency of paleobotanists to see resemblances to *Quercus* in fossil leaves with a toothed or lobate margin irrespective of other and more important foliar characters is greatly to be deprecated.

The present species is distinguishable with difficulty from the Patoot forms named *Quercus marioni* by Heer,[40] which similarly is to be referred to *Myrica*. Both the Patoot flora and that of the Ripley furnish a galaxy of mostly small, toothed-margin forms that are very liable to confusion unless their characters are carefully analyzed.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Myrica minor Berry, n. sp.

Plate VI, figures 2, 3

Leaves small, elliptical, with an acute tip and a cuneate or somewhat cordate base. Margins with a few large crenate-serrate teeth. Texture subcoriaceous. Length 1.75 to 2 centimeters; maximum width, in the middle part of the leaf, 8 to 13 millimeters. Petiole stout, curved, 3 to 5 millimeters in length. Midrib stout, prominent on the under surface of the leaf. Secondaries stout; four or five pairs diverge from the midrib at acute angles and ascend in rather straight courses to the tips of the marginal teeth (craspedodrome). Tertiaries obsolete.

This little species is somewhat variable, the extremes being figured. In the broader forms the base becomes cordate and the basal secondaries diverge at wider angles. Superficially these tiny leaves suggest the juvenile leaves of the associated *Myrica ornata* Berry, but their long petioles negative this suggestion. Although represented by only three specimens, the species is present at the two principal outcrops where Ripley plants have been collected in Tennessee.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County,

[40] Heer, Oswald, Flora fossilis arctica, vol. 7, p. 23, pl. 56, figs. 1–6, 1883.

and Cooper pit, near Hollow Rock, Carroll County, Tenn.

Myrica ornata Berry, n. sp.

Plate VI, figures 4, 5

Ovate-lanceolate leaves of medium size and striking appearance, varying somewhat in size and proportions, generally widest below the middle, tapering upward to the more or less extended acuminate tip and downward to the broadly or narrowly cuneate base. Margins entire for the basal one-fourth their length, their upper three-fourths divided into large aquiline serrate cuspidate teeth, which decrease regularly in size above the middle. Teeth from seven to ten on each side, varying from a crenate-serrate form to the elegant type reproduced photographically, in which the prominent teeth are slightly awned. Leaf substance thick and polished, subcoriaceous. Length from 7 to 9 centimeters; maximum width from 1.9 to 3.1 centimeters. Petiole short and stout, curved, about 2 millimeters in length. Midrib stout, prominent on the under side of the leaf; seven to ten subopposite pairs diverge from the midrib at acute angles of about 35°, pursue a but slightly curved ascending course, and terminate in the marginal teeth (craspedodrome). The tertiaries are immersed in the leaf substance. They are thin and form arches along the margins and are percurrent between the secondaries. The areolation is fine and indistinctly seen and is not that of *Quercus*, a genus which might possibly be suggested by the general form of the leaf.

This handsome species is a characteristic element in the Ripley flora and is not uncommon at the Carroll County locality. It is readily distinguished from the numerous associated species of *Myrica*. Among previously described fossil forms it is somewhat suggestive of *Myrica parvula* Heer, of the Raritan formation of New Jersey and the Patoot beds of Greenland, which I redescribed as *Comptonia microphylla* (Heer) Berry.[41] That form is smaller, however, with fewer and obtuse teeth, and lacks the acuminate tip. *Myrica ornata* also resembles the juvenile leaves of the existing *Comptonia peregrina* (Linné) Coulter, but the latter are shortly pointed or rounded distad, with the margins lobed rather than toothed. Somewhat similar Tertiary forms in both Europe and North America are *Comptonia vindobonensis* (Ettingshausen) Berry and *Comptonia insignis* (Lesquereux) Berry. Attention should also be called to the leaves from the Patoot beds of Greenland which Heer[42] described as *Quercus johnstrupi* and which demonstrate the presence in Greenland of a very similar and congeneric type also present in the Ripley flora and referred to *Myrica* by me in the present work.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Myrica torreyi Lesquereux

Plate VI, figures 6, 7

Myrica torreyi Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 392, 1873; U. S. Geol. Survey Terr. Rept., vol. 7 (Tertiary flora), p. 129, pl. 16, figs. 3–10, 1878.

Ward, U. S. Geol. Survey Sixth Ann. Rept., p. 551, pl. 40, fig. 4, 1886; U. S. Geol. Survey Bull. 37, p. 32, pl. 14, fig. 5, 1887.

Knowlton, U. S. Geol. Survey Bull. 163, p. 34, pl. 6, figs. 1–3, 1900; U. S. Geol. Survey Prof. Paper 98, p. 90, pl. 17, fig. 7; p. 336, pl. 86, fig. 1, 1916; Prof. Paper 101, p. 256, pl. 37, figs. 2–4, 1918.

Cockerell, Colorado Univ. Studies, vol. 7, p. 150. 1910.

The material from Tennessee is narrower and more prominently toothed than the type material but appears identical with the western forms referred to this species by Knowlton. The type was collected near the Cretaceous-Eocene boundary at Black Buttes, Wyo., and the species has been recorded from a considerable number of localities and horizons in the Cretaceous of Wyoming, Colorado, and New Mexico but has not hitherto been found in the Coastal Plain Cretaceous. It is common at the Carroll County locality in Tennessee but has not been found in the collections from Henry County.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

[41] Berry, E. W., Am. Naturalist, vol. 40, p. 508, pl. 4, figs. 1, 3, 4, 1906.

[42] Heer, Oswald, Flora fossilis arctica, vol. 7, p. 24, pl. 56, figs. 7–12, 1883.

Myrica torreyi obtusata Berry, n. var.

Plate VI, figure 8

Leaves relatively small, linear, with a blunt tip and a narrowly cuneate decurrent base. Margins dentate, with an occasional tooth assuming a serrate form. Length about 6.5 centimeters; maximum width about 5 millimeters. Petiole stout, curved, 7 millimeters in length. Midrib stout, prominent, usually curved. Secondaries thin but well marked, diverging from the midrib at angles of over 45°, alternately craspedodrome to the marginal teeth and abruptly camptodrome, the latter forming with the branches from them to the craspedodrome veins a pseudomarginal vein. Tertiaries thin, forming an open polygonal areolation.

The general form and especially the blunt tip show a decided resemblance to the fossil leaves commonly referred to the genus Banksia, but the venation is not that of *Banksia* and is of the type commonly referred to Myrica and exactly similar to that shown in the contemporaneous forms referred to *Myrica torreyi*. The new variety differs from *Myrica torreyi* in its small size, narrow form, and blunt tip. Marginal characters are rather variable among the forms that have been referred to *Myrica torreyi*. Those from the Cretaceous of Tennessee that are considered to represent that species have more prominent and more closely spaced teeth than this new variety.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Myrica brittoniana Berry

Plate VI, figure 9

Myrica brittoniana Berry, Torrey Bot. Club Bull., vol. 32, p. 46, 1905; New Jersey Geol. Survey Ann. Rept. for 1905, p. 138, 1906; U. S. Geol. Survey Prof. Paper 84, p. 31, pl. 7, figs. 17, 18, 1914.

Myrica heerii Berry, Am. Naturalist, vol. 37, p. 682, figs. 7, 8, 1903 [homonym, Boulay, 1887].

Leaves elongate-lanceolate, 13 to 14 centimeters long by 2.7 centimeters in greatest width, which is in the middle part of the leaf. Apex elongated, narrowed, bluntly pointed. Base attenuated. Margin entire, or entire below and undulate or distantly and obtusely toothed above. Texture coriaceous. Petiole and midrib fairly stout and prominent on the underside of the leaf. Secondaries thin, immersed, often obsolete, branching from the midrib at rather large angles, comparatively straight, abruptly camptodrome, forming a pseudomarginal vein, which is especially prominent in the Ripley material and which gives off a short and inconspicuous branch to the marginal teeth.

This striking species was described by me from specimens found in the Magothy formation of New Jersey and was subsequently recorded from the Black Creek formation in South Carolina. At both of these localities the matrix is rather coarse, and the detailed characteristics of the species come out much more clearly in the present specimens, preserved in the fine plastic Ripley clay. The species is well marked and abundant in the Ripley deposits of Henry County but has not yet been found elsewhere in Tennessee or in the western Cretaceous.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County. Tenn.

Myrica brittoniana obtusata Berry, n. var.

Plate V, figures 1, 2

This variety differs from the type in its relatively shorter and broader form and in its conspicuously rounded tip. Length from 10 to 12 centimeters; maximum width from 2 to 2.5 centimeters. The midrib is prominent below and channeled on the upper surface of the leaf. The secondaries are more numerous, more prominent, and straighter, and the marginal vein is more conspicuous.

This variety is not abundant and is associated with the normal form of *Myrica brittoniana* and may therefore simply represent abnormal leaves of that species. The more obtuse tip that has suggested the name for this variety is a feature of slight weight, but the channeled midrib and more prominent and slightly different secondary venation seem to be characters of diagnostic value.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Order SALICALES

Family SALICACEAE

Genus SALIX Linné

Salix gardneri Knowlton?

Plate V, figure 3

Salix gardneri Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 257, pl. 37, fig. 1, 1919.

The present species is described as follows by Knowlton:

Leaves linear-lanceolate, broadest about the middle, thence tapering gradually to the long wedge-shaped lower portion and in about equal degree to the acuminate apex; margin perfectly entire; midrib fairly strong; secondaries numerous, about twelve pairs, alternate, at an angle of about 45°, very much curved upward, each joining the one next above, the lower ones by a series of several loops, the upper ones making themselves a series of conspicuous loops; nervilles prominent, approximately at right angles to the midrib.

This handsome little species is represented by the nearly perfect example figured as well as several more or less fragmentary specimens. The figured specimen is 7 centimeters long and 1 centimeter wide: the others are slightly smaller.

This species is undoubtedly most closely related to *Salix plicata* Knowlton, of the Vermejo formation, with which it agrees closely in size and shape but from which it differs in the disposition of the less numerous secondaries; the finer nervation is also a more conspicuous feature in the present species.

The Ripley material is only tentatively identified with this Vermejo species, which is only doubtfully related to the genus *Salix*. The Ripley material shows a long petiole and is much like a variety of lanceolate members of the Ripley flora but differs from all of these in venation.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Order FAGALES

Family FAGACEAE

Genus DRYOPHYLLUM Debey

Dryophyllum gracile Debey

Dryophyllum gracile Debey, Feuilles querciformes d'Aix-la-Chapelle, p. 10, figs. 10, 11, 1881.
Berry, Torrey Bot. Club Bull., vol. 43, p. 290, pl. 16, fig. 6, 1916; U. S. Geol. Survey Prof. Paper 112, p. 75, pl. 32, fig. 2, 1919.

Lanceolate to oblong-lanceolate, with a cuneate base and a gradually narrowed tip. Length about 12 centimeters; maximum width, about midway between the apex and the base, from 1.75 to 2.5 centimeters. Petiole missing. Texture subcoriaceous. Margin with regularly spaced, fairly prominent, nearly straight serrate teeth. Midrib stout, prominent on the lower surface of the leaf. Secondaries thin, regularly spaced, about fifteen craspedodrome pairs branching from the midrib at angles of 45° or more, curving regularly upward, subparallel, terminating in the marginal teeth. Tertiaries thin, partly percurrent and partly alternating, joined midway between adjacent secondaries by a zigzag vein.

This well-marked species is represented by several specimens from the McNairy sand member of the Ripley formation of Tennessee. None of these are complete, each showing about two-thirds of a leaf, but this is enough to demonstrate their identity with the European type, which came from the Turonian or Emscherian of Aix-la-Chapelle, Rhenish Prussia. Additional European localities are Tannenberg, Bohemia, and Kieslingswalde, Silesia, all at about the same horizon and probably in the Santonian substage of the Emscherian.

Occurrence: Ripley formation (McNairy sand member), big cut on Southern Railway near Cypress and 2½ miles southwest of Selmer, McNairy County; Cooper pit, near Hollow Rock, Carroll County (rare), Tenn.

Dryophyllum protofagus Berry, n. sp.

Plate V, figures 4, 5

Leaves relatively small, alternate in arrangement, oval, widest in the median region and about equally tapering to the acute apex and base, the apex slightly more tapering than the base. Margins dentate. Texture subcoriaceous. Petiole short and stout, about 2.5 millimeters in length. Midrib stout and prominent on the lower surface of the leaf. Secondaries stout, subopposite to alternate, numerous, subparallel, craspedodrome; they diverge from the midrib at angles of 45° to 50°, pursue a nearly straight ascending course, and terminate in the marginal teeth. Tertiaries well marked, numerous, prevailingly percurrent. The margins are entire for a variable distance below, and the teeth increase in size somewhat toward the tip of the leaf. Length about 3.5 centimeters; maximum width about 1.7 centimeters.

margins, along which they arch. Tertiaries comprise arches along the margins which send short branches into the teeth and percurrent veins between the secondaries which are connected transversely in the median region.

These leaves, which are somewhat suggestive of some modern species of the genus *Cordia*, resemble *Celtis* in their general form and marginal teeth, curved petiole and midrib, slightly falcate form, and secondary and tertiary venation.

The genus *Celtis* comprises shrubs and trees of the warm temperate and tropical portions of the Northern Hemisphere, with outlying species in the Mascarenes, New Caledonia, Java, and Polynesia. It is divided into several subgenera, some of which are probably of generic rank, such as the score of tropical American forms of *Momisia* Dumortier. The *Euceltis* section of the genus contains between 30 and 40 existing species of the warmer parts of North America and Eurasia. A considerable number of fossil species of *Celtis* have been described, but the only previously known form from the Cretaceous with such an implied relationship is *Celtidophyllum praeaustrale* Krasser,[44] from the Cenomanian of Kunstadt, Moravia. This assignment does not appear especially convincing to me, and I would be inclined to consider the form a *Zizyphus*.

The oldest certainly determined forms heretofore known come from the lower and middle Oligocene of France. The genus is well represented in the European Miocene, with no less than eight species, and is present at Florissant, in the Colorado Rockies, as well as in Wyoming. The Pliocene species include representatives in both Europe and eastern Asia. The existing European *Celtis australis* Linné is found in the Pleistocene of Hungary, and both *C. occidentalis* Linné and *C. mississippiensis* Bosc, as well as an extinct species, occur in the Pleistocene of the United States.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

[44] Krasser, Fridolin, Beiträge zur Kenntniss der fossilen Kreideflora von Kunstadt in Mähren, p. 18, pl. 6, figs. 8–14, 1896.

Family MORACEAE

Genus ARTOCARPUS Forster

Artocarpus cretacea Berry, n. sp.

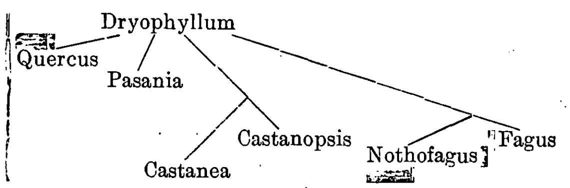
Plates VIII, IX

Leaves large, elliptical or broadly ovate, deeply divided into long, narrow pinnate segments. Estimated length 40 centimeters; maximum width about 22 centimeters, in the median region. Texture coriaceous. Apex acuminate. Base decurrent. This species is unfortunately based upon fragments, the largest of which are shown on Plate IX. These show, however, the apex, the base, and a median portion of the leaf, and I have had in addition a sketch of a larger median portion made by E. S. Perry from a specimen in place in the clay pit. From all this material the restoration shown on Plate IX, greatly reduced in size, has been reconstructed. The reader should bear in mind that such features as the actual number of lobes may have been more or less or the direction of the lobes below the apical portion represented by actual specimens may have been more ascending. Similarly the sinuses may not all have been so deep as in the median and basal regions actually represented by specimens. Aside from these features the restoration is absolutely correct.

The species may now be described in more detail. The leaf is divided into about ten pairs of opposite to alternate linear-lanceolate acuminate lobes separated by nearly parallel sinuses which extend almost to the midrib, the lamina in these regions constituting little more than a narrow wing. The lobes are somewhat irregular in size and spacing, especially in the apical and basal portions of the leaf; they expand slightly outward, and some of those in the median portion of the leaf, which form an angle of about 65° with the midrib, develop a subordinate rounded lobule on their distal margins about two-thirds of the distance from the base to the tip. The basal lobes are more ascending, and the apical lobes are especially unsymmetrical and falcately ascending. The petiole is very stout, of unknown length but presumably short, with winged margins formed by the decurrent lateral margins of

This well-marked small leaf conforms in its characters to the genus *Dryophyllum* and also shows many characters prenuncial of the genus *Fagus* of this family, a fact which has suggested the specific name. The character of the margin and the details of venation are well shown in the figured enlargement of a portion of the leaf. Among previously described fossil forms the present species shows considerable resemblance to a species from the Patoot beds of Greenland which Heer described[43] as *Quercus marioni* but which is probably a *Myrica* and not a *Quercus*.

The genus *Dryophyllum* embraces a large number of well-characterized forms found throughout the late Upper Cretaceous and early Eocene of the Northern Hemisphere. It has long been considered, and rightly so, the ancestral stock of *Castanea*, *Castanopsis*, *Pasania*, and *Quercus*. Its relationship to the modern genus *Fagus* has not been so clear, but the present Ripley species shows plainly that *Fagus* was undoubtedly derived from the same stock. A great many Cretaceous species of *Quercus* have been described, largely on insufficient evidence, and a large number of the earlier fossil oaks of the willow-leafed and chestnut-oak types are probably not true oaks. The present distribution of the family is a subject of exceeding interest. The direct ancestry of the modern forms is still obscure, and much more information is needed regarding the Tertiary forms, especially of the Asiatic region. The general relationship among the different genera may be expressed diagrammatically as follows:



Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Genus FAGUS Linné

Fagus ripleyensis Berry, n. sp.

Plate V, figure 6; Plate VII, figure 1

Leaves of medium size, widest in the middle and narrowing about equally to both ends. Apex acute. Base broadly cuneate. Margins entire at base, above which remotely and coarsely crenate. Texture subcoriaceous. Length about 8 centimeters; maximum width about 3.5 centimeters. Petiole stout, enlarging proximad, about 9 millimeters in length. Midrib stout, prominent, curved. Secondaries thin, subparallel; about eleven equally spaced pairs diverge from the midrib at approximately regular intervals at angles of about 50° to 55°, pursue a but slightly curved ascending course, and terminate in the marginal teeth. Tertiaries obsolete.

Five Upper Cretaceous species have been referred to the genus *Fagus*—one from Saxony, one from Northwest Territory (Peace River), and three from the Dakota sandstone. None of these are at all similar to the present species, nor has the genus been recorded from the Upper Cretaceous of Greenland. The existing beeches form a compact group of four species of eastern Asia, southeastern North America, and Europe. Their segregation indicates a former more extensive distribution, abundantly verified by the numerous species of the geologic record.

Leaves similar to *Fagus ripleyensis* have been referred to both *Quercus* and *Planera* but are in my judgment representative of a different stock.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Order URTICALES

Family ULMACEAE

Genus CELTIS Linné

Celtis cretacea Berry, n. sp.

Plate VII, figure 2

Leaves of medium size, ovate, with a gradually narrowed acuminate tip and a broadly rounded base. Margins entire in the rounded basal region, above which they are regularly coarsely serrate. Leaf substance thin. Length about 9 centimeters; maximum width, in the basal half of the leaf, about 3 centimeters. Petiole stout, curved, expanded at base, about 1.2 centimeters in length. Midrib stout, curved, prominent on the lower surface of the leaf. Secondaries thin, five or six pairs, the basal pair opposite and slightly suprabasilar, the remainder alternate; they diverge from the midrib at rather wide angles and curve upward, ascending parallel with the lateral

[43] Heer, Oswald, Flora fossilis arctica, vol. 7, p. 23, pl. 56, figs. 1–6, 1883.

the basal lobe. The midrib is very stout and prominent on the under side of the leaf. The secondaries or midveins of the lobes are relatively stout, prominent on the under side; they conform to the angle and direction of the lobes, terminating at the tips of the lobes. The tertiary venation is exceedingly fine and largely immersed in the leaf substance. It comprises irregularly spaced tertiaries, of which some preserve a camptodrome course but more are lost in the prevailingly quadrangular and rather open areolation.

The present species is strikingly distinct from previously described species of *Artocarpus* in its extremely pinnate lobation, departing in this respect from both the recent and the described fossil forms. If it is correctly identified it would seem that so specialized a form implies the existence of other and less modified forms in the same or antecedent Cretaceous deposits. The only other fossil forms that it seems at all necessary to discuss in the present connection are *Artocarpus dissecta* Knowlton,[45] from the Vermejo formation of southeastern Colorado, and *Liriodendron snowii* Lesquereux,[46] from the Dakota sandstone of Kansas. Both are clearly distinct from the Ripley form, which they resemble in their pinnate lobation, and both are strikingly alike in outline and venation, a feature not discussed by Knowlton. It would seem that the anomalous form of *Liriodendron snowii* absolutely precludes its reference to *Liriodendron*, the most bizarre fossil forms of which it does not in the least resemble, and that it should be referred to the Euartocarpeae; at least both *Liriodendron snowii* and *Artocarpus dissecta* are congeneric, and if *Artocarpus cretacea* is correctly identified then the other two should be referred to the same or an allied genus. Similarly *Liriodendron quercifolium* Newberry [47] is open to suspicion and the same interpretation. This would trace back the ancestral breadfruit in North America both in the East and in the West to about the same time that it appeared in the Cretaceous record of west Greenland.

In the existing flora the two score or more known species of *Artocarpus* are indigenous to the southeastern Asiatic region, although some of them are cultivated in all tropical countries. The breadfruit is found throughout Oceanica and was present in Hawaii and the Marquesas when those islands were first visited by Europeans. It was introduced into the West Indies in 1793. Of the tribe Euartocarpeae, of which *Artocarpus* is the largest existing genus, five genera are confined to Central and South America, one is confined to tropical west Africa, two to the southeastern Asiatic region, one to Borneo, and one ranges from Japan to Australia. Though the geologic history of *Artocarpus* is only imperfectly known, at least 27 different fossil species have been described. The oldest that is certainly identified is a well-marked form based on characteristic leaves and parts of the fruit that show the typical surface features. It was fully described by Nathorst [48] and came from the Atane beds (Cenomanian) of west Greenland. Here would belong the Dakota sandstone form called *Liriodendron snowii* by Lesquereux, which is found from Kansas to Texas. Slightly younger is a less well-defined form recorded from the Emscherian of Westphalia and the somewhat doubtful genus *Artocarpophyllum* of Dawson, from the Upper Cretaceous of Vancouver Island. Another Cretaceous species is recorded from the Laramie formation, and the genus is widely distributed in the basal Eocene of North America. It continued in the Gulf region until the end of the Oligocene, the latest recorded occurrence being in the sands of the Alum Bluff formation at Alum Bluff on Apalachicola River, western Florida. On the Pacific coast it is found in deposits in California and Oregon which are referred to the Miocene. In the European area a great variety of forms described by Principi have been found in lower Oligocene (Sannoisian) of Italy (Liguria). The genus is also represented in the Tongrian of France, the Tortonian of Baden, the Pontian of France and Italy, and the Pliocene of

[45] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 267, pl. 42, fig. 6, 1917.

[46] Lesquereux, Leo, U. S. Geol. Survey Mon. 17, p. 209, pl. 29, figs. 1, 2, 1892.

[47] Newberry, J. S., U. S. Geol. Survey Mon. 26, p. 81, pl. 51, figs. 1–6, 1896.

[48] Nathorst, A. G., K. Svenska Vet.-Akad. Handl., Band 24, No. 1, 10 pp., 1 pl., 1890.

Italy. It is present in both the Pliocene and Pleistocene of the island of Java.

Artocarpus is said to be represented by petrified wood in the Oligocene of the island of Antigua, and it was evidently a member of the American flora from the Upper Cretaceous until late in the Tertiary, although, like the genera *Cinnamomum*, *Nipa*, and *Phoenix*, it is not represented in post-Pleistocene American floras.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, and Cooper pit, near Hollow Rock, Carroll County, Tenn.

Genus FICUS Linné

Ficus ripleyana Berry, n. sp.

Plate VII, figure 6

Leaves lanceolate, widest in the middle region and tapering almost equally upward and downward, the apex being slightly more extended and acuminate. Base acute, decurrent. Margins entire, somewhat undulate. Texture coriaceous. Length about 15 centimeters; maximum width about 3.75 centimeters. Petiole very stout and round, about 1 centimeter in length. Midrib very stout, prominent on the under surface of the leaf. Secondaries thin but well marked, numerous, diverging from the midrib at angles of about 65°–70° at regular intervals of about 4 millimeters and abruptly camptodrome in the marginal region. Areolation typical of the modern fig leaves of the *Ficus benjaminea* and *Ficus elastica* type.

The general form of this species is very similar to that of the mostly widespread and abundant Upper Cretaceous species such as *Ficus crassipes* Heer, *F. krausiana* Heer, and *F. atavina* Heer, with which specimens failing to show venation are liable to be confused. *Ficus georgiana* Berry,[49] from the Ripley of Georgia, is relatively much wider, with a more open venation and more truncatedly rounded base. *Ficus matawanensis* Berry,[50] of the Matawan formation in the New Jersey area, has a similar venation but a more linear form and stouter midrib. *Ficus atavina* Heer[51] has a somewhat similar venation but is a relatively much narrower, more elongated form; the associated *Ficus crassipes* Heer and *Ficus krausiana* Heer have a decidedly different venation.

Occurrence: McNairy sand member of the Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Ficus krausiana Heer

Ficus krausiana Heer, Schweizer. paleont. Gesell. Neue Denkschr., vol. 23, p. 15, pl. 5, figs. 3–6, 1869.

Frič, Naturwiss. Landesdurchforschung Böhmen Archiv, vol. 4, pp. 18, 94, 1878.

Lesquereux, U. S. Geol. Survey Mon. 17, p. 81, pl. 1, fig. 5, 1892.

Hollick, U. S. Geol. Survey Mon. 50, p. 58, pl. 9, fig. 9; pl. 10, figs. 1–3, 1907.

Berry, U. S. Geol. Survey Prof. Paper 84, pp. 38, 110, pl. 11, figs. 4–7; pl. 19, fig. 4, 1914; Maryland Geol. Survey, Upper Cretaceous, p. 823, pl. 59, fig. 1, 1916.

Ficus beckwithii Lesquereux, Cretaceous and Tertiary floras, p. 46, pl. 16, fig. 5; pl. 17, figs. 3, 4, 1883.

Ficus suspecta Velenovsky, Die Flora der böhmischen Kreideformation, pt. 4, p. 10, pl. 5, figs. 6, 9, 1885.

Leaves generally large, ovate-lanceolate, broadest at or below the middle. Apex and base acutely pointed, the apex often extended and attenuated. Petiole and midrib stout. Secondaries regular, open, thin, ascending, camptodrome, branching from the midrib at angles of 45° or more. Length about 17 centimeters.

This well-known Upper Cretaceous species was described originally from specimens found in the Cenomanian of Moravia, and it has been subsequently recorded from both the Cenomanian and Turonian of Bohemia. It occurs at a large number of American localities. In the West it occurs in the Dakota sandstone; in the East it is common from Marthas Vineyard to Alabama and is present between these limits in Maryland, North Carolina, South Carolina, and Georgia. These occurrences are all in beds of Magothy age or younger. In both North and South Carolina *Ficus* fruits are associated with this species,

[49] Berry, E. W., U. S. Geol. Survey Prof. Paper 84, p. 111, pl. 20, fig. 1, 1914.

[50] Berry, E. W., Torrey Bot. Club Bull., vol. 38, p. 399, pl. 19, fig. 3, 1911.

[51] Heer, Oswald, Flora fossilis arctica, vol. 6, pt. 2, p. 69, pl. 11, figs. 5b, 7b, 8b; pl. 17, fig. 8b; pl. 19, fig. 1b; pl. 20, figs. 1, 2, 1882.

but whether they are to be referred to it or to some of the other rather numerous species of *Ficus* that occur at the same localities can not be determined.

It is especially abundant in the Middendorf arkose member of the Black Creek formation in South Carolina and occurs in the lower Eutaw in both Georgia and Alabama, and in the Coffee sand member of the Eutaw formation in western Tennessee. It has not heretofore been recorded from a horizon as young as the Ripley, nor is it at all common in the McNairy sand member. In the West it does not appear to have been present in post-Dakota time.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Ficus obtusa-sessilia Berry, n. sp.

Plate VII, figures 3, 4

Spatulate leaves of medium size, widest above the middle, with a broadly rounded tip and a cuneate, eventually truncate and clasping base, with a thin but somewhat polished surface and evenly rounded entire margins. Length about 9 centimeters; maximum width about 1.9 centimeters. Midrib stout and prominent, expanding rapidly toward the base. Secondaries numerous, thin, subparallel, diverging from the midrib at angles of 50° or more, straightly ascending, their tips joined some distance within the margins by flat arches. Tertiaries thin, comprising a series of loops along the margins and narrow transversely elongated areoles within the secondaries.

The venation is that typical of the lanceolate figs of the *Ficus elastica* type, but the obtuse tip and broadly clasping sessile base are unique and serve at once to distinguish this species. Among previously described fossil forms the present species has the same size and outline as the leaves from the Magothy formation of New Jersey which I described some years ago [52] as *Santalum novae-caesareae*, but that was a doubtful generic determination, and the form differs decidedly from the present one in its ascending camptodrome secondaries.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Ficus crassipes (Heer) Heer

Plate VII, figure 5

Proteoides crassipes Heer, Flora fossilis arctica, vol. 3, pt. 2, p. 110, pl. 31, figs. 6–8, 1874.

Ficus crassipes Heer, idem, vol. 6, pt. 2, p. 70, pl. 17, fig. 9a; pl. 24, figs. 1, 2, 1882.

Lesquereux, U. S. Geol. Survey Mon. 17, p. 79, pl. 13, fig. 3, 1892.

Berry, U. S. Geol. Survey Prof. Paper 84, pp. 37, 110, pl. 10, fig. 4; pl. 12, figs. 8–10, 1914; Maryland Geol. Survey, Upper Cretaceous, p. 821, pl. 58, fig. 5; pl. 59, figs. 2, 3, 1916.

Leaves entire, narrowly lanceolate, about equally tapering to the acuminate apex and base. Length 12 to 20 centimeters; greatest width, in middle part of leaf, 1.8 to 2.5 centimeters. Texture coriaceous. Midrib stout, often extraordinarily so. Secondaries thin, open, ascending, camptodrome.

This species was described originally from material obtained in the Atane beds of western Greenland, and the first rather fragmentary specimens collected suggested a relationship with the genus *Proteoides*. Subsequently the original describer referred it to *Ficus*, where it undoubtedly belongs. Lesquereux has recorded it from the Dakota "group," and it is common in the Magothy formation of the northern Atlantic Coastal Plain and in the Black Creek formation of North Carolina. It occurs in the Eutaw formation of Georgia and is especially common in the Middendorf arkose member of the Black Creek formation in South Carolina. It is not especially common in the Tuscaloosa formation. It occurs in the Coffee sand member of the Eutaw formation in western Tennessee and in the Bingen sand of Arkansas. It does not appear to be common in the Ripley, nor has it been found in strata younger than the Dakota sandstone in the West.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

[52] Berry, E. W., New Jersey State Geologist Ann. Rept. for 1905, p. 153, pl. 20, fig. 7; pl. 22, fig. 3, 1906.

Ficus celtifolius Berry

Plate X, figure 1

Ficus celtifolius Berry, U. S. Geol. Survey Prof. Paper 84, p. 37, pl. 12, fig. 4, 1914.

Leaves small, entire, elliptical-ovate, with an obtusely pointed apex and a broadly rounded base. Margins entire. Texture subcoriaceous. Petiole relatively stout, of variable length. Midrib stout. Secondaries stout, remote, three or four pairs, the lower pair opposite, diverging from the midrib at its base or just above and functioning as lateral primaries, the rest alternate and less straight. All branch from the midrib at angles of about 45° and are camptodrome some distance from the margin. Tertiaries distinct, the inner transverse, the peripheral camptodrome in uniform broad arches.

This handsome species was first found in the Middendorf arkose member of the Black Creek formation in South Carolina, where it is rare. The South Carolina form was 5.5 centimeters in length and 3.7 centimeters in maximum width in the basal half of the leaf and had a petiole 6 millimeters in length. The Ripley form, which is not common in the collections, is obviously identical specifically with the type but is somewhat smaller, being just over 4 centimeters in length and 3.1 centimeters in maximum width, with a petiole 9 millimeters in length. It is very much like the smallest leaves in the Vermejo flora which Knowlton refers to *Ficus leei*.[53]

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County. Tenn.

Ficus leei Knowlton

Ficus leei Knowlton, U. S. Geol. Survey Prof. Paper 98, p. 338, pl. 90, fig. 2, 1916; Prof. Paper 101, p. 261, pl. 39, figs. 1–6; pl. 40, figs. 1, 2, 1917.

This species, which is exceedingly common in the Vermejo formation of southeastern Colorado and northeastern New Mexico, is described by Knowlton as follows:

> Leaves very thick and fleshy in texture, the nervation strongly impressed; shape broadly elliptical, ovate-elliptical, or sometimes nearly orbicular the base from rounded and truncate to deeply cordate-auriculate, the apex abruptly rounded and obtuse or sometimes slightly pointed; margin entire or occasionally very slightly undulate; petiole short, thick; nervation strong, the midrib straight or at most slightly flexuose, with from three to six pairs of strong secondaries, the lowest pair arising at the base of the blade, of the same size as the midrib and together producing a three-ribbed effect; the lowest pair of secondaries (or ribs) with from three to as many as ten tertiary branches on the outside, the lowest of these, in the larger leaves, nearly at right angles to the midrib, with a number of quaternary branches on the lower side, which supply the extreme basal portion of the blade; the secondaries on the midrib are usually remote, alternate, or subopposite, and sometimes with a few branches on the outside; all nervation camptodrome and arching just inside the margin; nervilles numerous, strong, mainly unbroken; finer nervation producing an abundance of irregularly quadrangular areolae.
>
> In all these leaves the nervation is essentially the same. Thus, regardless of size, all are three-ribbed from the very base of the blade, and all show the same camptodrome secondaries or their branches, with the same strong, mainly unbroken nervilles. As the leaves become more deeply heart-shaped at base the secondary and tertiary nerves which supply the basal portion of the blade become more and more branched.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock. Carroll County, Tenn. (not common).

Ficus cooperensis Berry, n. sp.

Plate X, figure 2

Leaves fairly large, ovate, with full rounded margins, widest below the middle, with a pointed, not prolonged, apex and a full base rounded in general form but slightly decurrent at the petiole. Texture coriaceous. Length about 11 centimeters; maximum width about 5.5 centimeters. Petiole very stout, curved, about 1.5 centimeters in length. Midrib very stout, prominent on the lower surface of the leaf, slightly curved. Secondaries thin but prominent, about nine opposite to alternate subparallel pairs diverge from the midrib at angles of about 45° and are camptodrome in the marginal region. Tertiaries thin but well marked, percurrent.

This belongs to a type of ovate fig leaf which is common in both recent and fossil floras, one in which the basal secondaries tend to be slightly more prominent than those above them and eventually lead to forms like *Ficus schimperi* Lesquereux or *Ficus pseudopopulus* Lesquereux, found in the lower Eocene of this same region.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

[53] See, for example, U. S. Geol. Survey Prof. Paper 101, pl. 39, fig. 3, 1917.

Ficus georgiana Berry

Ficus georgiana Berry, U. S. Geol. Survey Prof. Paper 84, p. 111, pl. 20, fig. 1, 1914.

This species is represented in the collections from the Ripley of western Tennessee only by the lower half of a single leaf and is therefore included with some hesitation, although the rounded base and decurrent margins appear characteristic. The species was described by me in 1914 as follows:

Leaf ovate-lanceolate in outline, gradually tapering to an acute point. Proximately the leaf is broadly and abruptly rounded to a point within 2 to 3 millimeters of the midrib, thence decurring as a narrow wing 1 millimeter or less in width and preserved for a distance of 1 centimeter. Length about 17 centimeters. Greatest width, which is near the base of the leaf, 4.5 centimeters. Midrib fairly stout. Margins entire. Secondaries thin, parallel, and numerous, branching from the midrib at angles of about 50° and curving upward distally, camptodrome.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn. Cusseta sand member of Ripley formation, near Buena Vista, Marion County, Ga. (the type locality for this species).

Ficus carrollensis Berry, n. sp.

Plate X, figure 3

Leaves of variable size, lanceolate, with an acuminate tip and a gradually narrowed acuminate base. Margins entire. Texture coriaceous. Length from 9 to 16 centimeters; maximum width from 2 to 3 centimeters. Petiole short and stout. Midrib stout, prominent on the lower surface of the leaf. Secondaries thin, numerous, subparallel, diverging from the midrib at angles of about 50° at intervals of about 2 millimeters, pursuing a rather straight ascending course to the marginal region, where their tips are joined by arches subparallel with the margins. Areolation thin, reticulate, mostly obsolete.

These leaves have a form and venation such as is frequently referred to *Eucalyptus* or *Myrtophyllum* but is more strictly comparable to that of lanceolate species of figs of the *Ficus elastica* type. The present species shows considerable resemblance to *Ficus laurophylla* Lesquereux, of the Dakota sandstone of the West and the Magothy formation of the Atlantic Coastal Plain and may be descended from that species. It differs in having a less prominent midrib, more ascending secondaries, and less prominent areolation. It is a common form in the McNairy sand member, being much more abundantly represented in the collections than any other of the *Ficus* species present. It may be matched by a considerable number of existing species of *Ficus* and also suggests comparisons with the lower Eocene *Ficus wilcoxensis* Berry, which may represent a Wilcox descendant of the present form. It is named from its occurrence in Carroll County.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Order PLATANALES

Family PLATANACEAE

Genus PLATANUS Linné

Platanus ripleyensis Berry

Platanus ripleyensis Berry, U. S. Geol. Survey Prof. Paper 112, p. 84, pl. 32, fig. 6, 1919.

This species was described in the publication cited above. So far as known it is confined to the marine Ripley near Eufaula, Barbour County, Ala.

Platanus sp. Berry

Platanus sp. Berry, U. S. Geol. Survey Prof. Paper 112, p. 85, pl. 31, figs. 7, 8, 1919.

This form, of which only incomplete material is known, was described and figured in the publication cited above. It occurs in the Ripley of eastern Alabama. In several particulars it suggests the genus *Credneria* of Zenker.

Occurrence: Ripley formation, Cowikee Creek, Barbour County, Ala.

Order RANALES

Family MAGNOLIACEAE

Genus LIRIODENDRON Linné

Liriodendron laramiense Ward

Plate XI, figure 13; Plate XXIII, figure 6

Liriodendron laramiense Ward, U. S. Geol. Survey Bull. 37, p. 102, pl. 48, fig. 2, 1887.

Leaves relatively large, rectangular, with nearly vertical sides, a wide truncate base and a deeply emarginate apex, giving it a butterfly-like form. Apical lobes inequilaterally rounded. Length 9 to 10 centimeters; maximum width 9 to 10 centimeters; petiole stout, not alate, its total length unknown. Midrib stout, straight, and prominent on the lower surface of the leaf. Secondaries pinnate, five or six pairs, stout and prominent proximad, diverging from the midrib at angles of about 60°, camptodrome, brachiodrome; the suprabasilar pair, which are subopposite, curve upward more than the others and give off numerous camptodrome branches from their outer sides; eventually the secondaries unite with those adjacent to form the characteristic *Liriodendron* loops some distance within the margin, which is bordered all around by smaller loops of the third and fourth order. Nervilles traversing the larger areas percurrent and straight or curved, or forking and inosculating in the middle region; those within the festoons resolving into an areolation of regular quadrate or rectangular meshes. Texture subcoriaceous.

This is a very characteristic type of *Liriodendron* leaf in size, outline, and venation. The present specimens from Tennessee are almost exact counterparts of the less perfect type, which came from the Montana group at Point of Rocks, Wyo. The type failed to show the deeply emarginate sinus reaching two-fifths of the distance to the base, but as the two agree exactly in all the details observable there can be no doubt that they are identical or that the Point of Rocks form had a similar emarginate apex.

The form of *Liriodendron laramiense* is one often approximated by leaves of the modern *Liriodendron tulipifera* in localized situations, such as are supposed to have a phylogenetic bearing. That it does not represent such a variant of a normally lobate *Liriodendron* of Upper Cretaceous age is substantiated by the exact agreement in form between these two occurrences over 1,000 miles apart and the entire absence of any other forms of *Liriodendron* either at these localities or in beds of the same age in the vicinity. In general outline *Liriodendron laramiense* is somewhat suggestive of *Liriodendron alatum* Hollick,[54] of the Belly River and Vermejo formations, particularly the large oblong type of that species. It is less like the smaller and more rounded specimens of *L. alatum* figured by Knowlton[55] and differs from all of these in lacking the conspicuous alate petiole, which is so striking a feature of that species.

The past history of *Liriodendron* is exceedingly interesting and has been commented upon at length by me in a number of earlier papers.[56] At the present time 28 fossil species have been recorded, some of which are of doubtful value, although the majority are convincing evidence of the past variation, abundance, and wide distribution of the genus. Twenty-three of these fossil species are recorded from the Upper Cretaceous; all of these except one are from North America, and this one, *Liriodendron schwarzii* Richter,[57] is an exceedingly doubtful identification from the Senonian of Saxony, which I have no hesitation in disregarding entirely. The only other recorded Cretaceous occurrence of *Liriodendron* in Europe is the identification by Engelhardt[58] of *Liriodendron meekii* Heer in the Cenomanian of Niederschoena, Saxony, and this same species has been reported by Kurtz[59] from the Upper Cretaceous of Argentina. As neither of these occurrences has been figured it is impossible to speak with absolute assurance, but the fact that *Liriodendron meekii* is one of the least well-characterized species of *Liriodendron* and one to which a great variety of leguminous leaflets have been referred by former students leads me to disregard also these supposed Cretaceous occurrences in Europe and South America as having been based upon incorrect identifications.

This conclusion is to some extent rendered more certain by the great variety of perfectly characteristic forms of *Liriodendron* in North America at that time. Here they are found from the Atlantic to the Pacific in great abundance. In the present Atlantic Coastal Plain region they extend from Long Island to Alabama, Tennessee, Arkansas, and Texas. In

[54] Torrey Bot. Club Bull., vol. 21, p. 467, pl. 220, 1894.

[55] Knowlton, F. H., U. S. Geol. Survey Bull. 163, p. 13, pl. 1, fig. 6, 1900; U. S. Geol. Survey Prof. Paper 101, p. 269, pl. 48, fig. 3, 1918.

[56] Berry, E. W., Torrey Bot. Club Bull., vol. 28, pp. 493–498, pls. 41, 42, 1901; Torreya, vol. 1, pp. 105–107, pls. 1, 2, 1901; vol. 2, pp. 33–37, pls. 1, 2, 1902; vol. 3, pp. 129–132, 4 figs., 1903; Bot. Gaz., vol. 34, pp. 44–63, 3 figs., 1902.

[57] Richter, P. B., Beiträge zur Flora der oberen Kreide Quedlinburgs, pt. 1, p. 6, pl. 1, fig. 10, 1905.

[58] Engelhardt, Hermann, Naturwiss. Gesell. Isis in Dresden Abh. 7, p. 100, 1891.

[59] Kurtz, Federico, Mus. La Plata Rev., vol. 10, p. 53, 1903.

the West they are found in Kansas, Nebraska, Colorado, Montana, Utah, Iowa, and on Vancouver Island. Most of these are clearly defined and readily recognized distinct species, although it is possible that some of the eleven species recorded from a small area in the Dakota sandstone of Kansas and Nebraska may represent merely variations of fewer botanic species. In North American Tertiary strata *Liriodendron* has not yet been recognized, although it would seem that this genus must have been present, for the existing species is very common in the Pleistocene of southeastern North America. In Europe, on the other hand, *Liriodendron* appears to have been abundant, especially in the later Tertiary, as its maximum occurrences are in the Pliocene and come right down to the first glacial deposits, in which fruits and seeds were found which the Reids[60] were unable to distinguish from the existing American species. Presumably the genus was as abundant in Asia, as undoubted leaves are recorded by Schmalhausen[61] from the Altai region of central Asia in beds of probably Pliocene age. This form undoubtedly represents the stock from which came the existing Chinese variety.

The geologic history of the genus is graphically summarized on the accompanying sketch map of the world (fig. 5), the only drawback to a rather complete understanding of this history being the lack of information about the Cretaceous floras of Asia, a knowledge of which would probably greatly modify our present conceptions. All the undoubted Cretaceous records are seen to be North American, and all the Tertiary records are Arctic and Eurasian. The results of Pleistocene glaciation restricted the range of the American form and its Chinese variety to the regions shown. Although many paleogeographers have questioned a land bridge across the north Atlantic and see in the successive convergences and divergences of the terrestrial faunas and floras of Europe and North America a succession of interchanges and separations in the Bering Strait region, the presence of an early Tertiary *Liriodendron* in west Greenland, Iceland, the British Isles, and central Europe would seem to indicate a north Atlantic path of migration as shown on the accompanying map.

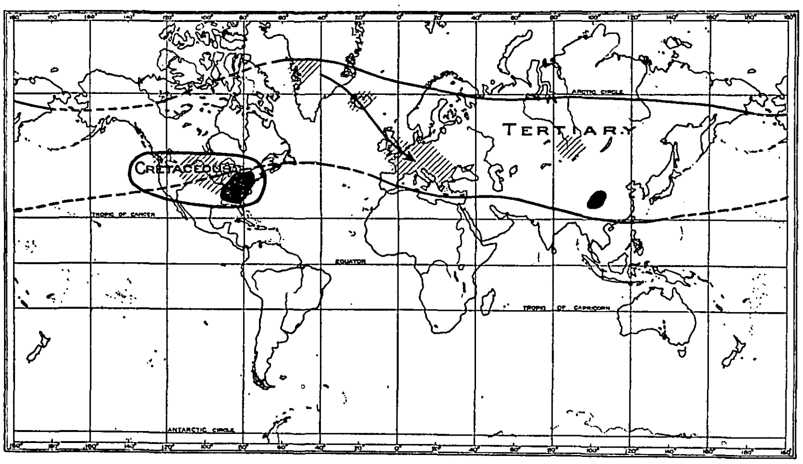


FIGURE 5.—Sketch map of the world summarizing the geologic history of *Liriodendron*. Cretaceous occurrences, lined area within heavy ellipse; Tertiary occurrences, lined areas within latitudinal lines; existing distribution in solid black. Arrow indicates the Upper Cretaceous-Eocene path of migration

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Genus MAGNOLIA Linné

Magnolia capellinii Heer

Magnolia capellinii Heer, Phyllites cretacées du Nebraska, p. 21, pl. 3, figs. 5, 6, 1866; Flora fossilis arctica, vol. 3, Abt. 2, p. 115, pl. 33, figs. 1–4, 1874; idem, vol. 6, Abt. 2, p. 90, pl. 24, figs. 3–5, pl. 25, figs. 1–3, pl. 45, fig. 1, 1882.

Velenovsky, Die Flora der böhmischen Kreideformation, pt. 2, p. 20, pl. 7, figs. 8, 9, 1883.

[60] Reid, C. and E. M., Pliocene flora of the Dutch-Prussian border, p. 93, pl. 8, figs. 1–5, 1915.

[61] Schmalhausen, J., Palaeontographica, vol. 33, p. 211, pl. 21, figs. 20, 21, 1887.

Lesquereux, The flora of the Dakota group, p. 203, pl. 46, fig. 1, 1892.
Dawson, Roy. Soc. Canada Trans., 1st ser., vol. 11, sec. 4, p. 63, pl. 11, fig. 49; pl. 13, fig. 49a, 1894.
Hollick, New York Acad. Sci. Trans., vol. 12, p. 234, pl. 6, fig. 6, 1893; New York Bot. Garden Bull., vol. 3, p. 413, pl. 78, fig. 3, 1904; The Cretaceous flora of southern New York and New England, p. 63, pl. 17, figs. 3, 4, 1907.
Berry, Torrey Bot. Club Bull., vol. 31, p. 76, pl. 3, fig. 3, 1904; New Jersey Geol. Survey Ann. Rept. for 1905, p. 138, 1906; Torrey Bot. Club Bull., vol. 34, p. 195, pl. 12, figs. 4, 5, 1907; U. S. Geol. Survey Prof. Paper 112, p. 89, pl. 18, fig. 1; pl. 32, fig. 7, 1919.
Magnolia sp. Berry, Johns Hopkins Univ. Circ., new ser., No. 7, p. 81, 1907.

This species has been repeatedly described and figured in recent years. It has been found at but a single locality in the Ripley and is not altogether typical, so that there is a possibility that the Ripley material represents a different species.

Occurrence: Eutaw formation (basal beds), McBrides Ford, Chattahoochee County, Ga. Ripley formation (McNairy sand member), 2½ miles southwest of Selmer, McNairy County, Tenn.

Family MENISPERMACEAE

Genus MENISPERMITES Lesquereux

Menispermites variabilis Berry

Menispermites variabilis Berry, U. S. Geol. Survey Prof. Paper 84, p. 113, pl. 21, figs. 1–4, 1914.

This species was discovered in the Eutaw formation of western Georgia and described in the following terms:

> Leaves of medium size, trilobate but variable in shape. Length about 9 or 10 centimeters. Greatest width, which is from tip to tip of the laterally directed lobes, as much as 16 centimeters in one specimen. Lobes broad and separated by wide, shallow sinuses. Margin entire but in some specimens scalloped, the scallops rounded and nearly equilateral, separated by acute sinuses. Base peltate, broadly rounded as in *Aspidiophyllum* or with a cordate sinus, which does not, however, reach the top of the petiole. Primaries stout, three or four in number, palmately divergent from the peltate base, three of them generally equal in caliber. Secondaries slender and numerous, some apparently camptodrome and others craspedodrome.

This peculiar species is represented by fragmentary remains which contribute nothing toward a better understanding of its characters. Exceedingly variable in outline, as are most of the fossil species that have been referred to *Menispermites*, its most constant features are its trilobate form and peltate base, well shown in the Ripley specimens. A more complete knowledge of the species must await better material, but it is clearly distinct from other members of Upper Cretaceous floras and is rather readily recognized even in fragmentary specimens. The type came from McBrides Ford, in Chattahoochee County, Ga., and the present occurrence demonstrates for the species a geologic range through the Eutaw and a considerable portion of the Ripley formation. Nothing closely similar from the Upper Cretaceous floras of other regions has been described.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Order PAPAVERALES

Family CAPPARIDACEAE

Genus CAPPARIS Linné

Capparis proeocenica Berry, n. sp.

Plate X, figures 4, 5

Graceful leaves of small size, oblanceolate, widest medianly, with a rounded tip and acute decurrent base and entire, evenly rounded margins. Length from 3.5 to 5 centimeters; maximum width from 6 to 11 millimeters. Petiole short and stout, about 2.5 millimeters in length in the smaller specimens to 6 millimeters in the larger. Midrib stout and straight. Secondaries thin, numerous, and subparallel; they diverge from the midrib at angles of about 45° and are camptodrome in the marginal region; the lowest pair are opposite and parallel with the margins.

This species presents some features that suggest the Leguminosae, but on the other hand it is very similar to certain existing American species of *Capparis*, as well as to the smaller leaves of *Capparis eocenica* Berry,[62] which is a common form in the lower Eocene (Wilcox group) of the Mississippi embayment region. This resemblance is so conclusive that the present form is regarded as ancestral to the Wilcox form, a feature emphasized in the name. The genus has not heretofore been recognized in beds as old as the Upper Cretaceous, and the

[62] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 218, pl. 44, figs. 1–3; pl. 52, fig. 5, 1916.

present species is not common in the collections on which this paper is based.

The genus *Capparis* embraces more than 100 existing species of shrubs or small trees, chiefly tropical, and although found also in the Eastern Hemisphere most of the species occur in the American Tropics, particularly in Central and South America. *Capparis domingensis* is a small Antillean tree, and its leaves, much like this Cretaceous species, are rather smaller than those of most of the other members of the genus. Several of the West Indian forms—for example, *Capparis ferruginea* Linné, *C. amygdalina* Lamarck, and *C. cynophallophora* Linné—are shrubs or small trees of the strand flora, *C. ferruginea* being especially common in such an environment. The fossil species is somewhat similar to a form from the Pliocene of Bolivia described by Engelhardt [63] as *Capparis multinervis*, which is compared with the existing *Capparis angustifolia* Humboldt, Bonpland, and Kunth, of southern Mexico; *Capparis jacobinae* Moricaud, of Brazil; and *Capparis longifolia*, from the Antilles, all forms comparable with *Capparis prococenica*. Unger [64] many years ago described *Capparis ogygia*, from the middle Miocene of Parschlug, Styria, but Schimper [65] referred that species to the Phaseoleae. In addition Schenk has described petrified material from the Tertiary of Egypt as *Capparidoxylon*, and F. von Müller has described two or three species of fruits of the genera *Dieune* and *Plesiocapparis* from the late Tertiary of Australia. *Plesiocapparis* is said to be most closely related to the section *Busbeckia* of *Capparis*.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Order ROSALES

Family MIMOSACEAE

Genus ACACIAPHYLLITES Berry

Acaciaphyllites cretaceum Berry, n. sp.

Plate X, figure 6

Inequilateral sessile falcate-lanceolate phyllodelike leaflets, widest below the middle, with acute apex and base and entire slightly undulate margins. Texture firm and scarious. Venation comprising about ten subparallel acrodrome veins, the central ones approximated to simulate a midrib, the lateral ones equidistant. They are connected by many thin oblique forking nervilles.

This unique form, represented by two specimens, finds its closest modern analogue in certain species of *Acacia* in which the leaves are reduced to phyllodes, as, for example, in *Acacia longifolia* Willdenow. The genus *Acacia* comprises between 450 and 500 existing species of tropical and subtropical regions, largely oriental in their distribution. The section Phyllodineae, to which the present fossil appears referable, includes more than 300 existing species confined to Australia and Oceanica. Similar fossil species are extremely rare, although several are known from the Tertiary of both Europe and America.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Genus MIMOSITES Bowerbank

Mimosites cooperensis Berry, n. sp.

Plate X, figure 7

Petiolulate lanceolate leaflets of somewhat variable size, with pointed tip and narrower cuneate base, slightly inequilateral. Margins entire. Texture subcoriaceous. Petiolule stout, about 2 millimeters in length. Midrib stout, curved, prominent. Secondaries thin but well marked, numerous, camptodrome. Length from 1.4 to 2.5 centimeters; maximum width, slightly above the middle, from 3.5 to 5 millimeters.

This well-marked species is found at both the principal plant-bearing Ripley outcrops in western Tennessee. It appears to possess the characters of the genus *Mimosites*, which is so extensively developed in the lower Eocene (Wilcox group) of the Mississippi embayment region, and may be regarded as the late Upper Cretaceous prototype of those forms.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County; Cooper pit, near Hollow Rock, Carroll County; 2½ miles south of Mifflin, Chester County, Tenn.

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[63] Engelhardt, Hermann, Naturwiss. Gesell. Isis in Dresden Sitzungsber., 1894, p. 7, pl. 1, fig. 18.

[64] Unger, Franz, Genera et species plantarum fossilium, p 443, 1850.

[65] Schimper, W. P., Paléontologie végétale, vol. 3, p. 350, 1874.

Family CAESALPINIACEAE

Genus CAESALPINITES Saporta

Caesalpinites perryensis Berry, n. sp.

Plate X, figure 8

Narrowly obovate, markedly inequilateral sessile leaflets with entire margins, rounded apex, cuneate base, and decidedly coriaceous texture. Length about 3 centimeters; maximum width, in the median region, about 9 millimeters. Midrib very stout, prominent, curved. Secondaries few, remote, irregular, stout, and camptodrome. Tertiary areolation well marked, forming a fine isodiametric mesh.

This is a well-marked species, clearly differentiated from associated forms and those previously described by the peculiar venation. It is represented in the present collections by a single specimen and counterpart.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Caesalpinites ripleyensis Berry, n. sp.

Plate XI, figure 6

Small, elliptical, inequilateral, sessile leaflets, with broadly rounded, distinctly apiculate tip and cuneate base. Margins entire. Texture subcoriaceous. Length about 1.8 centimeters; maximum width, in median region, about 7.5 millimeters. Midrib stout, prominent, straight. Secondaries stout, five or six widely spaced pairs, diverging from the midrib at wide angles, and camptodrome by a single sweeping arch.

Like the other Ripley leaflets of the Leguminosae alliance, this species is rare in the present collections. It resembles somewhat *Caesalpinia middendorfensis* Berry,[66] of the Middendorf arkose member of the Black Creek formation in South Carolina, but is entirely distinct from that species and may be regarded as the prototype of the numerous forms of this type in the lower Eocene (Wilcox group) flora of the Mississippi embayment region.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

[66] Berry, E. W., U. S. Geol. Survey Prof. Paper 84, p. 46, pl. 10, fig. 7, 1914.

Genus BAUHINIA Linné

Bauhinia ripleyensis Berry

Bauhinia ripleyensis Berry, Torrey Bot. Club Bull., vol. 43, p. 294, pl. 16, fig. 1, 1916; U. S. Geol. Survey Prof. Paper 112, p. 100, pl. 23, fig. 7, 1919.

Leaves of medium size, more or less bilobate but much less deeply divided than in the preceding species, obovate. Length along the midrib 4.5 centimeters; from apex of lobes to base 6.7 centimeters; width across upper part of the leaf 5.5 centimeters. Apical sinus open, extending about one-fourth of the distance toward the base of the leaf, its margins at the tip of the midrib forming an angle of about 90°, curving slightly upward and then conspicuously outward to the pointed tips of the lobes, which are directed laterally. Outer margins of the leaf full and rounded, becoming straight toward the broadly cuneate base. Midrib of medium size. Lateral primaries branching from the base at angles with the midrib of about 25°, of medium size, curving upward and then outward, and running to the tips of the lobes. They give off four or five camptodrome secondaries on the outside and two or three on the inside. The midrib, in its upper half, also gives off one or two secondaries on each side. Leaf substance somewhat coriaceous.

This species, which is sparingly represented in the argillaceous greensand marls along Cowikee Creek and is associated with shallow-water or estuarine mollusks of the Ripley formation, is markedly distinct from any other described species of *Bauhinia*. It is much smaller and less deeply divided than *Bauhinia gigantea* Newberry or *Bauhinia alabamensis* Berry and is much less ornate in character. It is, on the other hand, much larger than *Bauhinia marylandica* Berry, of the Magothy formation in the Maryland area. It differs from all these American Cretaceous species in its pointed, outward-directed lobes but is not unlike a number of existing species of this genus.

Occurrence: Cusseta sand member of Ripley formation, right bank of Cowikee Creek, one-eighth of a mile above its mouth, Barbour County, Ala.; McNairy sand member of Ripley formation, 2½ miles southwest of Selmer, McNairy County, Tenn.

Family PAPILIONACEAE

Genus DALBERGIA Linné (son)

Dalbergia cretacea Berry, n. sp.

Plate XI, figure 3

Leaflets apparently sessile, inequilateral, ovate-emarginate, widest above the middle. Apex widely and openly emarginate, with obtusely rounded ears and a nearly straight-sided angular sinus, forming an angle of about 105°. Base cuneate, markedly inequilateral. Margins entire, full and rounded. Texture coriaceous. Midrib stout, prominent, markedly curved proximad. Secondaries thin but well marked; four or five pairs diverge from midrib at angles of about 45°, somewhat irregularly spaced and camptodrome. Tertiaries thin but well marked, forming a very fine isodiametric areolation of quadrangular or polygonal meshes. Length about 2.75 centimeters; maximum width about 1.6 centimeters.

This well-marked form is not abundant in the collections. It is larger and more coriaceous than the associated *Dalbergia prewilcoxiana* Berry and much broader, more inequilateral, and with a more prominent venation than *Dalbergia perryana* Berry. It is much like some of the Greenland Cretaceous forms that Heer erroneously referred to *Liriodendron meekii*,[67] which are the same as the types of Heer's *Colutea primordialis* of the Atane beds,[68] but it is unlike the forms from the United States that are commonly referred to *Colutea primordialis*. These all occur at somewhat earlier horizons, and in the absence of comparative material from Greenland the problem of revision must be left open, although it seems doubtful if any of these forms represent the genus *Colutea*.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Dalbergia perryana Berry, n. sp.

Plate XI, figure 4

Narrow leaflets, spatulate, widest near the tip, the rather straight margins gradually approaching to form the narrowly cuneate base. Apex retuse, the midrib extending in the sinus as a mucronate point. Texture coriaceous. Length about 3 to 3.75 centimeters; maximum width about 8 or 9 millimeters; slightly inequilateral. Leaflets practically sessile, the short and stout petiolule being not over 1 millimeter in length. Midrib straight, very stout and prominent. Secondaries numerous, thin, immersed in the leaf substance and visible only under favorable illumination; they diverge from the midrib at angles of about 45° and are camptodrome and scarcely more prominent than the fine tertiary areolation.

This relatively long and narrow species is readily distinguished from the associated species of *Dalbergia* and from previously described species by its retuse apiculate tip. It is represented in the collections by two specimens and may be ancestral to the lower Eocene species *Dalbergia eocenica* Berry,[69] of this same region.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Dalbergia prewilcoxiana Berry, n. sp.

Plate XI, figure 5

Leaflets petiolulate, narrowly ovate-emarginate, only slightly inequilateral, with an emarginate apex and somewhat dissimilar rounded ears. Base narrow cuneate, slightly inequilateral. Margins entire, full and evenly rounded. Texture subcoriaceous. Length about 13.5 millimeters; maximum width, above the middle, about 5.5 millimeters. Petiolule stout, relatively long (about 3 millimeters). Midrib very stout and prominent, slightly curved. Secondaries thin, immersed; five or six camptodrome pairs diverge from midrib at acute angles. Areolation fine, immersed.

This tiny species is almost identical with and undoubtedly ancestral to the Eocene embayment species *Dalbergia wilcoxiana*,[70] a fact indicated by the name chosen for it. It differs from *Dalbergia wilcoxiana* in its more prominent ears and in having the venation more completely immersed. It is readily distinguished from the other Dalbergias in the Ripley formation by its general form and smaller size. Not common in collections.

[67] Heer, Oswald, Flora fossilis arctica, vol. 6, pt. 2, pl. 22, figs. 4, 6, 1882.
[68] Idem, p. 99, pl. 27, figs. 7–11; pl. 43, figs. 7, 8.
[69] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 245, pl. 53, figs. 1, 2, 1916.
[70] Idem, p. 246, pl. 53, fig. 7; pl. 54, figs. 1, 2.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

LEGUMINOSAE (position uncertain)

Genus LEGUMINOSITES Bowerbank

Leguminosites canavalioides Berry

Leguminosites canavalioides Berry, Maryland Geol. Survey, Upper Cretaceous, p. 842, pl. 76, fig. 6, 1916.

Leaves compound, probably trifoliate. Leaflets large, elliptical, with a rounded apex and base. Length about 7 centimeters; maximum width, in the middle part of the leaflet, about 6 centimeters. Margins entire. Texture subcoriaceous. Petiolule wanting. Midrib stout, becoming attenuated distad. Secondaries numerous, thin, camptodrome, about ten pairs, diverging from the midrib at angles of about 55°. Tertiary areolation papilionaceous, mostly immersed.

This species represents a leguminous leaflet of unknown generic affinity named from its resemblance to the leaflets of the existing species *Canavalia*, which number about a dozen, of the Tropics of both hemispheres. In the lower Eocene of southeastern North America there is an undoubted species of *Canavalia* very close to the existing *Canavalia obtusifolia* (Lamarck) De Candolle, a common West Indian strand plant.

This species was described recently from specimens found in the Magothy formation of Maryland. What appears to be the same species was apparently more common along the Ripley coast. The Ripley leaves are more truly elliptical and not quite so broad. The texture is subcoriaceous, and the typically leguminous areolation is well shown in some of the specimens. The species may well have been ancestral to the lower Eocene forms from the Mississippi embayment which have been referred directly to *Canavalia*.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, and Perry place, Henry County, Tenn.

Leguminosites perryensis Berry, n. sp.

Plate XI, figure 2

Leaflets small, sessile, nearly equilateral, spatulate, with an obtusely pointed tip and a cuneate base. Margins entire, slightly undulate on the narrower side. Texture relatively coriaceous. Midrib relatively stout. Secondaries not differentiated from the transversely elongated areolation. Length about 1.65 centimeters; maximum width, in upper part of leaflet, about 5 millimeters.

This is a rare form of no decided generic affinities but differing from the other leaflets of this alliance represented in the Ripley flora.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Leguminosites carrollensis Berry, n. sp.

Plate XI, figure 1

Small oval or elliptical leaflets with entire margins, rounded tip, and slightly reduced base. Sessile and with a midrib which is pronounced proximad and immersed distad, as is the balance of the venation. Length about 10 millimeters; maximum width about 7 to 8 millimeters.

This form is of unknown relationship among the numerous similar leaflets in the Leguminosae. It is readily distinguishable from the other members of this alliance found in the Ripley.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Genus GLEDITSIOPHYLLUM Berry

Gleditsiophyllum preovatum Berry, n. sp.

Plate XI, figures 11, 12

Small, markedly inequilateral, obovate, sessile leaflets, with full, entire margins, rounded, slightly apiculate tip, and decidedly inequilateral decurrent base. Texture coriaceous for so small a form. Midrib stout, expanded proximad, attenuated distad. Secondaries numerous, thin, ascending, inosculating, camptodrome. Length about 1.75 centimeter; maximum width, above the middle, about 7 millimeters.

This characteristic small form is similar in venation to *Gleditsiophyllum proeocenicum* Berry, with which it is associated. It is similar to and may be regarded as the prototype of *Gleditsiophyllum ovatum* Berry,[71] which,

[71] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 239 pl. 51, fig. 1, 1916.

though of the same size and proportions, has the secondaries more individual. *G. ovatum* is a member of the lower Eocene or Wilcox flora in the Mississippi embayment region.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Gleditsiophyllum proeocenicum Berry, n. sp.

Plate XI, figures 8–10

Small, ovate, inequilateral, sessile leaflets, with a bluntly pointed apex and a somewhat wider obtuse base. Margins entire, full, rounded. Somewhat chartaceous in texture. Length about 2.75 centimeters; maximum width, in the medial region, about 7.5 millimeters. Midrib thin, curved. Secondaries thin but distinct, numerous, ascending, inosculating and forming inequilateral camptodrome meshes.

This well-marked small species resembles a host of existing and fossil leaflets of various genera of the Leguminosae alliance. It is therefore referred to the form genus *Gleditsiophyllum* rather than to *Leguminosites*, as it foreshadows the great display of these types in the lower Eocene of the Mississippi embayment region. It is readily differentiated from the other members of the Ripley flora and may be considered the prototype in that flora of *Gleditsiophyllum eocenicum* Berry,[72] which is so abundant in the lower Eocene Wilcox flora in this region. It is not common in the present collections. In some respects it is similar to the form from the Middendorf arkose member of the Black Creek formation in South Carolina described as *Acaciaphyllites grevilleoides* Berry.[73]

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Gleditsiophyllum aristatum Berry, n. sp.

Plate XI, figure 7

Leaflets lanceolate, falcate, petiolulate, acuminate, widest below the middle and narrowed upward, the midrib produced as a conspicuous aristate process. Base acute, slightly inequilateral. Margins entire, slightly unsymmetrical. Texture subcoriaceous. Length about 4.5 centimeters; maximum width about 6.5 millimeters. Petiolule short and stout, decidedly curved, about 3.5 millimeters in length. Midrib stout, curved. Secondaries numerous, thin, immersed, camptodrome. Tertiaries obsolete.

A well-marked form conspicuous among the Ripley species of the Leguminosae alliance by reason of its modern appearance, lanceolate shape, and aristate tip. Not common in the collections. Closely comparable with a variety of modern species of *Mimosa*, *Cassia*, *Caesalpinia*, and *Gleditsia*.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Order GERANIALES

Family MELIACEAE

Genus CEDRELA Linné

Cedrela prewilcoxiana Berry, n. sp.

Plate XII, figure 1

Leaflets practically sessile, lanceolate and falcate, widest in the middle and about equally pointed at both ends, with regularly entire margins. Texture subcoriaceous. Length about 3.5 centimeters; maximum width about 5 or 6 millimeters. Base slightly inequilateral. Midrib relatively stout, expanded proximad. Secondaries thin, numerous, camptodrome, immersed.

This species, which is rare in the present collections, is so similar to *Cedrela wilcoxiana* Berry,[74] from the lower Eocene (Wilcox group) of the Mississippi embayment region, as to suggest the ancestral relationship implied in the name chosen for the Ripley species. Its distinguishing characters are its somewhat more linear form and expanded midrib at the sessile base, the Wilcox species being petiolulate.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

[72] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 238, pl. 46, 1916.

[73] Berry, E. W., U. S. Geol. Survey Prof. Paper 84, p. 45, pl. 9, figs. 9, 10, 1914.

[74] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 253, pl. 56, fig. 1, 1916.

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Family EUPHORBIACEAE

Genus EUPHORBIOPHYLLUM Ettingshausen

Euphorbiophyllum petiolatum Berry, n. sp.

Plate XII, figures 2, 3

Andromeda novaecaesareae Berry, U. S. Geol. Survey Prof. Paper 84, p. 130 (in part), 1914 (not Hollick); Prof. Paper 112, p. 130, pl. 30, figs. 1, 2, 1919.

Small obovate or incised leaves with rounded apex and decurrent base. Margins entire except where leaves are incised by deep acute sinus reaching to the midrib. Texture coriaceous. Length about 2 centimeters; maximum width about 6 to 8 millimeters. Petiole stout, long and curved, about 1 centimeter in length. Midrib very stout, prominent. Secondaries thin, camptodrome.

This form has been previously found in both the Eutaw and the Ripley formations and heretofore identified with *Andromeda novaecaesareae* Hollick,[75] although attention was called to its obtuse form and sometimes incised margin. It resembles some of the variants of that species but not the normal lanceolate form with numerous ascending secondaries. The normal type has not been found in deposits later than the Tuscaloosa formation in the Mississippi embayment region, the later forms all being obovate or oblanceolate, so that they evidently represent a distinct species, which is also much more coriaceous. Similar forms have been referred to the genus *Crotonophyllum*.

Occurrence: Eutaw formation, Coffee Bluff, Tenn. Cusseta sand member of Ripley formation, Buena Vista, Ga. McNairy sand member of Ripley formation, Perry place, Henry County; Cooper pit, near Hollow Rock, Carroll County; 2½ miles south of Mifflin, Chester County, Tenn.

Euphorbiophyllum tennesseensis Berry, n. sp.

Plate XII, figure 4

Obovate leaves of medium size, widest in the middle with a rounded apex and pointed base. Margins entire, conspicuously undulate. Texture coriaceous. Length about 5.5 centimeters; maximum width about 1.5 centimeters. Midrib stout, prominent, and curved. Secondaries numerous, thin, prominent; about ten pairs diverge from the midrib at angles of about 70° and are camptodrome in the marginal region. Tertiaries obsolete.

This is a relatively shorter and wider form with more prominent venation than *Euphorbiophyllum antiquum* Saporta and Marion, differing from that species as well as from *E. cretaceum* Berry in its obovate form and undulate margins. Like the other two species of *Euphorbiophyllum* of the Ripley flora, it is not a common form in the present collections. It is very much like *E. vetus* Saporta,[76] from the Lutetian of France.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Euphorbiophyllum cretaceum Berry, n. sp.

Plate XII, figure 6

Spatulate leaves of medium size, with a broadly rounded tip and a narrowly cuneate base. Margins entire. Texture coriaceous. Length about 6.5 centimeters; maximum width, in the upper part of the leaf, about 1.8 centimeters. Midrib very stout and prominent. Secondaries thin, camptodrome, diverging at wide angles. Tertiaries obsolete.

This species is similar to *Euphorbiophyllum antiquum* Saporta and Marion but much wider, with a finer areolation and more prominent midrib, as well as a more coriaceous texture. It differs from the associated *E. tennesseensis* Berry in general form and in lacking the undulate margins and prominent secondaries of that species. It is not common in the present collections.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Euphorbiophyllum antiquum Saporta and Marion

Plate XII, figure 5

Euphorbiophyllum antiquum Saporta and Marion, Évolution du règne végétal, Phanérogames, p. 117, fig. 125 C, 1885.

Leaves spatulate or linear-spatulate, with a rounded or slightly emarginate apex and a narrowly cuneate decurrent base. Margins entire. Texture subcoriaceous. Length 5.5 to 6.5 centimeters; maximum width, above the middle, 1.2 to 1.4 centimeters. Petiole want-

[75] Hollick, Arthur, in Newberry, J. S., U. S. Geol. Survey Mon. 26, p. 121, pl. 42, figs. 9–12, 28–31, 1896.

[76] Saporta, Gaston de, Le monde des plantes avant l'apparition de l'homme, pl. 48, figs. 1, 2, 1879.

ing. Midrib stout, less prominent than in the associated species, curved. Secondaries numerous, thin, diverging at wide angles, camptodrome. Tertiaries obsolete.

The material from Tennessee can not be distinguished from that from the Turonian of Bagnols, in southern France, figured by Saporta and Marion, although it may well be doubted if both represent the same botanic species and not closely related types not distinguishable by their foliar characters. These remains are not uncommon in the Ripley flora, where they are associated with three other species of *Euphorbiophyllum*. The genus was established by Ettingshausen,[77] as a form genus for leaves of the family Euphorbiaceae. A considerable number of Tertiary species have been referred to it. These are mostly from European localities but include a form from Greenland and one from Brazil. The genus has not heretofore been recognized in this country, except for a single species recorded by me from the lower Eocene of Tennessee, a descendant from one of these Ripley forms. A second European Cretaceous species, *E. primordiale*, from the Cenomanian of Portugal, was described by Saporta.[78]

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Genus MANIHOTITES Berry

Manihotites georgiana Berry

Manihotites georgiana Berry, Torrey Bot. Club Bull., vol. 37, p. 507, figs. 1, 2, 1910; U. S. Geol. Survey Prof. Paper 84, p. 114, pls. 22, 23, 24, figs. 4, 5; text figs. 2, 3, 1914; Torrey Bot. Club Bull., vol. 43, p. 295, 1916.

This remarkable form was recently described by me in the papers cited above, and the discussion need not be repeated here.

Occurrence: Eutaw formation, basal beds, McBrides Ford, Chattahoochee County, Ga. Coffee sand member of Eutaw formation, Coffee Bluff, Hardin County, Tenn. Cusseta sand member of Ripley formation, near Buena Vista, Marion County, Ga.; McNairy sand member of Ripley formation 2½ miles southwest of Selmer, McNairy County, Tenn.

[77] Ettingshausen, Constantin von, K.-k. geol. Reichsanstalt Abh., vol. 2, pt. 3, No. 2, p. 77, 1853.

[78] Saporta, Gaston de, Flore fossile du Portugal, p. 218, pl. 39, fig. 23, 1894.

Order SAPINDALES

Family CELASTRACEAE

Genus CELASTROPHYLLUM Goeppert

Celastrophyllum carolinensis Berry

Celastrophyllum carolinensis Berry, U. S. Geol. Survey Prof. Paper 84, p. 51, pl. 13, figs. 1–5, 1914; Prof. Paper 112, p. 109, pl. 24, figs. 6, 7, 1919.

This species was described in 1914 as follows:

> Leaves lanceolate in outline, with a pointed apex and a cuneate base, about 14 centimeters in length by 2.9 centimeters in greatest width, which is about midway between the apex and the base, tapering equally in both directions. Midrib stout, rather flexuous. Secondaries numerous, thin, branching from the midrib at acute angles of 45° or less, curving upward, usually camptodrome, a few craspedodrome in the upper part of the leaf, sending tertiary branches into the marginal teeth. Margin entire for a short distance at the base, above which it is crenate or biconvex, the teeth large and interspersed with smaller subordinate teeth of the same character. Leaf substance thin.

It is not uncommon in the Ripley, where some of the smaller specimens are only 7 centimeters in length by 1 centimeter in width. They also show considerable variation in marginal characters; the teeth are sometimes less biconvex and more drawn out, lacking subordinate teeth. It is possible that the Ripley forms represent a new variety, but the characters are such that a positive conclusion on this point is not possible; they are certainly affiliated with this species, and the fact of their occurrence in younger beds than those from which the type was collected suggests that they may represent a variety.

One feature of unusual interest in connection with this species is its great similarity in form, texture, and variability to *Ternstroemites ripleyensis* Berry. Superficially the two are indistinguishable, but the venation shows constant differences throughout a large amount of material. The numerous thin ascending secondaries of *Celastrophyllum carolinensis* are replaced in *Ternstroemites ripleyensis* by fewer, stouter camptodrome secondaries at nearly right angles to the midrib, so that the two are undoubtedly distinct. It seems probable that this is another of the so-called species of *Celastrophyllum* that should be referred to *Ternstroemites*, but as I have been unable to satisfy myself on this point I prefer not to make any change of name at present. The type material came from the Middendorf arkose member of the Black Creek formation in South Carolina, and the species was subsequently recorded from the Tuscaloosa formation of Alabama, where it is not common.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Celastrophyllum ripleyanum Berry, n. sp.

Plate XII, figures 8–10

Leaves of small size, obovate, with a blunt apex and a cuneate and slightly decurrent base. Texture subcoriaceous. Length about but prevailingly under 2 centimeters; maximum width, at or above the middle, about but prevailingly under 1 centimeter. Margins entire in the cuneate basal half of the leaf. Above the middle the margins show seven or eight relatively large crenate teeth, increasing gradually in size upward and then diminishing toward the rounded crenate tip. Petiole practically wanting, not extending beyond the decurrent margins. Midrib straight, relatively stout below, thin above. Secondaries, seven or eight thin pairs diverging from the midrib at acute angles and camptodrome some distance within the margins. Tertiaries thin, mostly long forking and inosculating veins subparallel with the secondaries, giving the leaves a *Myrsine*-like character.

The number of fossil species from the American Cretaceous that have been referred to *Celastrophyllum* is very great. The genus makes its appearance in the latest deposits of the Lower Cretaceous (Patapsco formation of Maryland and Virginia) and continues to be prominent throughout the Upper Cretaceous, especially in the Atlantic Coastal Plain region. It is much less common in western North America and in Europe, being represented in Europe by forms usually referred to other genera, although Ettingshausen recorded two species of *Celastrophyllum* from the Cenomanian of Niederschoena, in Saxony. Recently Kryshtofovich [79] has described a species from the Upper Cretaceous of Sakhalin Island, thus hinting at a Mesozoic display of these forms in Asia should plant beds of this age be subsequently discovered.

There are 8 species of *Celastrophyllum* recorded from the Patapsco formation, 12 from the Tuscaloosa formation, 9 from the Raritan formation, 7 from the Dakota sandstone, 5 from the Magothy formation, 2 from the Black Creek formation, and 3 from the Middendorf arkose member of the Black Creek formation in South Carolina. In Greenland there is one species in the Atane beds and three in the Patoot beds.

As has been mentioned in a previous publication, it seems very probable that a number of these species of *Celastrophyllum* should be referred to the family Ternstroemiaceae. Others, like the Ripley species, belong in the family Celastraceae.

The present species is not abundant in the Ripley collections. Among previously described species it is close to the smaller forms of *Celastrophyllum crenatum* Heer [80] and *Celastrophyllum newberryanum* Hollick.[80] Both of these are normally larger, and both have been recorded from beds at numerous horizons. Thus *Celastrophyllum crenatum* is found in the Patoot beds of Greenland and in the Raritan, Tuscaloosa, Magothy, and Black Creek formations of the Atlantic Coastal Plain. Its smallest leaves are twice the size of the present species and have more numerous and less ascending secondaries. *Celastrophyllum newberryanum* is also larger and relatively wider, with finer serrate teeth and decidedly different tertiary venation.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County; Cooper pit, near Hollow Rock, Carroll County, Tenn.

Celastrophyllum minimum Berry, n. sp.

Plate XII, figure 7

Small, somewhat inequilateral leaves, lanceolate, falcate distad, widest in the basal half, with an apiculate tip and inequilateral decurrent base. Margins somewhat irregularly and remotely serrate. Texture relatively coriaceous. Length about 2.25 centimeters; maximum width about 5 millimeters. Petiole stout, curved, about 3 millimeters in length. Midrib

[79] Kryshtofovich, A., Imp. Coll. Sci. Tokyo Jour., vol. 40, art. 8, p. 54, fig. 11, 1918.

[80] For a recent discussion of these species see Berry, E. W., U. S. Geol. Survey Prof. Paper 112, pp. 108, 109, 1919.

stout, not prominent, curved distad with a fold in the lamina, similar, for example, to many existing species of *Prunus*. Secondaries immersed, thin, numerous, camptodrome.

This small and characteristic form is only superficially suggestive of the associated *Celastrophyllum variabilis* Berry and seems to me clearly referable to the Celastraceae, although comparisons may be made with certain forms of Ilicaceae. It is rare in the present collections.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Celastrophyllum cassinoides Berry, n. sp.

Plate XII, figure 11

Leaves oval-lanceolate, widest midway between the apex and base and about equally pointed at both ends. Margins conspicuously undulate, leaf substance thin. Midrib fairly stout, curved, not prominent. Secondaries thin, remote, camptodrome a considerable distance from the margin; those in the basal part of the leaf diverging at acute angles and ascending; those higher up diverging at angles of 45° to 50°, straight about halfway to the margins, where each forms a wide sweeping arch to the secondary next above. Tertiaries forming open arches around the margin and an open mesh within the secondaries. Areolation very fine meshed. Length about 8 centimeters; maximum width about 3.1 millimeters.

This well-marked species is not closely related to most of the Upper Cretaceous forms referred to this form genus, many of which I have suggested should be transferred to the genus *Ternstroemites*, but as *Celastrophyllum* was proposed in the first instance for leaves of Celastraceae not generically determinable the reference to it of these leaves of Ripley species of undoubted Celastraceae is perfectly proper. The present species is somewhat smaller and narrower than the associated *Celastrophyllum perryi* Berry, with more pronounced undulate margins. A single dentate tooth is present on the left side of the figured specimen, but this is considered an anomaly. The species is not common in the collections, and the name is given in allusion to the resemblance to certain existing species of *Cassine* Linné, a genus to which *Elaeodendron* Jacquin is often referred.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Celastrophyllum perryi Berry, n. sp.

Plate XII, figure 12

Broadly ovate leaves of considerable size, widest midway between the apex and base and about equally pointed at both ends, the base decurrent to the short, stout petiole. Margins faintly and irregularly undulate. Leaf substance thin. Length about 10 centimeters; maximum width about 4.25 centimeters. Midrib straight and stout, especially in the lower half of the leaf. Secondaries thin, five or six pairs, diverging from the midrib at angles of about 45° and camptodrome some distance within the margins. Tertiaries forming open arches as continuations of the secondaries and inside the margins, and open meshes within the secondaries; the secondaries are thin and immersed, as is the fine meshed areolation.

In general facies this species is very similar to the associated *Celastrophyllum cassinoides* Berry, from which it differs in larger size, more elliptical form, and more irregular and less conspicuous undulate margins. The lower secondaries are less ascending, a feature correlated with the wider basal region. The two are closely related, however, and it is possible that they may represent the variants of a single botanic species, a supposition that can be thoroughly tested only when very much more material is available for study. The present form suggests the genus *Elaeodendron* Jacquin, which is confined to Africa in the existing flora but which had a much more extensive range in the late Cretaceous and Tertiary.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Celastrophyllum variabilis Berry, n. sp

Plate XIII, figure 1

Leaves small, of somewhat variable form, lanceolate, with pointed tip, prominently crenate margins, and decurrent base. Leaf substance of considerable consistency. Length 2.25 centimeters or less; maximum width, in the median region, 5 to 7 millimeters. Petiole short, stout, and curved. Midrib stout, curved. Secondaries thin, camptodrome, sending short branches to the marginal teeth. Tertiaries obsolete.

These small somewhat protean leaves are considered to represent a Ripley species of Celastraceae, although this assignment is not conclusive, for they may be compared with forms in a variety of families. For example, the Ilicaceae contains similar forms, as does also the genus *Myrica*. They also show a resemblance to some of the forms referred to the genus *Ternstroemites*, and finally Velenovsky [81] has described a similar leaf from the Chlomeker sandstone (Emscherian) of Bohemia as *Rhus cretacea*.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Genus PACHYSTIMA Rafinesque?

Pachystima? cretacea Berry

Pachystima? cretacea Berry, U. S. Geol. Survey Prof. Paper 84, p. 49, pl. 10, fig. 6, 1914.

Remains identical with the type material of this species are present in western Tennessee. It was described by me in 1914 as follows:

> Leaves of small size, oblong or obovate in outline, with a rounded apex and a narrowed descending base; about 2 centimeters in length by 3 millimeters in greatest width. Texture coriaceous. Petiole short and stout. Midrib stout. Secondaries numerous, fine, immersed, ascending.

It may well be doubted whether these Upper Cretaceous forms represent the modern genus *Pachystima*, and it would probably have been better if they had been referred to the form genus *Celastrophyllum*.

There are only two existing species of *Pachystima*, one from the East and one from the Rocky Mountain area. They are shrubs of dry situations, with evergreen, more or less revolute leaves. As above stated, the generic identification is doubtful, but a fossil species of this genus is known from the Miocene of Colorado.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Family ACERACEAE

Genus ACER Linné

Acer cretaceum Berry, n. sp.

Plate XIII, figure 2

Leaves of medium size, ovate, feebly trilobate. Apex and lobes mucronate pointed. Base cordate. Leaf substance thin but of considerable consistency. Length about 6 centimeters; maximum width about 6.75 centimeters. Margins, except the entire cordate base, with unequal coarse dentate teeth, which become mucronate where a primary or secondary vein runs to their apex. Petiole stout, curved and expanded proximad, 2.65 centimeters in length. Midrib stout, becoming thin distad, prominent on the lower surface of the leaf. Lateral primaries diverge from the midrib at angles of about 50° to 55° at its extreme base; they are stout and run to the tips of the lateral lobes. Secondaries from the midrib, two or three subopposite pairs, diverging at angles of about 50°, stout at first, rapidly thinning, craspedodrome. Secondaries from the lateral primaries, three on proximal side and one on distal side, rather straight, craspedodrome, terminating in enlarged mucronate pointed teeth.

This is a very handsome and characteristic species of maple, quite distinct from the earlier leaves that have been referred to the genus *Acer*, all of which hitherto recorded from the Upper Cretaceous are of doubtful identity. In so far as the present collections go this species is not common in the Ripley, but it should be realized that negative evidence of this kind has very little real weight. The maples are essentially Tertiary trees, although they evidently originated and enjoyed a considerable dispersal prior to their known Eocene occurrences.

In addition to the present Ripley species eight other Cretaceous leaves have been referred to *Acer* with more or less certainty. A review of these shows that for most of them the evidence of identity is far from conclusive. Thus *Acer paucidentatum* Hollick [82] and *Acer minutum* Hollick,[83] from the Upper Cretaceous of Staten Island, N. Y., and Cliff-

[81] Velenovsky, Josef, Die Flora der böhmischen Kreideformation, pt. 4, p. 7, pl. 4, figs. 7–12, 1885.

[82] Hollick, Arthur, New York Acad. Sci. Trans., vol. 16, p. 132, pl. 14, figs. 2, 3, 1897.

[83] Idem, vol. 12, p. 35, pl. 3, fig. 6, 1892.

wood, N. J., are very doubtful and in my judgment do not represent *Acer; Acer amboyense* Newberry,[84] based on fruits from New Jersey and Marthas Vineyard, probably represents *Pinus; Acer saskatchewense* Dawsón,[85] from Northwest Territory, is of uncertain value; and *Acerites multiformis* Lesquereux,[86] from the Dakota sandstone, and *Acer antiquum* Ettingshausen,[87] from the Cenomanian of Saxony, are very doubtful, although they somewhat resemble one another and show a certain resemblance to *Negundo.*

The only Cretaceous species outside the Ripley that are of unquestionable identity are *Acer caudatum*[88] and *Acer edentatum.*[89]

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Order RHAMNALES

Family RHAMNACEAE

Genus RHAMNUS Linné

Rhamnus ripleyensis Berry, n. sp.

Plate XIII, figure 3

Leaves lanceolate, somewhat irregular in form, with a narrowly pointed tip and a more abruptly pointed base. Margins entire but irregularly rounded. Texture coriaceous. Length about 9 centimeters; maximum width, slightly below the middle, about 2.2 centimeters. Petiole short and stout. Midrib very stout and prominent on the lower surface of the leaf, slightly flexuous. Secondaries numerous, stout, prominent, subparallel, diverging from the midrib at angles of about 65°, curving regularly, camptodrome close to the margins. Tertiaries thin, very close-set, percurrent.

This species is distinct among the various Upper Cretaceous species that have been referred to *Rhamnus.* It is relatively more narrowly elongate than most of the other species of this genus but conforms to the type, with numerous well-marked secondaries, camptodrome close to the margins, and with numerous subparallel percurrent tertiaries. It does not appear to have been a common form in the Ripley.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Genus ZIZYPHUS Linné

Zizyphus laurifolius Berry

Plate XIII, figure 4

Zizyphus laurifolius Berry, U. S. Geol. Survey Prof. Paper 84, p. 116, pl. 21, fig. 7, 1914; Prof. Paper 112, p. 113, 1919.

Leaves linear-lanceolate, with entire margins, about equally and abruptly pointed at the apex and base. Length 9 to 11 centimeters; maximum width 1.5 to 2 centimeters. Petiole missing in all specimens so far discovered. Primaries three, diverging at or a short distance above the base. Midrib stouter and much more prominent than the lateral primaries, which diverge from it at acute angles and sweep upward, parallel with the lateral margins, to or above the middle of the leaf, where they join short branches from the lowest secondaries. Secondaries thin; three or four alternate to opposite pairs diverge from the midrib at acute angles in the upper part of the leaf and sweep upward in long, regularly and but slightly arched camptodrome curves. A few thin camptodrome secondaries diverge at acute angles from the outer sides of the lateral primaries. Tertiary venation obsolete. Texture coriaceous.

This species was described from the lower Eutaw of the Chattahoochee drainage basin, where it was represented by a scant amount of rather poorly preserved material. The material from western Tennessee is similarly scanty but somewhat better preserved and enables me to amplify somewhat the previous characterization of the species. It is easily distinguished from the associated Ripley species by its entire margins and may be readily distinguished from all the other Upper Cretaceous entire-margined species except *Zizyphus cliffwoodensis* Berry [90] by its size and elonga-

[84] Newberry, J. S., U. S. Geol. Survey Mon. 26, p. 106, pl. 46, figs. 5–8, 1896.
[85] Dawson, J. W., Roy. Soc. Canada Trans., vol. 3, sec. 4, p. 16, 1886.
[86] Lesquereux, Leo, U. S. Geol. Survey Mon. 17, p. 156, pl. 34, figs. 1–9, 1892.
[87] Ettingshausen, Constantin von, Kreideflora von Niederschoena, p. 25, pl. 3, fig. 17, 1867.
[88] Heer, Oswald, Flora fossilis arctica, vol. 7, p. 38, pl. 65, figs. 1, 2, 1883.
[89] Idem, p. 39, pl. 65, fig. 3.
[90] Johns Hopkins Univ. Circ., new ser., No. 7, p. 88, fig. 5, 1907.

tion. *Zizyphus cliffwoodensis*, which comes from the Magothy formation of New Jersey, is still larger, ovate-lanceolate, and with numerous conspicuous percurrent tertiaries.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, 1½ miles south of Hollow Rock, Carroll County, Tenn.

Zizyphus ripleyensis Berry, n. sp.

Plate XIII, figures 5–9

Leaves of variable size, lanceolate or ovate-lanceolate, widest slightly below the middle, tapering downward to the acute base, which is sometimes inequilateral, and upward to the slender, acute, and slightly extended tip. Length 4.5 to 9 centimeters; maximum width 1.5 to 2.4 centimeters. Margins entire for their basal third, above which they are beset with somewhat remote serrate teeth, which are often unequally spaced and vary in prominence not only from specimen to specimen but in a single individual. Primaries three, diverging at or near the base, the midrib being much the stoutest. The lateral primaries diverge at acute angles, curving upward parallel with the lateral margins and becoming thinner in the distal third of the leaf as they arch from end to end of the straight outer branches of the superjacent secondaries. Secondaries from the midrib two or three pairs in the upper part of the leaf, diverging at acute angles and sweeping upward in long ascending curves. Tertiaries thin, approximately transverse, either percurrent or inosculating midway between lateral primaries and the midrib; those from the outer side of the lateral primaries form abruptly camptodrome arches and send off short branches to the marginal teeth. Texture coriaceous.

This well-marked species is readily distinguishable from the other known Cretaceous species, the only one of which that at all resembles it being *Zizyphus dakotensis* Lesquereux,[91] a prevailingly larger and much more elongated form with thinner primaries and more prominent teeth. Among recent species the leaves of *Zizyphus vulgaris* Lamarck are not unlike the present fossil species. The great variety of leaves of *Zizyphus* in the Upper Cretaceous of North America and their absence from the numerous Cretaceous plant-bearing beds of Europe is a fact of considerable significance. No less than ten different species have been recorded from the American Cretaceous, and although some of these are of doubtful validity, as, for example, *Zizyphus oblongus* Hollick,[92] the majority are well characterized and undoubtedly related to *Zizyphus*. The only Eurasian *Zizyphus* known from the Cretaceous is the form identified as *Zizyphus dakotensis* Lesquereux by Kryshtofovich,[93] from the Cenomanian of the Ural region, and the indistinctness of his figure precludes passing a critical judgment on the identification, although it appears to be correct. If it is correct, then the oldest known form is from the Cenomanian of the Ural region, on the assumption that the age of the beds in which it was found was correctly determined, which is doubtful, for all the American occurrences are post-Raritan and presumably post-Cenomanian. Although *Zizyphus* is recorded from the Cretaceous of Kansas and New Mexico and doubtfully from Alaska, it makes its greatest display both in numbers and variety in the Atlantic Coastal Plain. With the dawn of the Eocene the genus appeared in force in Europe, although equally abundant on both continents, ten species being recorded from each, the bulk in both being in the lower Eocene.

There are 10 Oligocene and 20 Miocene species, the genus being clearly cosmopolitan in the Miocene epoch. The Pliocene records shrink to 4 or 5 species, all European, although the presence of fruits in the Pleistocene of New Jersey and Florida would seem to indicate continuous residence in North America until comparatively recent time. The modern species number two score, largely shrubs, many of which are prostrate or scrambling, and a few small trees, with their maximum development in the Indo-Malayan region, although present in the Tropics of eastern Asia, America, Africa, and Australia, as well as in Mediterranean Europe and South Africa.

Some of the existing species are extensively planted, and *Zizyphus vulgaris* has become naturalized in some of our Gulf States, so that the extinction of the genus in North America

[91] Lesquereux, Leo, The flora of the Dakota group: U. S. Geol. Survey Mon. 17, p. 167, pl. 36, figs. 4–7, 1892.

[92] Hollick, Arthur, U. S. Geol. Survey Mon. 50, p. 92, pl. 34, figs. 9, 10, 1906.

[93] Kryshtofovich, A., Acad. imp. sci. St.-Pétersbourg Bull., 6th ser., p. 608, fig. 7, 1914.

in late Pleistocene or postglacial time is another one of the unsolved mysteries of plant history. The accompanying sketch map (fig. 6) shows the limits of natural range of *Zizyphus* in the existing flora. It will be noted that the Cretaceous occurrences are mainly occidental, and from early Eocene time onward the genus is cosmopolitan in the Northern Hemisphere. The late Tertiary occurrences are largely European and would seem to indicate the waning of the genus in the Western Hemisphere, although the presence of fruit remains in the late Pleistocene of New Jersey and Florida indicates straggling species down to almost recent time.

from the base of the midrib at acute angles, ascending rather straight about halfway to the tip, where they join an outward branch from the lowest secondary. Secondaries four or five subopposite remotely spaced pairs, stout, camptodrome; the lowest pair longest and regularly curved; the others straight halfway to the margin and then each with a single flat camptodrome curve to the secondary next above. Secondaries from the outside of the primaries forming rather straight-sided and flat-arched areas. Tertiaries relatively stout and prominent, forming arches immediately within the margins and an open, prevailingly quadrangular mesh within the secondaries and

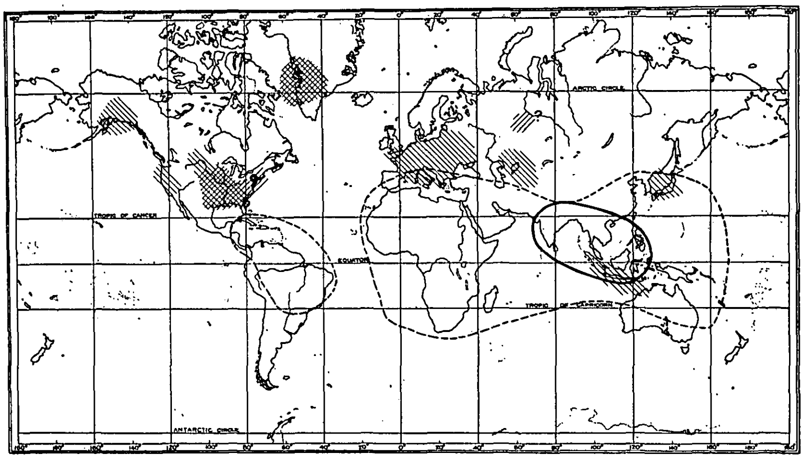

FIGURE 6.—Sketch map of the world summarizing the geologic history of *Zizyphus*. Area within heavy line, maximum existing development; area within thin lines, limit of existing natural range; northeast-southwest diagonal lines, regions of Cretaceous occurrences; northwest-southeast diagonal lines, regions of Tertiary occurrences; solid circles, areas of Pleistocene occurrences

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn. (common); Cooper pit, near Hollow Rock, Carroll County, Tenn. (rare).

Zizyphus perryi Berry, n. sp.

Plate XIII, figure 10

Leaves fairly large, ovate, widest below the middle, tapering in almost straight converging lines to the acute tip; the lower lateral margins full and rounded, and the base broadly cuneate. Margins irregularly dentate to serrate, the teeth tending to be most prominent below the middle, in general with shallowly rounded, almost equilateral sinuses. Texture subcoriaceous. Petiole missing in all the specimens. Midrib stout, prominent, curved. Lateral primaries stout, diverging

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primaries. Length about 10 centimeters; maximum width about 4.5 centimeters.

This characteristic form is named in appreciation of the Perry family, on whose property the fossiliferous Ripley clays are exposed and whose intelligent interest was most helpful in making the collections. It is a larger and relatively wider species than *Zizyphus ripleyensis* Berry, with much smaller marginal teeth. The remains are usually broken but are not uncommon in the collections. The specimen figured is the only one showing the whole leaf, one other upper half and four basal halves of leaves representing the rest of the material referred to this species.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Family VITACEAE

Genus CISSITES Heer

Cissites crispus Velenovsky

Cissites crispus Velenovsky, Die Flora der böhmischen Kreideformation, pt. 4, p. 12, pl. 4, fig. 6, 1885 (not Newberry, 1896, nor Berry, 1911). Berry, Torrey Bot. Club Bull., vol. 43, p. 296, 1916.

Cissites crispus was identified from the Raritan formation of New Jersey by Newberry and from the Magothy formation of that State by Berry, but neither of these occurrences represents the European form, so that recently I have made them the basis of a new species, *Cissites newberryi*.[94]

A perfectly well characterized, small-leafed form that appears to be identical with the Bohemian type of *Cissites crispus* is, however, present in the Ripley formation of western Tennessee. It differs from *Cissites newberryi* in its relatively shorter and wider form, its crenate instead of serrate or dentate teeth, its less ascending secondaries, and its cordate base.

The type and only other known occurrence of *Cissites crispus* is in the Chlomeker beds (Emscherian) of Bohemia.

Occurrence: McNairy sand member of Ripley formation, 2½ miles southwest of Selmer, McNairy County, Tenn.

Cissites panduratus Knowlton

Plate XIV

Cissites panduratus Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 274, pl. 49, fig. 10, 1918.

Leaves of variable size, multilobate, prevailingly quinquelobate, derived from a trilobate ancestor by the development of subordinate basal lobes on either side, which in the Tennessee material tend to be shorter than in the type material from the Raton Mesa region, although the medium-sized specimen from Tennessee figured here is almost an exact duplicate of the type. Main sinuses extending more than halfway to the base, broadly and rather evenly rounded; middle lobe obovate, with a lateral lobe of greater or less development on either side, obtusely pointed; main lateral lobes unsymmetrically obovate, narrower than the terminal lobe, obtusely pointed, entire on the distal side, entire on proximal side in the small leaf figured, in the other with a subordinate lobe developed to a greater or less degree; basal lobes narrower and less extended than the others, obtusely rounded, at right angles to midrib, without subordinate lobes, although the beginning of a lobule is indicated on the right proximal side in the medium-sized specimen figured. Length from 5.5 to 12 centimeters: maximum width 5 to 11.5 centimeters. Petiole missing in Tennessee material, long and stout in the type, at least 3 centimeters in length. Venation quinquepalmate from point at or near the base. Midvein fairly stout and nearly straight. Midveins of main lateral lobes diverging from central vein at angles of 25° to 40°, nearly straight or somewhat curved, as shown in specimens figured; midrib of basal lobes of lesser caliber, tending to be inserted just above the base of the lateral primaries, diverging at angles of 30° to 40° and curving outward; in the single type specimen the basal lobes are somewhat wider than in the Tennessee material and their midvein is nearest the distal margin, whereas in the Tennessee specimens they are more nearly central in position. Secondaries rather remote and slender, diverging at acute angles and curving upward in gentle long curves; those that run to the tips of subordinate lobes somewhat stouter and longer; the rest camptodrome except those that run to the sinuses, which unite to form a more or less well-developed marginal hem, such as is so well developed in the modern and some of the fossil lobate leaves of *Sassafras*. The tertiary areolation is not discernible. The texture is thin and not coriaceous but scarcely merits the term membranaceous applied to the type.

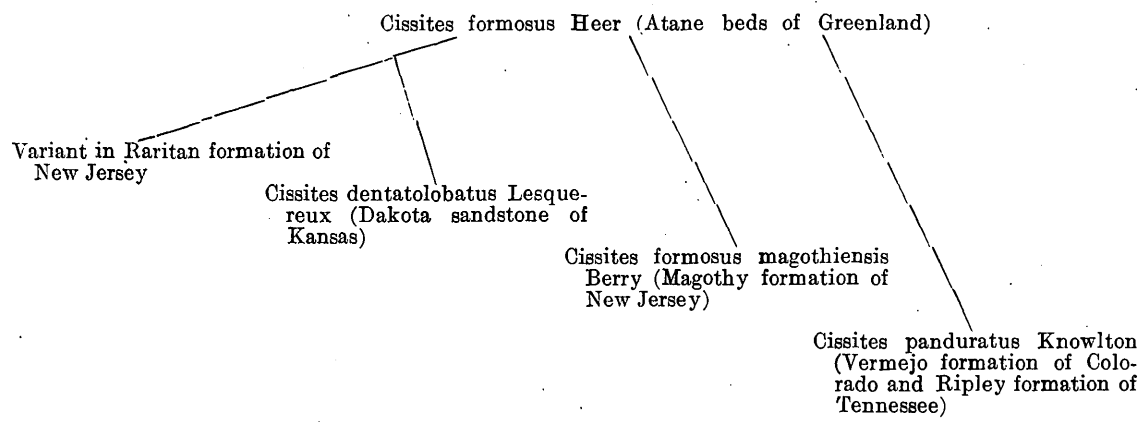
This species was based upon the single specimen figured by Knowlton, from the Vermejo formation of southeastern Colorado. It is very abundant in the McNairy sand member of the Ripley formation of Tennessee, so that the description can be somewhat amplified and the range in size and outline can be evaluated. Knowlton compared the species with *Acer*, *Liriodendron*, *Cissus*, and *Vitis* and pointed out its resemblance to *Cissites formosus* Heer, more especially to the trilobate forms from the Dakota sandstone ascribed to that species by Lesquereux. Heer's type of *Cissites formosus*,

[94] Berry, E. W., Maryland Geol. Survey, Upper Cretaceous, p. 856, 1916.

as well as the forms from the Raritan formation of New Jersey referred to this species by Newberry are distinctly not trilobate and, though they show considerable variation, are extremely close to the present species, as can be appreciated by referring to the restorations published in 1917.[95] There is not the slightest doubt that *Cissites panduratus* is properly referred to *Cissites*, and I consider it specifically distinct from *Cissites formosus*, which has departed less from the original trilobate stock; the basal lobes are still lobules of the lateral lobes, from which they are separated by a shallow sinus and are not yet independent basal lobes; the basal margin is decurrent and not truncate; and the primaries are three and distinctly suprabasilar.

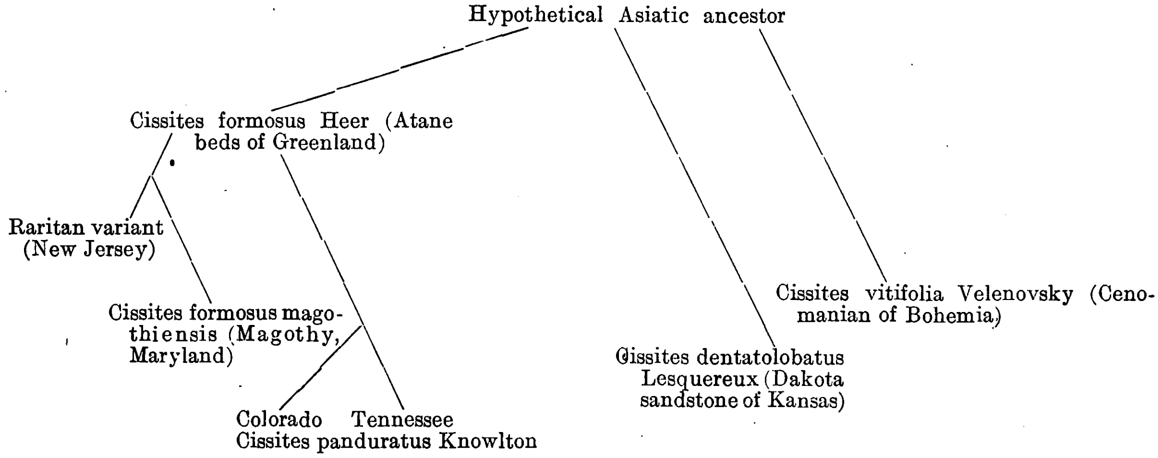
An interesting series of variations from this central and ancestral stock of the Atane beds of western Greenland has since come to light. In the Raritan formation of New Jersey it is represented by forms distinctly more sublobate, and the same tendency results in the form *Cissites dentatolobatus*, from the Dakota sandstone, described by Lesquereux, which is not unlike a form from the Perucer beds (Cenomanian) of Bohemia described by Velenovsky. A narrow, less sublobate, and more elongate variant of *Cissites formosus* that preserves the ancestral decurrent basal margins and tripalmate suprabasilar primaries is *Cissites formosus magothiensis* Berry, from the somewhat later Magothy formation of Maryland. *Cissites panduratus*, from the approximately contemporaneous but later horizon in Colorado and western Tennessee, may be derived from Heer's type by the truncation of the base, the deepening of the sinuses, and the corresponding downward and outer movement of the lobule of the lateral lobes, which become distinct though somewhat subordinate lobes with a corresponding change in position of their midveins. We have here as clearly marked an evolutionary series as can be cited from allied fields of paleozoology, for although we are dealing with only foliar remains they preserve their generic facies through rather wide variations, and although at each recorded horizon they are variable in form, these variations culminate in successively younger occurrences, so that the latest form is most decidedly distinct from the earliest. It would perhaps be well to consider the Raritan form as a constant enough variant of *Cissites formosus* to merit a distinct varietal name, but that is of little consequence in the present connection, as I wish to emphasize here the place of origin and subsequent modification and radiation of this series of forms. This might be repeated diagrammatically as follows:

[95] Berry, E. W., Maryland Geol. Survey, Upper Cretaceous, pl. 79, figs. 1, 2, 1917.



The diagram clearly shows the relationship of these forms, but it implies an Arctic origin, which does not fully accord with the facts as I understand them. As allied species occur in the Atane beds of Greenland, the Cenomanian of central Europe, and beds of approximately the same age in New Jersey and Kansas, it is obvious that none of these specific regions correspond with the original center of radiation, and if the current conceptions of mid-Cretaceous paleogeography are considered it will be seen that the region which exactly fits the requirements is the central or north Asiatic region, from which it spread southwestward into

Europe, across the Arctic mainland to Greenland, and across the Bering region to Kansas. The diagram may be recast more correctly and somewhat amplified as follows:



Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Order MALVALES

Family TILIACEAE

Genus GREWIOPSIS Saporta

Grewiopsis ripleyensis Berry, n. sp.

Plate XV, figure 2

Ovate to narrowly cordate leaves of medium-large size, with pointed tip and a somewhat cordate base. Substance thin but firm and polished. Margins with large, somewhat irregular serrate teeth. Length about 10 centimeters; maximum width, near the base, about 7 centimeters. Petiole missing, obviously stout. Midrib stout, fairly prominent. Lateral primaries three on each side, diverging at acute angles from the top of the petiole. Outside pair short and straight, directed at right angles to midrib, craspedodrome. Second pair also short and straight, about 50 per cent longer than the outside pair, terminating in marginal teeth in the lower half of the leaf. Third pair longer, diverging from midrib at angles of about 35°, curving upward and terminating in marginal teeth in the upper half of the leaf, sending off on the outside regularly spaced craspedodrome branches. Secondaries from the midrib generally three alternate pairs, the lowest 3 centimeters or more above the lateral primaries, diverging from the midrib at angles of about 45° or 50°, curving regularly upward and craspedodrome, sending outward thin branches to the marginal teeth. Tertiaries thin but well marked, curved, percurrent or inosculating in the region midway between secondaries and primaries. Areolation fine meshed, largely immersed in the leaf substance.

This handsome species is obviously new. It is a type of leaf often referred to the genus *Populus*, and similar forms have sometimes been considered as representing nonlobate leaves of *Platanus*, but it is certainly not related to these two genera and is obviously related to a variety of forms in the order Malvales. In order not to be too specific in its generic determination it is referred to the form genus *Grewiopsis*, which was instituted by Saporta in 1866 for leaves referable to the order Malvales but not positively referable to existing genera. He compared these leaves, which were abundant in the "Paléocène" of Sézanne, France, with the existing genera *Sida*, *Abutilon*, *Pterospermum*, *Dombeya*, *Grewia*, *Sparmannia*, *Luhea*, and *Tilia* of this order. They have also been compared, on what seem to me doubtful grounds, with the extinct genus *Credneria* Zenker. About a score of species are known, largely from the early Eocene of Europe and America. Two species are known from the Dakota sandstone, *Grewiopsis aequidentata* and *Grewiopsis flabellata*. both described by Lesquereux. Lesquereux described a third species, *Grewiopsis mudgei*, but this was an unintentional redescription of the type of *Grewiopsis aequidentata*. *Grewiopsis flabellata* has been recorded from the Magothy formation in the Coastal Plain of Maryland. A third species, *Grewiopsis cle-*

burni, has been recorded by Lesquereux from the Cretaceous of the Montana group, and there are two well-characterized species in the Tuscaloosa formation of Alabama.

The two Tuscaloosa forms, as well as the present species, are more closely allied to certain modern genera of the family Tiliaceae. These are *Grewia* Linné, which has about 90 species, mostly tropical, in the Old World; *Hockenya* Willdenow, which has about 15 species in the American Tropics, extending from the Antilles and Central America to Brazil; and *Triumfetta* Linné, with about 60 species in the Tropics of both hemispheres, extending northward in America to the Antilles.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Grewiopsis inequilateralis Berry, n. sp.

Plate XV, figure 1

Leaves smaller than those of *Grewiopsis ripleyensis*, markedly inequilateral in all the four specimens contained in the present collection, oval, with a bluntly pointed, not extended tip and an obliquely truncated rounded base. Texture much more coriaceous than in the preceding species. Length from 3.5 to 5.5 centimeters; width in the median region 2.5 to 4 centimeters. Margins entire below; above the truncated base with large dentate teeth, showing a tendency to become slightly sublobate with rounded shallow sinuses. Petiole long and stout. Midrib stout and prominent. Lateral primaries from the top of the petiole, usually two on one side and one on the other, diverging from one another at acute angles. The odd one is short and not much curved, craspedodrome. The pair are curved, ascending, and craspedodrome; all send regular curved secondaries on the outside to the marginal teeth. Beyond an interval above the primaries the midrib sends off a pair of curved craspedodrome secondaries, and there are two additional small pairs in the upper part of the leaf. Tertiaries percurrent and not prominent; areolation obsolete.

The largest specimen of this species is figured, and it should be noted that the peculiar base is normal and not broken in any way. One of the smaller specimens is less inequilateral, but the other two are similar in this respect to the figured specimens.

The species is obviously distinct from previously described forms and readily recognized. The only fossil leaf to which I have noted any resemblance is a form from the lower Eocene which Ward[96] identified with *Acer indivisum* Weber, an obvious mistake. This has since been considered an abnormal form of the American leaves that have been referred to *Platanus guillelmae* Goeppert.

The present species finds its nearest living analogues in the tiliaceous genera *Grewia*, *Triumfetta*, and *Hockenya*.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, and Cooper pit, near Hollow Rock, Carroll County, Tenn.

Family STERCULIACEAE

Genus STERCULIA Linné

Sterculia snowii tennesseensis Berry

Sterculia snowii tennesseensis Berry, Torrey Bot. Club Bull., vol. 43, p. 296, pl. 16, fig. 5, 1916; U. S. Geol. Survey Prof. Paper 112, p. 117, pl. 32, fig. 1, 1919.

Leaf bilobate, with a bluntly pointed base and gradually narrowed acuminate recurved apical lobes. Length about 11 centimeters; width of the entire basal part of the leaf 2.5 to 2.75 centimeters; width of lobes 1.1 to 1.6 centimeters. Margins entire. Texture subcoriaceous. Sinus extending halfway to the base or less, open, narrowly rounded. Midrib stout, flexuous. Lateral primary stout, diverging from the midrib at an acute angle about 3 centimeters above its base. Secondaries thin, largely immersed, diverging from the primaries at wide angles and at regular intervals, arching in a camptodrome manner near the margins.

This striking form is unfortunately represented by only two specimens, both of which are bilobate, although, like so many other fossil and existing species of *Sterculia*, it may well have varied from entire to trilobate. Among previously described fossil forms it may be compared with the species from the Magothy formation in New Jersey and Maryland, *Sterculia minima* Berry, which is a smaller and more variable form, or with the species from the Dakota sandstone, *Sterculia mucronata*

[96] Ward, L. F., U. S. Geol. Survey Bull. 37, p. 66, pl. 29, fig. 5, 1887.

Lesquereux and *Sterculia snowii* Lesquereux. *Sterculia snowii*, though often much larger and with five lobes, is extremely variable. Two named varieties of it have already been recognized, and the general character and venation of this Tennessee form leads me to conclude that it represents another variety of this protean species.

Occurrence: McNairy sand member of Ripley formation, 2½ miles southwest of Selmer, McNairy County, Tenn.

Order PARIETALES

Family DILLENIACEAE

Genus DILLENITES Berry

Dillenites cretaceus Berry, n. sp.

Plate XV, figure 5

Leaves of medium size, ovate, widest below the middle and tapering upward to the acuminate tip. Base rounded or broadly cuneate. Margins dentate. Length about 8 to 9 centimeters; maximum width 3.4 to 4 centimeters. Petiole medium stout, about 1 centimeter in length. Midrib stout and prominent. Secondaries thin but prominent, numerous, subopposite to alternate, subparallel, camptodrome; about nine to twelve pairs diverge from the midrib at angles of about 45°. Tertiaries thin, percurrent.

These leaves are clearly allied to the several species of *Dillenites* from the lower Eocene of the Mississippi embayment which I have described and which represent early forms of Dilleniaceae. The present species is the only one thus far recognized in the Upper Cretaceous. It differs from the Eocene species in having camptodrome secondaries and in sending short branches into the marginal teeth, but this feature is partly seen in *Dillenites microdentatus*, the type of the genus. The present form is not uncommon in the Ripley.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Family TERNSTROEMIACEAE

Genus TERNSTROEMITES Berry

Ternstroemites ripleyensis Berry, n. sp.

Plate XV, figures 3, 4; Plate XVI, figure 1

Leaves of variable size, lanceolate, with an extended and gradually narrowed acuminate tip and a cuneate base decurrent on the winged petiole. Length from 5 to 18 centimeters; maximum width, below the middle, from 1 to 3 centimeters. Leaf substance thin. Margins regularly crenate except for a short distance proximad, where they are entire. Teeth variable but uniform on single leaves, regularly spaced, either close set or remote. Petiole long, conspicuously winged, 2 centimeters long in a medium-seized specimen. Midrib stout, prominent. Secondaries thin, diverging from the midrib at angles of about 70° at regular intervals and abruptly camptodrome in the marginal region, sending short branches to the marginal teeth. Tertiaries obsolete.

This is one of the commonest species in the Ripley, being represented by a large amount of material. Superficially it is much like the form known as *Celastrophyllum carolinensis*, but it differs in the elongated winged petiole, the extended tip, and the less numerous and less ascending secondaries. It appears to be ancestral to the lower Eocene species *Ternstroemites preclaibornensis* Berry, of the Wilcox group, which is in turn ancestral to *Ternstroemites claibornensis* Berry, of the Claiborne group.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Ternstroemites tennesseensis Berry, n. sp.

Plate XVI, figure 3

Leaves of medium size, elliptical-lanceolate, with a bluntly pointed apex and a similarly pointed cuneate base. Length 8 centimeters; maximum width, halfway between the apex and the base, 3.7 centimeters. Leaf substance thin. Margins regularly and somewhat coarsely crenate except proximad, where they are entire for about one-fourth their extent. Midrib stout, straight, and prominent on the lower surface. Secondaries thin; about 12 pairs diverge from the midrib at wide angles, as much as 60° in the median part of the leaf; they are approximately straight and parallel at regular intervals and are joined by a camptodrome loop only about two-thirds of the distance to the margin. Tertiaries obsolete.

This species is typical of the group of leaves which are so common in the Upper Cretaceous of the Atlantic Coastal Plain and which have heretofore been referred to *Celastrophyllum*, although they are obviously not Celastraceae but appear to represent the Ternstroemiaceae. The present species shows points of resemblance to *Celastrophyllum crenatum* Heer,[97] *C. undulatum* Newberry,[98] and *C. grandifolium* Newberry,[99] without being identical with either. They range in age from the Tuscaloosa and Raritan formations upward and are congeneric, showing marked contrasts with the other Coastal Plain species that have been referred to *Celastrophyllum.*

The type of *Ternstroemites* represented by the foregoing species appears to have been waning during Ripley time, and the contrasted types represented by *Ternstroemites ripleyensis* and *T. cretaceus*, equally old, appear to have furnished the stock of the lower and middle Eocene species in the embayment region.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Ternstroemites cretaceus Berry, n. sp.

Plate XVI, figure 2

Leaves of variable size, broadly lanceolate, with an acuminate tip and a narrowly cuneate base. Margins regularly but remotely serrate. Texture subcoriaceous. Length from 10 to 17 centimeters; maximum width, in middle region, 1.5 to 3.25 centimeters. Petiole missing. Midrib stout, straight, prominent on the lower surface of the leaf. Secondaries thin, close-set, straight, and subparallel, diverging from the midrib at angles of about 40°, inosculating or joined by percurrent tertiaries, their tips joined by abrupt and flat camptodrome loops, from which short branches are sent to the teeth.

This well-marked species is readily distinguished from the other Ripley species of *Ternstroemites.* It appears to be descended from *Celastrophyllum decurrens* Lesquereux, of the Dakota sandstone and the Raritan and Tuscaloosa formations, and also to be related to *Myrica hollicki* Ward, of the Raritan formation, both of which are forms of *Ternstroemites* and not related to *Celastrophyllum* or *Myrica.* It is probably ancestral to the lower Eocene *Ternstroemites eoligniticus* Berry, of the Wilcox group of the embayment region.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, and Cooper pit, near Hollow Rock, Carroll County, Tenn.

97 Heer, Oswald, Flora fossilis arctica, vol. 7, p. 41, pl. 62, fig. 21, 1883.

98 Newberry, J. S., U. S. Geol. Survey Mon. 26, p. 102, pl. 38, figs. 1–3, 1896.

99 Idem, p. 104, pl. 19, fig. 8; pl. 21 figs. 1–4.

Order THYMELEALES

Family LAURACEAE

Genus CINNAMOMUM Blume

Cinnamomum newberryi Berry

Plate XVI, figure 5

Cinnamomum newberryi Berry, Torrey Bot. Club Bull., vol. 38, p. 423, 1911; New Jersey Geol. Survey Bull. 3, p. 150, pl. 16, fig. 3, 1911; U. S. Geol. Survey Prof. Paper 84, pp. 54, 117, pl. 9, figs. 12, 13; pl. 21, figs. 9–11, 1914; Maryland Geol. Survey, Upper Cretaceous, p. 860, pl. 71, fig. 6, 1916; U. S. Geol. Survey Prof. Paper 112, p. 118, pl. 21, figs. 6–9, 1919.

Cinnamomum sezannense Heer, Flora fossilis arctica, vol. 6, Abt. 2, p. 77, pl. 19, fig. 8; pl. 33, figs. 11, 12, 1882 [not Watelet]; idem, vol. 7, p. 30 pl. 61, fig. 1a, 1883 [not Watelet].

Lesquereux, The flora of the Dakota group: U. S. Geol. Survey Mon. 17, p. 107, pl. 12, fig. 7, 1892 [not fig. 6, which is a leaf of *Cinnamomum membranaceum* (Lesquereux) Hollick].

Dawson, Roy. Soc. Canada Trans., 1st ser., vol. 2, sec. 4, p. 64, pl. 13, fig. 58, 1894 [not Watelet].

Hollick, Torrey Bot. Club Bull., vol. 21, p. 53, pl. 180, figs. 5, 7, 1894 [not Watelet].

Penhallow, Roy. Soc. Canada Trans., 2d ser., vol. 8, sec. 4, p. 46, 1902 [not Watelet].

Hollick, New York State Mus. Fifty-fifth Ann. Rept. for 1901, p. r50, 1903.

Cinnamomum intermedium Smith, On the geology of the Coastal Plain of Alabama, p. 348, 1894 [nomen nudum].

Newberry, The flora of the Amboy clays: U. S. Geol. Survey Mon. 26, p. 89, pl. 29, figs. 1–8, 10, 1896 [not Ettingshausen].

Berry, New Jersey State Geologist Ann. Rept. for 1905, p. 139, pl. 20, figs. 2–6, 1906 [not Ettingshausen]; Torrey Bot. Club Bull., vol. 33, p. 179, pl. 7, figs. 3, 4, 1906 [not Ettingshausen].

Hollick, The Cretaceous flora of southern New York and New England: U. S. Geol. Survey Mon. 50, p. 74, pl. 29, fig. 7; pl. 30, figs. 1, 2, 1907 [not Ettingshausen].

Berry, Torrey Bot. Club Bull., vol. 37, p. 27, 1910 [not Ettingshausen].

Leaves subcoriaceous, lanceolate to ovate-lanceolate, varying greatly in size and consequently in appearance. Apex short, pointed, or more or less narrowly extended. Base broad, narrowed to the petiole. Primaries three, usually suprabasilar. This species is primarily distinguished from *Cinnamomum heerii* Lesquereux by its relatively narrower form and acute base. The Georgia material is not scanty but is for the most part extremely fragmentary. The single complete leaf is of the short type like that shown in Newberry's figure 10,[1] or like the leaves from the Arctic and from the Dakota sandstone which have usually been referred to *Cinnamomum sezannense* Watelet. That they are not in the slightest degree related to this European basal Eocene type may be readily seen by a comparison of the American Cretaceous material with the figures of the true *Cinnamomum sezannense* as given by Watelet, Saporta, and others.[2]

The present species, as here revised according to the foregoing citations, has a remarkable range in the Upper Cretaceous. The Raritan formation of New Jersey is the oldest formation in which it has been found. Above the Raritan horizon it occurs in the Atane and Patoot beds of Greenland, in the Magothy formation from Long Island to Maryland, in the Black Creek formation of North Carolina, in the Middendorf arkose member of the Black Creek of South Carolina, in the Tuscaloosa formation of Alabama, where it is especially abundant at certain localities, and in the Dakota sandstone of Kansas. It appears to be present in the Upper Cretaceous of the Pacific coast on Vancouver Island and is probably represented in the Texas remains of *Cinnamomum* recorded by Knowlton[3] from the Woodbine sand in Cooke County, Tex. It has also been recorded from the Eutaw formation in the Chattahoochee drainage basin in Georgia. Although not known from Europe, the forms from the Cenomanian of Bohemia which Velenovsky describes as *Aralia daphnophyllum* are very similar to this American species.

It must be obvious to any rational botanist that this great range in time can scarcely represent a single botanic species. I regard this statement as self-evident, and yet I can discern no criteria except stratigraphic for specific segregation. *Cinnamomum* leaves are notoriously variable both in the existing and in extinct floras, and the same unsurmountable difficulties are presented by a number of Tertiary species, so called. I have studied a great many specimens of *Cinnamomum newberryi* from earlier horizons and can not see in the Ripley leaves which I refer to this species any features that will differentiate them from the abundant remains in the much older Raritan and Tuscaloosa formations. In themselves they are characteristic enough, as the accompanying figure shows, and are not readily confused with other Cretaceous or with Eocene species of *Cinnamomum*.

Occurrence: McNairy sand member of Ripley formation, 2½ miles south of Mifflin, Chester County, and a quarter of a mile west of Buena Vista, Carroll County, Tenn.

Cinnamomum newberryi lanceolatum Berry, n. var.

Plate XVI, figure 4

Small slender leaves, lanceolate, widest below the middle and tapering upward to the extended acuminate tip. Base narrow, slightly decurrent. Texture subcoriaceous. Margins strictly entire. Length about 4 centimeters; maximum width about 8 millimeters. Petiole stout, 3 millimeters in length. Midrib stout, prominent. Lateral primaries stout, diverging at acute angles from the base of the midrib, somewhat thinner than the midrib, ascending near the margins two-thirds of the distance to the tip, where they join the basal of two or three pairs of short camptodrome secondaries that are developed in that region of the leaf. Nervilles thin, percurrent.

This variety is probably merely a small narrow, perhaps juvenile leaf of the associated larger-leafed species, the suppression of camptodrome secondaries from the outer sides of the lateral primaries being conditioned by the narrowing of the leaf. It is sufficiently distinct in appearance to merit a name, and it rests with the future to verify or disprove this assumption.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

[1] Newberry, J. S., The flora of the Amboy clays: U. S. Geol. Survey Mon. 26, pl. 29, fig. 10, 1896.

[2] Watelet, A., Description des plantes fossiles du bassin de Paris, pl. 50, fig. 2, 1866. Saporta, Gaston de, Flore fossile de Sézanne, pl. 8, fig. 5, 1865; Végétation à l'époque des marnes heersiennes de Gelinden, pl. 6, figs. 5, 6, 1873; Revision de la flore heersienne de Gelinden, pl. 9, figs. 2–6. 1878. Friedrich, P. A., Beiträge zur Kenntniss der Tertiärflora der Provinz Sachsen, pl. 1, fig. 5, 1863.

[3] Hill, R. T., U. S. Geol. Survey Twenty-first Ann. Rept., pt. 7, p. 317, 1901.

Cinnamomum newberryi minimum Berry, n. var.

Plate XVI, figure 6

Leaves small, ovate, widest in the basal half of the leaf and tapering upward to the acute tip. Base broadly rounded. Length about 3.5 centimeters; maximum width about 1.2 centimeters. Petiole stout, 6.5 millimeters in length. Primaries three, from top of the petiole. In general form and venation an exact miniature of *Cinnamomum newberryi*, except that the lateral primary on one side is craspedodrome, terminating in a well-marked and relatively prominent serrate tooth. Otherwise the margins are entire.

This variety is probably only a reduced and perhaps abnormal leaf of the contemporaneous form identified as *Cinnamomum newberryi*. The fact that only a single specimen is known makes this supposition still more probable.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Cinnamomum newberryi ellipticum Berry, n. var.

Plate XVI, figure 7

A relatively shorter and more robust form of leaf than is typical in *Cinnamomum newberryi* but not greatly different from many forms that have been referred to that species. The fact that in the specimen here figured there were two apparently opposite leaves at the apex of an abortive twig may indicate that the leaves are merely somewhat abnormal leaves of the type. Length about 7.5 centimeters; maximum width about 3.25 centimeters. Petiole stout, curved, 1.3 centimeters in length. Primaries stout, three, slightly suprabasilar. Secondary venation typical of *Cinnamomum.*

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Cinnamomum praespectabile Berry, n. sp.

Plate XVII, figures 4, 5

Medium to large coarse leaves, obovate, widest above the middle, narrowing gradually proximad to the sharply cuneate base and narrowing abruptly distad to the extended apiculate tip. Length from 8 to 13 centimeters; maximum width from 4 to 6.5 centimeters. Petiole stout, 1.25 to 2 centimeters in length. Midrib stout, prominent on under side of leaf. Lateral primaries suprabasilar, diverging from the midrib at angles of about 25° to 30°, stout and prominent below but becoming thin distad, parallel with the leaf margins. There are two or three pairs of camptodrome secondaries in the distal half of the leaf and two or three sweepingly curved camptodrome secondaries from the outer sides of the primaries. Tertiaries very thin, typical of the genus, running transversely from midrib to lateral primaries and usually inosculating midway between the two. Texture coriaceous.

This species in its size, general outline, coriaceous texture, and coarse suprabasilar primaries is exceedingly close to the European Tertiary species *Cinnamomum spectabile* Heer,[4] a form that has been recorded from a large number of European localities ranging in age from Oligocene to Pliocene and recorded by Knowlton[5] from the early basic breccias of Fort Union age in Yellowstone Park. Another similar form, somewhat smaller in size and more delicate in texture, is *Cinnamomum buchii* Heer,[6] a widespread Eocene to Pliocene form in Europe and recorded from the Wilcox Eocene of Louisiana.[7] It is difficult to appreciate the differences that have led European students to separate the two species just mentioned, for they appear to intergrade. Moreover, it is an unsettled question to what extent the normally lanceolate or ovate-lanceolate Cinnamomums assume this apiculate form in their broader leaves. Certainly among the leaves of the existing *Cinnamomum camphora* Nees and Ebermaier the broader leaves tend to be apiculate and approach the fossil species enumerated above, although the narrower leaves are ovate-lanceolate and quite different in general appearance.

Amid the abundant materials referred to *Cinnamomum* from this and earlier Upper Cretaceous horizons none are at all closely similar to the present species. The relation of

[4] Heer, Oswald, Flora tertiaria Helvetiae, vol. 2, p. 91, pl. 96, figs. 1–8, 1856.

[5] Knowlton, F. H., U. S. Geol. Survey Mon. 32, p. 727, pl. 94, fig. 6, 1899.

[6] Op. cit., p. 90, pl. 95, figs. 1–8.

[7] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 299, pl. 79, fig. 10, 1916.

this species to the Eocene forms from American rocks that have been referred to either *Cinnamomum buchii* or *Cinnamomum spectabile* is close. The name chosen is intended to suggest that it stood in an ancestral relationship, and I am inclined to think that the two American Eocene forms above mentioned are not only identical but distinct from the essentially later European types of those species. A recent species that is similar to all of these is *Cinnamomum glanduliferum* Meissner.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Genus NECTANDRA Roland

Nectandra prolifica Berry, n. sp.

Plate XVII, figures 1–3

Lanceolate, mostly falcate leaves of variable size and coriaceous texture, widest below the middle, tapering upward to an extended acuminate tip and downward to a narrowly cuneate or slightly decurrent base. Margins entire, often somewhat undulate. Length from 8 to 12 centimeters; maximum width from 7 to 14 millimeters. Petiole stout, about 1 centimeter in length. Midrib stout, prominent, usually curved. Secondaries relatively stout, well marked, irregularly and rather remotely spaced, diverging from the midrib at angles of about 45° and in general ascending in sweeping camptodrome arches; some of them diverging at more open angles and pursuing a straighter course, particularly in the upper part of the leaf. Tertiaries thin, forming a typical lauraceous areolation.

This species is exceedingly abundant at the Carroll County plant locality and constitutes a well-marked element in the Ripley flora, which when the venation is considered is readily distinguishable. The general form is, however, that of a number of unrelated genera, and in the absence of venation it might readily be confused with *Myrcia*, *Salix*, or *Apocynophyllum*. For example, the present species has the identical form of the Eutaw and Ripley species *Myrcia havanensis* Berry[8] or of the Raritan species *Salix inaequalis* Newberry.[9]

[8] Berry, E. W., U. S. Geol. Survey Prof. Paper 112, p. 125, pl. 11, fig. 4; pl. 28, fig. 7, 1919.

[9] Newberry, J. S., The flora of the Amboy clays: U. S. Geol. Survey Mon. 26, p. 67, pl. 17, figs. 2–7, 1896.

Genus MALAPOENNA Nees

Malapoenna horrellensis Berry

Malapoenna horrellensis Berry, Torrey Bot. Club Bull., vol. 37, p. 198, pl. 24, figs. 1–9, 1910; idem, vol. 43, p. 299, 1916.

I described this species in 1910 as follows:

Leaves ovate-lanceolate, about 8 centimeters long by 2.5 centimeters in greatest width; broadest at the evenly rounded or slightly acute base, narrowing gradually upward, the apex narrow and extended but obtusely pointed. Leaf substance thin but persistent, evidently coriaceous in life, since these leaves occur abundantly at a locality where all the vegetable remains except the resistant *Araucaria*, *Cunninghamites*, and *Pistia* were evidently thoroughly macerated before entombment. Secondaries four to six pairs, subopposite, curved upward, camptodrome, branching from the midrib at an acute angle, the lowest pair branching from the top of the petiole and extending upward halfway to the apex or farther, giving the leaf a triple-veined appearance. Perhaps they should be termed lateral primaries, although they are much finer than the medium-stout midrib. The next pair of secondaries branch at a less acute angle a considerable distance above the base, one-third to one-half the distance to the apex. Tertiary venation typically lauraceous.

This species is markedly distinct from the species of lauraceous leaves hitherto described in its rounded base, the only genus of this family with such a character being *Cinnamomum*. The present species is possibly liable to be confused with *Cinnamomum heeri* Lesquereux when only the basal part of the leaf is found, but the general proportions and characters of the whole leaf are perfectly distinct.

It was described from several localities in the upper part of the Black Creek formation of North Carolina and is represented in the collections from the basal part of the Eutaw formation of Alabama in Hale County. It is also present in the basal beds of the Eutaw in western Georgia.

Occurrence: Eutaw formation, Havana, Hale County, Ala.; Broken Arrow Bend, Chattahoochee County, Ga. McNairy sand member, of Ripley formation, Big Cut, near Cypress, and 2½ miles southwest of Selmer, McNairy County, Tenn.

Genus LAURUS Linné

Laurus atanensis Berry

Laurus atanensis Berry, Torrey Bot. Club Bull., vol. 38, p. 420, 1911; U. S. Geol. Survey Prof. Paper 84, p. 53, pl. 13, fig. 7, 1914.

Laurus angusta Heer, Flora fossilis arctica, vol. 7, pt. 2, p. 76, pl. 20, figs. 1b, 7; pl. 43, fig. 1c, 1882; vol. 7, p. 30, pl. 57, fig. 1b, 1883 [not Rafinesque].

Lesquereux, Flora of the Dakota group: U. S. Geol. Survey Mon. 17, p. 93, pl. 16, fig. 7, 1892.

Hollick, New York Bot. Garden Bull., vol. 3, p. 408, pl. 70, figs. 10, 11, 1904; U. S. Geol. Survey Mon. 50, p. 81, pl. 27, figs. 11, 12, 1907.

Leaves entire, linear-lanceolate, tapering about equally to the acuminate apex and base. Length 12 centimeters or less, some of Heer's Greenland material considerably under this dimension; width about 1.5 centimeters, although some specimens reach 2 centimeters. Midrib relatively thin. Secondaries thin, somewhat widely separated, branching from the midrib at acute angles (45° or less), nine to twelve alternate pairs, finally ascending along the margin, camptodrome. Tertiaries forming the characteristic areolation of the genus.

Heer originally compared this species with *Laurus plutonia*, pointing out that it was more linear and acuminate. He also remarks that it is somewhat smaller, but this generalization has been found not to hold good, even for the Greenland material, and is especially not true of the forms from the Middendorf arkose member of the Black Creek formation in South Carolina and those from the Ripley of Tennessee. The primaries are sparser and more ascending than in *Laurus plutonia*, and the more linear form gives the leaf a decidedly different aspect. There can be no doubt that the two are perfectly distinct species, naturally possessing certain lauraceous characters in common. *Laurus plutonia* did not persist in the Upper Cretaceous as late as *Laurus atanensis*.

Laurus atanensis was described from specimens found in the Atane beds of Greenland and was subsequently recorded from the Patoot beds. Lesquereux identified it in material from the Dakota sandstone of Kansas, although this record was based upon extremely doubtful material, and Hollick has recorded it from the clays of Northport, Long Island, which are probably of Magothy age. Characteristic material was described by me from the Middendorf arkose member of the Black Creek formation in South Carolina, and identical remains occur in considerable abundance in the Ripley formation in Henry and Carroll counties, Tenn. Some of the specimens from the Cooper pit are considerably wider than the average but are otherwise identical.

The species is not found in the Magothy formation of New Jersey or Maryland nor in the Tuscaloosa formation of Alabama, and as the occurrences cited from Lesquereux and Hollick are both based upon questionable evidence it may be regarded as a form more diagnostic of the horizon of the Patoot beds of Greenland and the Ripley of the Atlantic Coastal Plain.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, and Cooper pit, near Hollow Rock, Carroll County, Tenn.

Laurus asiminoides Berry, n. sp.

Plate XVIII, figures 1, 2•

Asimina cocenica? Knowlton, U. S. Geol. Survey Bull. 163, p. 57, pl. 14, fig. 3, 1900 [not Lesquereux, 1878].

Leaves broadly lanceolate, relatively small, with a similarly acuminate apex and base, regularly rounded entire margins, and subcoriaceous texture. Length 7.5 to 8 centimeters; maximum width, midway between the apex and the base, 2.1 to 2.5 centimeters. Petiole stout, curved, 1 centimeter in length. Midrib stout. Secondaries stout, six or seven pairs, diverging from the midrib at acute angles and sweeping upward in long, slightly irregular curves, eventually camptodrome. Tertiaries thin, forming open meshes.

The earliest known specimen of this species comprised a single leaf from the Montana group of Wyoming which Knowlton identified with some doubt as *Asimina eocenica* Lesquereux.[10] In describing the supposed Midway Eocene plants from Texas in 1916 I pointed out [11] that the Montana group leaf was distinct from Lesquereux's type of material from the Denver formation and Black Buttes, Wyo., both of which are now considered by Knowlton of Eocene age. Leaves similar to the one described by Knowlton are sparingly represented in the Ripley formation of Tennessee and substantiate this conclusion. They have all the characters of the Lauraceae and are uniformly smaller than those of *Asimina*

[10] Lesquereux, Leo, Tertiary flora, p. 251, p. 43, figs. 5–8, 1878.

[11] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 14, 1916.

eocenica Lesquereux, with fewer and much more ascending secondaries, shorter petioles, and less stout midribs.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Laurus ripleyensis Berry, n. sp.

Plate XVIII, figure 3

Leaves relatively small, ovate, widest in the middle and narrowing distad to a bluntly pointed tip, remaining full proximad and narrowing rapidly to an acuminate base. Margins entire. Texture subcoriaceous. Petiole fairly long and very stout, 1.25 centimeters in length. Midrib stout and usually curved, prominent on the under side of the leaf. Secondaries stout, camptodrome, about seven pairs, those in the basal half of the leaf ascending subparallel with the lower lateral margins. Upper four pairs diverging from the midrib at conspicuously wider angles, rather straight in their courses, conspicuously camptodrome by a single large loop some distance within the margins. Tertiaries typically lauraceous, prominently seen only on impressions showing the lower surface of the leaf. Length about 8 centimeters; maximum width about 2.2 centimeters.

This well-marked species, which is suggestive of our existing species of *Persea* of the southeastern United States, was apparently not common in the Ripley—at least it is a rare form in the collections. It is readily differentiated from the numerous Upper Cretaceous species of *Laurus* by its general ovate form and blunt tip.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Laurus coloradensis Knowlton

Laurus coloradensis Knowlton, U. S. Geol. Survey Prof. Paper 98, p. 340, pl. 88, fig. 4 [not fig. 5]. 1916; Prof. Paper 101, p. 268, pl. 45, fig. 3, 1917.

This species was described as follows by Knowlton in 1917:

Leaf narrowly lanceolate, tapering in about equal degree to both base and apex; petiole short (?), thick; midrib relatively very thick below but becoming very thin above; secondaries numerous, a dozen or more pairs, subopposite, much curved upward, camptodrome, arching near the margin and each joining the next above by a series of loops; intermediate secondaries frequent, usually joining the secondary next below; secondaries strong, oblique to the secondaries; finer nervation not preserved.

The leaf here figured as the type of this species is narrowly lanceolate in shape, being about 11 centimeters in length and 2.5 centimeters in width; the petiole is preserved for a length of 0.5 centimeter but probably is not complete.

In the matter of nervation the present species approaches very closely to *Laurus primigenia* Unger, as figured by Lesquereux,[12] but it differs from this in size and to some extent in shape, being much larger and narrower, especially at the base. Its thick petiole and thick basal portion of the midrib constitute other minor differences.

It is not common in the Ripley but is a characteristic form in the Vermejo formation in Colorado and the Fruitland formation in northwestern New Mexico and is probably present at Point of Rocks, Wyo., as Knowlton has pointed out.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Genus LAUROPHYLLUM Goeppert

Laurophyllum ripleyensis Berry, n. sp.

Plate XVIII, figures 4–8

Laurus coloradensis Knowlton, U. S. Geol. Survey Prof. Paper 98, pl. 88, fig. 5, 1916 [not fig. 4].

Elongate-lanceolate and generally falcate leaves of variable size and proportions. Tip generally much extended and acuminate. Base gradually narrowed, acuminate-cuneate, or decurrent. Margins entire. Texture coriaceous. Petiole very stout, curved, thickening proximad, 7 centimeters long in the smallest leaf, 1.5 centimeters in the largest. Midrib very stout, usually curved, prominent on the lower surface of the leaf. Secondaries numerous, thin, diverging at wide angles and camptodrome, obsolete by immersion in the thick leaf substance in most specimens. Tertiaries obsolete. The smallest perfect leaf in the collection is 4.5 centimeters long by 1.25 centimeters in maximum width; the largest is 12 by 3 centimeters, the region of maximum width being about midway between the apex and base. A great many leaves are somewhat more slender than these,

[12] Lesquereux, Leo, The Tertiary flora: U. S. Geol. Survey Terr. Rept., vol. 7, pl. 36, fig. 6, 1878.

and an average would perhaps be 10 centimeters in length and 2 centimeters in maximum width.

The present characteristic and exceedingly abundant species belongs to a type of leaf which is abundant throughout most of the Upper Cretaceous deposits of the world and is commonly referred to the genus *Laurophyllum*, which will serve the present purpose. The details of venation that would settle its reference to the Lauraceae can not be made out; consequently its true generic relations in the family can not be determined, although it shows a great similarity to the lower Eocene leaves from this same region which I have referred to the genus *Nectandra*.

One of the figured specimens from the Fruitland formation of San Juan County, N. Mex., described by Knowlton appears to be identical with this species and to differ from the other specimens from that formation and from the type of *Laurus coloradensis*, which came from the Vermejo formation.[13]

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County (very common); Cooper pit, near Hollow Rock, Carroll County (rare), Tenn.

Order MYRTALES

Family MYRTACEAE

Genus MYRCIA De Candolle

Myrcia havanensis Berry

Plate XIX, figure 9

Myrcia havanensis Berry, Torrey Bot. Club Bull., vol. 43, p. 300, 1916; U. S. Geol. Survey Prof. Paper 112, p. 125, pl. 11, fig. 4; pl. 28, fig. 7, 1919.

Eucalyptus attenuata Ward [not Newberry], U. S. Geol. Survey Fifteenth Ann. Rept., p. 371, 1895.

Leaves linear-lanceolate, falcate, about 9 centimeters in length by 1 centimeter in maximum width, which is in the lower half of the leaf. Margins entire. Apex gradually narrowed, acuminate. Base narrowly pointed, decurrent. Petiole very stout, tapering upward, 1.75 centimeters in length. Midrib stout, curved. Secondaries numerous, thin, somewhat irregularly spaced, 2 to 6 millimeters apart, branching from the midrib at angles of about 40°, running with but slight curvature to the well-marked and nearly straight longitudinal vein, which forms a marginal hem less than 0.5 millimeter from the margin. Texture coriaceous.

The present species is very close to some of the numerous forms which from time to time have been referred to *Eucalyptus geinitzi* (Heer) Heer. It is, however, distinct from that species, especially when compared with Heer's type or with the more typical American material. In general it is a smaller leaf, has a larger and longer petiole and an outline less inclined toward ovate, and is relatively much more produced apically. It is typically *Myrcia*-like in all its characters and is readily distinguishable from the forms from the Tuscaloosa formation which have been referred to *Eucalyptus geinitzi*. It is confined to the basal beds of the Eutaw formation in Hale County, Ala., and the Ripley formation in western Tennessee, and takes its name from the town of Havana Ala., near which the leaf-bearing laminated clays of the Eutaw formation crop out. A single specimen collected by R. T. Hill in 1891 at the big cut on the Southern Railway east of Pocahontas, Tenn., and identified by Ward as *Eucalyptus attenuata* Newberry proves to belong to this species.

Occurrence: Eutaw formation (basal beds), 2 miles south of Havana, Hale County, Ala. (McNairy sand member), of Ripley formation Camden-Paris road, 13 miles northwest of Camden, Henry County; big cut 1½ miles west of Cypress, 2½ miles southwest of Selmer, McNairy County; Cooper pit, near Hollow Rock, Carroll County, Tenn.

Myrcia dubia Berry, n. sp.

Plate XIX, figure 3

A tiny elongate-lanceolate leaf, widest below the middle and tapering upward to the acuminate tip and decurrent to the petiole. Margins entire. Texture coriaceous. Length about 3 centimeters; maximum width about 4 millimeters. Petiole expanded, about 7 millimeters in length. Midrib relatively very stout, expanding proximad. Stout acrodrome veins follow each margin, and ascending secondaries connect these with the midrib.

This form may represent a juvenile leaf, as it is represented in the collections by only two specimens, but its extremely coriaceous texture rather suggests that it represents a small-

[13] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 268, pl. 45, fig. 3, 1917.

leafed species of *Myrcia*, as the venation is characteristic of that genus. It resembles somewhat the lower Eocene (Wilcox group) species *Myrcia grenadensis* Berry.[14]

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Genus EUGENIA Linné

Eugenia? anceps Berry

Plate XIX, figure 6

Eugenia? anceps Berry, Torrey Bot. Club Bull., vol. 43, p. 301, pl. 16, figs. 2–4, 1916; U. S. Geol. Survey Prof. Paper 112, p. 125, pl. 32, figs. 3–5, 1919.

Coriaceous leaves of variable size and form, lanceolate or oblong-lanceolate. Apex and base equally acuminate, or the apex somewhat more attenuated. Margins entire. Length 7.75 to 10 centimeters; maximum width, midway between the apex and the base, 11 to 18 millimeters. Petiole enlarged, short and stout, 3 to 4 millimeters in length. Midrib stout. Secondaries thin, immersed in the leaf substance.

This species is referred to *Eugenia* with considerable hesitation. The material is abundant but poorly preserved, and these leaves resemble a variety of forms referred to such genera as *Salix* and *Laurophyllum*.

Eugenia has furnished a species in the Tuscaloosa formation of Alabama and another in the Dakota sandstone of the western United States, and it is not uncommon in the Eocene of the Mississippi embayment region.

Occurrence: McNairy sand member of Ripley formation, 2½ miles southwest of Selmer, McNairy County; Cooper pit, near Hollow Rock, Carroll County, Tenn.

Genus MYRTOPHYLLUM Heer

Myrtophyllum angustum (Velenovsky) Berry, n. comb.

Plate XIX, figure 1

Eucalyptus angusta Velenovsky, Die Flora der böhmischen Kreideformation, vol. 4, p. 3, pl. 3, figs. 2–12, 1885.

Berry, Torrey Bot. Club Bull., vol. 36, p. 260, pl. 18, fig. 5, 1909; idem, vol. 37, p. 504, 1910; U. S. Geol. Survey Prof. Paper 84, pp. 55, 119, pl. 14, fig. 2; pl. 20, figs. 2–4, 1914; New Jersey Geol. Survey Bull. 3, p. 193, pl. 28, figs. 1-4, 1911.

Leaves linear, with acuminate tip, narrowly cuneate base, prominent midrib, fine and close-set thin ascending secondaries, and marginal vein. Texture, coriaceous.

This so-called species was instituted by Velenovsky and based upon material from the Perucer beds of Bohemia, and despite the fact that this author describes supposed fruits in connection with it, I have transferred it from *Eucalyptus* to *Myrtophyllum*, for there are conclusive general reasons, which I have set forth in another connection,[15] for doubting its reference to *Eucalyptus*.

There is also grave doubt as to whether the references cited above all refer to the same species. The Bohemian material shows a wide range in size and is made to include leaves which in this country are commonly referred to *Eucalyptus geinitzi* Heer, a second wide-ranging and probably composite species.

Whatever may be the opinion as to the specific identity between the European and American forms, there is not the slightest doubt that the forms from the Black Creek, Eutaw, and Ripley formations are identical and represent a single species of Myrtaceae. These occur in the Black Creek formation of South Carolina and the Eutaw and Ripley formations of Georgia and are exceedingly common in the Ripley formation of western Tennessee. The characteristic venation of this species, which may be compared with Eocene and existing American species of *Myrcia*, is not shown in the specimen figured but is well illustrated in Professional Paper 84 (Pl. XIV, fig. 2; Pl. II, figs. 2–4).

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County; Cooper pit, near Hollow Rock, and a quarter of a mile west of Buena Vista, Carroll County; 2½ miles south of Mifflin, Chester County, Tenn. Cusseta sand member of Ripley formation, Buena Vista, Ga. Eutaw formation, McBrides Ford, Columbus, Ga.

Order UMBELLALES

Family ARALIACEAE

Genus ARALIA Linné

Aralia wellingtoniana minor Berry, n. var.

Plate XIX, figures 4, 5; Plate XXIII, figures 4, 5

Leaves relatively small, palmately three-lobed. Lobes acutely pointed, elongate, coni-

[14] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 316, pl. 91, fig. 3, 1916.

[15] Berry, E. W., Bot. Gaz., vol. 59, pp. 484–490, 1915; Science, new ser., vol. 49, pp. 91–92, 1919.

cal or sometimes slightly inflated, divided by open rounded sinuses more than three-fourths of the distance to the base. Base rounded or broadly cuneate. Margins remotely serrate. Texture subcoriaceous. Length about 9 centimeters; maximum width, from tip to tip of lateral lobes, about 11 centimeters. Petiole short and stout. Midrib stout, slightly flexuous, prominent on the lower surface of the leaf. Lateral primaries suprabasilar, stout, prominent, diverging from midrib at angles of about 35° and curving outward. Secondaries thin, numerous, relatively straight, running to a marginal hem, especially pronounced in the region of the sinuses. Short branches from the marginals enter the teeth. Tertiaries thin, mostly transverse to secondaries, forming a roughly quadrangular areolation.

This variety suggests the common Upper Cretaceous *Aralia wellingtoniana* Lesquereux in appearance but is clearly distinct. It is based upon three specimens from the Ripley formation which indicate a leaf not over half the size of the normal *A. wellingtoniana*. It lacks the decurrent base, a marked feature of that species, has more spreading and less inflated and more conical lobes, more aquiline teeth, straighter and less ascending secondaries, more open sinuses and the well-developed marginal hem, especially in the region of sinuses, which is not developed in *A. wellingtoniana.*

Aralia wellingtoniana is a characteristic species of the Dakota sandstone and the Woodbine and Raritan formations and is hence an older form than this variety. There has been some confusion in the past regarding its limits, as Lesquereux grouped under it certain five-lobed leaves belonging to his *Aralia saportana.*[16]

There is some resemblance between the Ripley form and *Aralia cottondalensis*, of the Tuscaloosa formation of Alabama. The latter has much shorter and more conical lobes, broadly rounded base, and crenate marginal teeth. This variety also shows a similarity to *Aralia decurrens* Velenovsky, a Cenomanian species from Bohemia.

The description of the present form as a variety of *Aralia wellingtoniana* naturally implies affiliation with the earlier records of that species in the same general region.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Aralia problematica Berry, n. sp.

Plate XX, figures 1, 2

Fragmentary remains present in considerable abundance and indicative of a palmately lobed or divided leaf of considerable size. The fragments, which range in length from 10 to 12 centimeters and in width from 2 to 4 centimeters, are inequilateral and have the margins irregularly and remotely sublobate. The texture is coriaceous, and the midvein is extremely stout, prominent, and longitudinally wrinkled. The secondary veins are stout and prominent, they diverge from the midvein at wide angles and irregular intervals, and most of them run straight to a conspicuous marginal vein that follows all the irregularities of the margin. The tertiaries are prominent, straight, and largely percurrent. The areolation is coarse and prevailingly quadrangular.

This species, obviously new, is unfortunately represented by fragments, so that its characters can not be fully determined. The material suggests a palmately lobate leaf, such as *Aralia multifida* Saporta[17] or *Aralia dissecta* Lesquereux,[18] but it may have been pedately divided, as one fragment that appears to be identical with the others has a petiole several millimeters in length. Both the irregular form and venation suggest certain existing leaves of the genus *Jatropha* of the family Euphorbiaceae, and it is of interest that *Aralia multifida* referred to above was described in the first instance as *Jatropha primaeva* by Saporta. On the other hand, the fragments may simply be those of an irregular simple leaf, in which case I would compare them with the genus *Dalechampia* Linné, a genus of the Euphorbiaceae not recorded in the fossil state but with about 60 existing species in the Tropics of both hemispheres.

I have referred the present species to *Aralia* more as a matter of convenience rather than from a conviction that it represents a Ripley

[16] See Berry, E. W., Torrey Bot. Club Bull., vol. 39, p. 402, 1912.

[17] Saporta, Gaston de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 1, p. 115, pl. 12, fig. 1, 1863.

[18] Lesquereux, Leo, Cretaceous and Tertiary floras, p. 176, pl. 35, 1863.

form of Araliaceae, as the material is too incomplete to serve for a new genus and *Aralia* as used by paleobotanists is sufficiently broad to include it. My own preference would be to refer it to the family Euphorbiaceae, but this conclusion as well as a more complete description must await the discovery of better material.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, and Cooper pit, near Hollow Rock, Carroll County, Tenn.

Family CORNACEAE?

Genus CORNOPHYLLUM Newberry

Cornophyllum minimum Berry, n. sp.

Plate XIX, figure 2

Leaves small, elliptical, widest in the middle, bluntly pointed and slightly decurrent to the long petiole. Margins entire, evenly rounded, and symmetrical. Leaf substance thin, chartaceous. Length about 2.5 centimeters; maximum width about 1.25 centimeters. Petiole long and stout, curved, about 11 millimeters in length. Midrib stout. Secondaries thin; about five pairs diverge from the midrib at acute angles, ascend subparallel with the lower lateral margins, and are eventually camptodrome. Tertiaries where seen are percurrent.

This is a not abundant form of uncertain relationship, referred to *Cornophyllum* from its resemblance in both form and ascending secondaries to the larger leaves commonly referred to that genus.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Series GAMOPETALAE

Order ERICALES?

Family ERICACEAE?

Genus ANDROMEDA Linné

Andromeda anceps Berry, n. sp.

Plate XX, figure 3

Lanceolate leaves of rather large size, with acute tip and base, widest below the middle and slightly more tapering distad than proximad. Margins entire, evenly rounded. Texture subcoriaceous. Length about 18.5 centimeters; maximum width about 4.25 centimeters. Petiole missing, presumably very stout. Midrib stout, prominent. Secondaries thin, about ten subopposite to alternate camptodrome pairs; those in the lower part of the leaf diverge from the midrib at actute angles and ascend in sweeping curves parallel to lower lateral leaf margins; the secondaries gradually become shorter and less ascending in the middle and upper part of the leaf. Tertiaries thin but well marked; below they are long, subparallel to secondaries, with which they inosculate at acute angles; above they form polygonal meshes, acute in the axis of direction of the secondaries, forming the characteristic areolation shown in the figure. Impressions of the lower surface indicate that the underside of the leaf was clothed with stout hairs.

This species is clearly allied to the group of somewhat earlier Upper Cretaceous forms that have been referred to the genus *Andromeda* and are so common in the Atlantic Coastal Plain, and of which *Andromeda parlatorii* Heer is probably the most common. Their generic reference is by no means beyond question. The present species differs from the earlier forms in the general outline, the majority being more acuminate, and also in the thinness of the secondaries. In outline it resembles some of the abundant lanceolate forms of *Ficus* of the Coastal Plain Cretaceous, but the venation is markedly different.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Order EBENALES

Family SAPOTACEAE

Genus CHRYSOPHYLLUM Linné

Chrysophyllum parvum Berry, n. sp.

Plate XIX, figures 7, 8

Leaves small, obovate, with a cuneate base and a slightly emarginate tip. Extremely coriaceous, with entire, slightly revolute margins. Length about 3 centimeters; maximum width about 1.5 centimeters. Petiole wanting. Midrib very stout and prominent, curved. Secondaries numerous, stout, subparallel; nine or ten subopposite pairs diverge from the midrib at wide angles (about 75° to 80°), pursue a straight outward course, and have their ends united by arches in the marginal region. Tertiaries well marked, comprising in the median region veins parallel with the secondaries, which break up to form open polygonal meshes in the marginal region.

This well-marked small form shows points of similarity with some modern species of *Mimusops*, a genus related to *Chrysophyllum*, and also with certain species of *Ficus*, as for example *Ficus nitida* Thunberg. It might be considered an aberrant *Ficus* leaf of the *Ficus benjaminea* type but appears to resemble most closely various species of *Chrysophyllum*. It shows some resemblance to the genus *Calyptranthes* Swartz, of the family Myrtaceae, but the venation is more nearly that characteristic of *Chrysophyllum*.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Genus BUMELIA Swartz

Bumelia prewilcoxiana Berry, n. sp.

Plate XX, figure 5; Plate XXI, figure 4

Leaves small, obcordate, with a wide retuse apex and a broadly rounded and ultimately decurrent base. Margins entire, full but slightly irregular. Texture subcoriaceous. Length 2 to 5 centimeters or slightly less; maximum width, in the upper half of the leaf, 1.75 to 3.5 centimeters. Ears broad, evenly rounded. Sinus retuse, extending one-sixth to one-seventh of the distance to the base. Petiole relatively long and very stout, curved, about 6 millimeters in length. Midrib very stout and prominent, curved. Secondaries stout but largely immersed in the leaf substance; four or five subopposite pairs diverge from the midrib at wide angles and are camptodrome. Tertiaries thin, largely percurrent.

This well-marked species is considered to have been ancestral to the lower Eocene species *Bumelia wilcoxiana* Berry,[19] as is indicated by the name assigned to it. *Bumelia wilcoxiana* is a somewhat larger, slightly more elongated form, with more cuneate base and shorter petiole. This form also shows some resemblance to the antecedent Tuscaloosa species *Sapotacites shirleyensis* Berry,[20] which I suggested as a possible ancestor of *Bumelia wilcoxiana* in discussing that species in 1916. The present species may also be compared with *Colutea obovata* Berry,[21] of the earlier Upper Cretaceous Tuscaloosa and Magothy formations, and with *Colutea protogaea* Heer,[22] of the Patoot beds of western Greenland. The species is represented in the present collection by two specimens.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Bumelia ripleyana Berry, n. sp.

Plate XX, figure 6

Leaves orbicular, divided one-third of the distance to the base by an open, rather straight-sided, proximally rounded sinus. Ears widely separated, inequilateral, rounded at their tips. Base broadly rounded to the point of attachment, where the margins are slightly decurrent. Margins entire, somewhat undulate. Texture coriaceous, the surface of the leaf polished. Midrib extremely stout and prominent. Secondaries thin, immersed in the substance of the leaf; four or five pairs diverge from the midrib at angles of about 45° and are camptodrome in the marginal region. Areolation a finely reticulated mesh of four or five sided areolae. Petiole wanting, which suggests that the leaf was sessile, as so thick a midrib would scarcely be separated from a petiole of corresponding thickness at this exact point had a petiole been present in life.

This is a well-marked member of the Ripley flora, readily distinguished from the associated emarginate or retuse forms. It is a type that has suggested the genus *Colutea* to some paleobotanists but is more profitably compared with *Bumelia*, of which there are a number of comparable forms in the early Eocene of the Mississippi embayment region. It may be compared with the somewhat similar *Sapotacites ettingshauseni* Berry,[23] of the Tuscaloosa formation in Alabama, which may possibly be looked upon as an ancestral type.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

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[19] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 336, pl. 100, figs. 4, 5; pl. 107, fig. 3, 1916.

[20] Berry, E. W., U. S. Geol. Survey Prof. Paper 112, p. 135, pl. 28, fig. 11; pl. 29, figs. 4–6, 1919.

[21] Berry, E. W., Torrey Bot. Club Bull., vol. 33, p. 175, pl. 8, figs. 5, 6, 1906.

[22] Heer, Oswald, Flora fossilis arctica, vol. 7, p. 43, pl. 61, fig. 1c; pl. 62, fig. 1c, 1883.

[23] Berry, E. W., U. S. Geol. Survey Prof. Paper 112, p. 135, pl. 29, fig. 7, 1919.

Order GENTIANALES

Family ASCLEPIADACEAE

Genus ACERATES Nilsson

Acerates cretacea Berry, n. sp.

Plate XX, figure 4

Leaves small, narrowly elongate-linear, generally falcate, gradually narrowed to the acuminate tip and abruptly narrowed to the pointed base. Margins entire. Texture subcoriaceous. Petiole short and stout, practically wanting. Midrib stout, curved, relatively prominent. Secondaries thin, numerous, ascending either obviously camptodrome or uniting to form a marginal vein. Length about 8 centimeters; maximum width, in the basal part of the leaf, about 3 millimeters.

This handsome slender species is much like *Acerates veterana* Heer, of the Arctic and European Tertiary. It is also much like certain European Tertiary forms that have been referred to the genus *Echitonium* of the allied family Apocynaceae. The venation is that characteristic of *Acerates* and of certain existing species of Asclepiadaceae and Apocynaceae. This species is not common in the Ripley but is an exceedingly characteristic form readily recognizable even when fragmentary if the venation can be seen.

The genus *Acerates* has seldom been recognized in fossil floras. Somewhat larger species than that of the Ripley are *Acerates arctica* Heer,[24] from the Atane and Patoot beds of Greenland; *Acerates amboyensis* Berry,[25] of the Tuscaloosa, Raritan, and Black Creek formations of the Atlantic Coastal Plain; and *Acerates veterana* Heer,[26] of the European and Arctic Tertiary. Cockerell[27] has referred a follicle from the Florissant Miocene to this genus.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

[24] Heer, Oswald, Flora fossilis arctica, vol. 6, pt. 2, p. 82, pl. 30, figs. 19, 20, 1882.

[25] Berry, E. W., Torrey Bot. Club Bull., vol. 36, p. 263, 1909.

[26] Heer, Oswald, Flora tertiaria Helvetiae, vol. 3, p. 20, pl. 104, figs. 5–8, 1859.

[27] Cockerell, T. D. A., Am. Naturalist, vol. 42, p. 580, fig. 10, 1908.

Family APOCYNACEAE

Genus APOCYNOPHYLLUM Unger

Apocynophyllum giganteum Berry, n. sp.

Plate XXI, figure 2

Leaves of variable but large size, lanceolate, apparently slightly inequilateral, widest in the middle and with an acute apex and an equally acute base. Margins entire. Texture coriaceous. Length about 22 centimeters; maximum width about 5 centimeters. The smallest specimen seen is 15 centimeters in length and 3.75 centimeters in maximum width. Petiole missing. Midrib stout, slightly flexuous, prominent on the lower surface of the leaf. Secondaries thin, numerous, and subparallel; they diverge from the midrib at angles of about 65° at regular intervals of about 6 or 7 millimeters, sweeping upward in regular curves and arching along the margins. Tertiaries thin, prevailingly obliquely percurrent, generally with an intermediate vein in the central region of the leaf midway between the adjacent secondaries, with which it is subparallel.

In general form these leaves resemble *Magnolia lanceolata* Lesquereux, but the venation is different and typical of *Apocynophyllum*, although there is some resemblance to certain fossil forms that have been referred to the genus *Ficus*.

The genus *Apocynophyllum* is a form genus for members of the family Apocynaceae whose generic position is uncertain and which resemble *Thevetia*, *Cerbera*, *Apocynum*, and other existing genera. A considerable number of fossil species have been described, including five or six from the Upper Cretaceous and over a score from the Eocene of both Europe and America. The genus has not been recognized in the earlier Upper Cretaceous of the Atlantic Coastal Plain but is present in the Dakota sandstone of the West. It is abundantly represented in the Eocene of the Mississippi embayment region, however.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Apocynophyllum perryensis Berry, n. sp.

Plate XXI, figure 1

Oblong obtuse leaves of considerable size, widest above the middle, with a broadly rounded tip and extended tapering base. Margins entire, somewhat undulate. Texture coriaceous. Lamina inequilateral and somewhat falcate. Length about 16 centimeters; maximum width about 2.5 centimeters. Midrib stout, prominent, and curved. Secondaries apparently not differentiated, the venation consisting solely of a very fine isodiametric areolation suggestive of the Proteaceae.

This peculiar species is based upon the single specimen figured. It is distinctive enough for stratigraphic assignment, but the features are not sufficiently developed for comparisons with the existing genera of Apocynaceae.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Apocynophyllum sumterensis (Berry) Berry

Quercus sumterensis Berry, U. S. Geol. Survey Prof. Paper 84, p. 35, pl. 10, figs. 9, 10, 1914.

"Undeterminable leaf," Berry, U. S. Geol. Survey Prof. Paper 112, pl. 31, figs. 5, 6, 1919.

Leaves large, linear, acuminate, coriaceous, entire, with a broadly cuneate base. Length about 15 to 16 centimeters; greatest width 3 centimeters. Petiole short and stout. Midrib stout. Secondaries thin, branching from the midrib at angles of 45° or more, taking a rather straight course almost to the margin and then turning sharply upward. Tertiaries obsolete, as are also the secondaries in some specimens.

The Ripley material is fully as long as the type material but prevailingly narrow, so that the base is more narrowly cuneate and the secondaries are slightly more ascending. The extremely elongate and usually somewhat falcate form is very characteristic.

Although this species was originally compared unhesitatingly with the willow and laurel oaks, this comparison no longer seems valid. The type material was preserved in a clay ironstone and showed less detail than that preserved in the fine-grained Ripley clay. The venation proves to differ decidedly from that of *Quercus* in the more close-set thin regular secondaries, the lack of prominence of the midrib, and the details of the areolation, as well as in the extremely elongate form of the leaf as a whole. On the other hand, it agrees with various fossil forms of *Apocynophyllum* and with several recent genera of the family Apocynaceae.

The fragments from the Ripley of Alabama (U. S. Nat. Museum catalog Nos. 34957, 34958) are now seen to be referable to this species.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn. Ripley formation, Cowikee Creek, Barbour County, Ala.

Apocynophyllum ripleyensis Berry, n. sp.

Plate XXI, figure 3

Leaves linear-lanceolate, widest in the lower half, gradually narrowed upward to the greatly extended and often falcate acuminate tip and downward to the decurrent base. Margins entire. Texture subcoriaceous. Length from 13 to 20 centimeters; maximum width from 1.1 to 2 centimeters. Petiole short and stout. Midrib stout, prominent. Secondaries thin, obsolete by immersion in most of the specimens, diverging at wide angles at regular intervals of about 3 millimeters, and camptodrome. Tertiaries thin, forming an open laterally elongated polygonal areolation.

This species is perhaps only a variety of *Apocynophyllum sumterensis* Berry, with which it is associated. It has the same general form but varies to a smaller size, is relatively narrower, with a different disposition of the more numerous secondaries. It is also a more abundant form in the collections. In specimens lacking the venation it is liable to be confused with various linear-lanceolate leaves of several genera such as *Myrcia* and *Nectandra*, but it is in general more elongated than any associated forms.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Apocynophyllum alatum Berry, n. sp.

Plate XXIII, figure 7

Elongate-lanceolate leaves with acuminate tips and rounded decurrent bases expanding to winged petioles. Margins entire, conspicuously undulate in some specimens. Leaf substance thin. Length from 13 to 15 centimeters; maximum width, below the middle, 1.75 to 2.25 centimeters. Petioles stout and expanded proximad, about 1.25 centimeters in length, curved, bordered by wings increasing in width from the sinus at the base of the lamina to the truncately rounded base, where they are 1 to 2 millimeters in width, making the total width at the base of the petiole about 6 millimeters. Midrib stout, curved. Secondaries numerous, thin, camptodrome. Tertiaries thin. Areolation minute.

This form is at once distinguished by its thin texture and its much expanded and conspicuously alate petioles.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

POSITION UNCERTAIN

Genus CALYCITES of authors

Calycites ripleyensis Berry, n. sp.

Plate XXII, figure 1

A scarious calyx of considerable consistency, consisting of five triangular lanceolate sepals coalescent proximad. The whole is about 15 millimeters in diameter; each sepal is about 6 millimeters in length and 3 millimeters wide at the base. There is no trace of any fruit in connection with the calyx.

This well-marked floral organ is represented by a single specimen. It suggests *Solanites* or *Symplocos* but might well represent a member of almost any gamosepalous family, for example, *Diospyros*, of the Ebenaceae. It is not characteristic of *Diospyros*, however, although it is identical with what Saporta calls *Diospyros rugosa*, a common form in the Oligocene of southeastern France.[28] Leaves of *Diospyros* are abundant in the American Upper Cretaceous, although none have been recognized in the Ripley, and a very distinctive calyx occurs in beds as old as the Raritan formation.[29]

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

[28] Saporta, Gaston de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 1, p. 111, pl. 11, fig. 3, 1863.

[29] Berry, E. W., Torrey Bot. Club Bull., vol. 38, p. 418, pl. 19, fig. 5, 1911.

Genus PHYLLITES Brongniart

Phyllites hydrilloides Berry n. sp.

Plate XXII, figure 2

A small and delicate form suggestive of an aquatic habitat, oblanceolate, widest above the middle, decurrent to the sessile base. Margin with tiny remote teeth. Midrib thin, greatly expanded at the sheathing base. Rest of the venation obsolete. Length about 1.9 centimeters; maximum width about 4 millimeters.

This tiny form may be a juvenile leaf of some of the associated lanceolate-toothed margined Ripley species, but it does not appear to be, and its delicate texture and lack of venation suggest its relationship to such a modern form as the genus *Hydrilla* L. C. Rich, of the family Hydrocharitaceae. This genus includes a wide-ranging water plant of the sea margins found in Europe, Asia, Africa, and Australia and generally considered monotypic, although this is very doubtful. In the absence of conclusive proof of such a relationship the fossil form is referred to the noncommittal genus *Phyllites*.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Phyllites hydrocharitoides Berry n. sp.

Plate XXII, figure 9

Elongated, slender, linear, forking foliar organs, flat, of slight consistency but with a prominent median vein or midrib. No other veins can be discerned in the lamina, which is about 2 millimeters in width.

These remains are common at the Carroll County locality, and massed fragments suggest some gymnospermous genus such as *Dicranophyllum*, *Trichopitys*, or *Czekanowskia*, but more complete material shows these suggestions to be remote from the facts. Undivided specimens as much as 13 centimeters in length have been observed and they are too lax to be even considered as Cyperaceae. In two specimens there is an aureole of flabellate branching appendages at the node or fork, suggestive of flattened rootlets from a branched flattened rootstock. They appear to me to be remotely comparable to *Phyllospadix* or *Vallisneria* or some related genus, and I would suggest that they represent some water weed of the Ripley sea margin referable to the Hydrocharitaceae or Potamogetonaceae.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Phyllites ripleyensis Berry, n. sp.

Plate XXII, figure 4

Medium large leaves, ovate, widest in the middle and about equally pointed at both ends, with entire, evenly rounded margins. Texture subcoriaceous. No traces of venation except the midrib and a thin, fine nondistinctive areolation. Length about 8.5 centimeters; maximum width about 4.2 centimeters.

This form is without geologic or botanic significance except that it indicates the presence of an otherwise unknown member of the Ripley flora. It is remarkable in showing no traces of a secondary venation, which should be pronounced in a leaf of this size.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

Carpolithus ripleyensis Berry, n. sp.

Plate XXII, figure 5

A relatively large drupaceous fruit, nearly 4 centimeters in length and 2.8 centimeters in maximum diameter as preserved in the shell marl of the Ripley formation at Coon Creek, Tenn. Consisting of a lignified sarcotesta of great thickness and a hard, smooth sclerotesta or stone. Botanic affinity unknown, and the specimen is interesting chiefly from the fact that it must have originally possessed considerable buoyancy, which is unusual in a fruit of this kind unless the surmise that it was drupaceous is erroneous and it was an indehiscent ligneous capsular fruit. The fact that the supposed stone is somewhat excentric in position renders this possible and suggests that the stone is a large hard seed and that more than one was originally present around the central axis. It should, perhaps, be compared with members of the Sapotaceae.

Occurrence: McNairy sand member of Ripley formation, Coon Creek, McNairy County, Tenn.

Carpolithus perryensis Berry, n. sp.

Plate XXII, figure 3

Turbinate fruits with a stout peduncle, enlarged seed-bearing distal portion, and apiculate tip, the whole about 7.5 millimeters in length and 3 millimeters in maximum diameter.

These remains are somewhat suggestive of the Upper Cretaceous genus *Protodammara*, abundant at earlier horizons in the Coastal Plain. They lack resin canals, however, are narrower and more spherical distad, and appear to contain seeds in this enlarged portion. It is believed that they are not coniferous but that they represent some dicotyledonous form.

Occurrence: McNairy sand member of Ripley formation, Perry place, Henry County, Tenn.

Carpolithus carrollensis Berry, n. sp.

Plate XXII, figure 6

A bluntly fusiform, fibrous, ligneous fruit of unknown botanic affinity, 3 centimeters in length and 1.5 centimeters in maximum diameter.

These poorly characterized fruits are, however, of great importance, as they appear to be identical with those from the lignites of Fuveau, in southern France, described by Saporta [30] and compared by him with the nuts of *Nipadites*, the Eocene representative of the existing nipa palm. The former fruits come from a horizon usually considered of Aturian age, and if the comparison of the Tennessee and French fruits is worth anything—and it seems to me to be a legitimate and close one—it is of considerable importance for purposes of correlation. It would seem that Saporta was justified in considering the French fruits those of some palm, and I believe that the same relationship is indicated for *Carpolithus carrollensis*.

Occurrence: McNairy sand member of Ripley formation, Cooper pit, near Hollow Rock, Carroll County, Tenn.

[30] Saporta, Gaston de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 1, p. 47, pl. 1, fig. 6, 1863.

Halymenites major Lesquereux

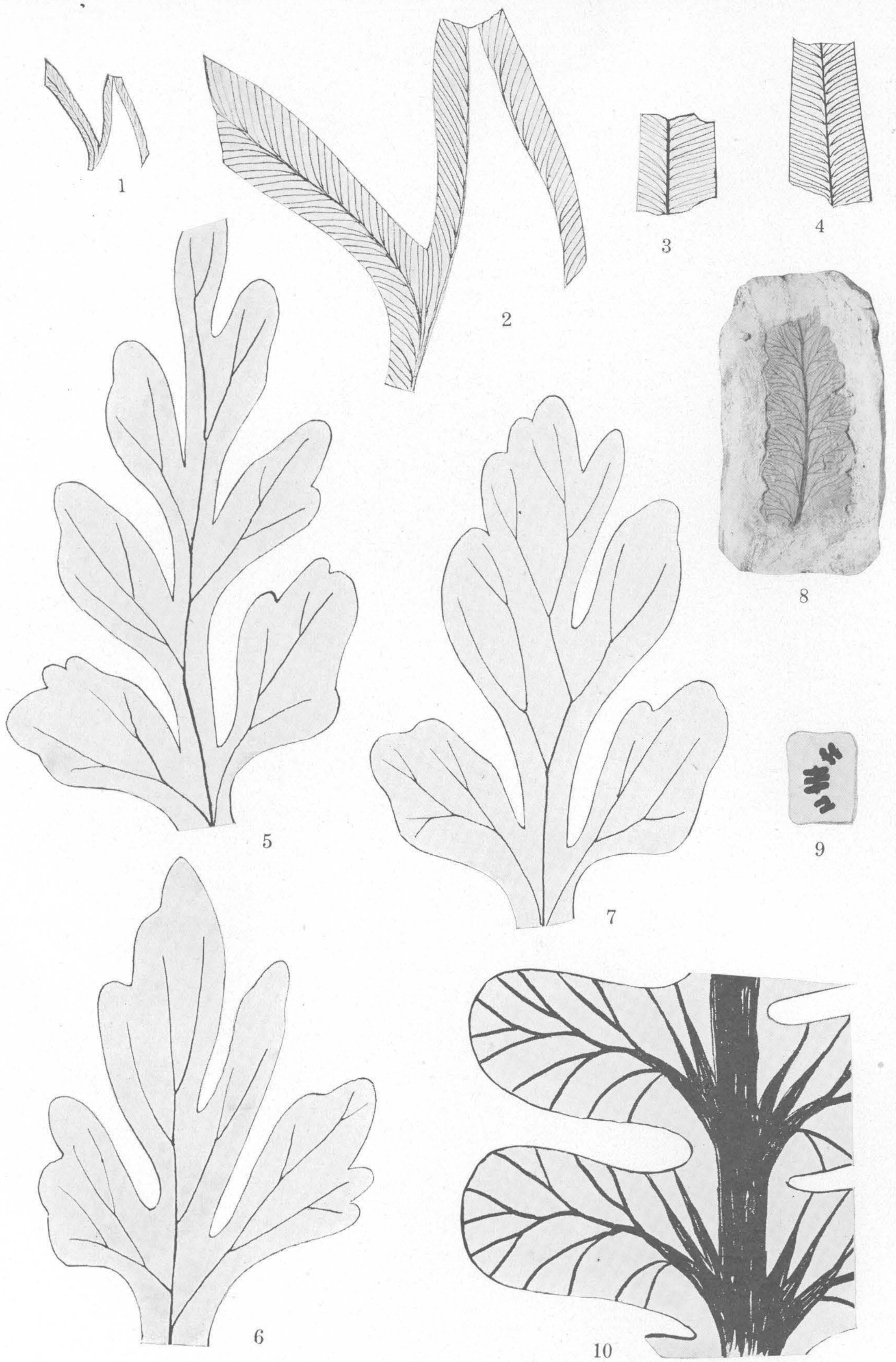
Halymenites major Lesquereux, Tertiary flora, p. 38. pl. 1, figs. 7, 8, 1878.

These objects, frequently considered to represent fossil fucoids, are very abundant in the western United States in sandy beds ranging in age from the Colorado group to the Eocene. They were long thought to be typical of the Fox Hills sandstone, in which they are abundantly developed, but have now been found in both older and younger beds and characterize sandy ferruginous sediments.

Typical material is plentiful in the Coffee sand member of the Eutaw formation and also at different horizons in the Ripley formation in western Tennessee. Generally, however, these objects are very friable, and the collected specimens represent only the beds enumerated below.

Occurrence: Coffee sand member of Eutaw formation, Coffee Bluff, Hardin County, Tenn. McNairy sand member of Ripley formation, McNairy County, Tenn.

PLATES



UPPER CRETACEOUS PLANTS FROM THE RIPLEY FORMATION

1, 2. *Monheimia aquisgranensis* Debey and Ettingshausen (p. 27). Cooper pit. Figure 2, × 3.
3, 4. *Taeniopteris* sp. (p. 27). Cooper pit.
5, 6, 7. *Raphaelia minuta* Berry (p. 26). Cooper pit. Figure 5, × 13; 6, × 14; 7, × 12.
8. *Raphaelia neuropteroides* Debey and Ettingshausen (p. 26). Cooper pit.
9, 10. *Asplenium calopteris* (Debey and Ettingshausen) Heer (p. 25). Cooper pit. Figure 10, × 22.

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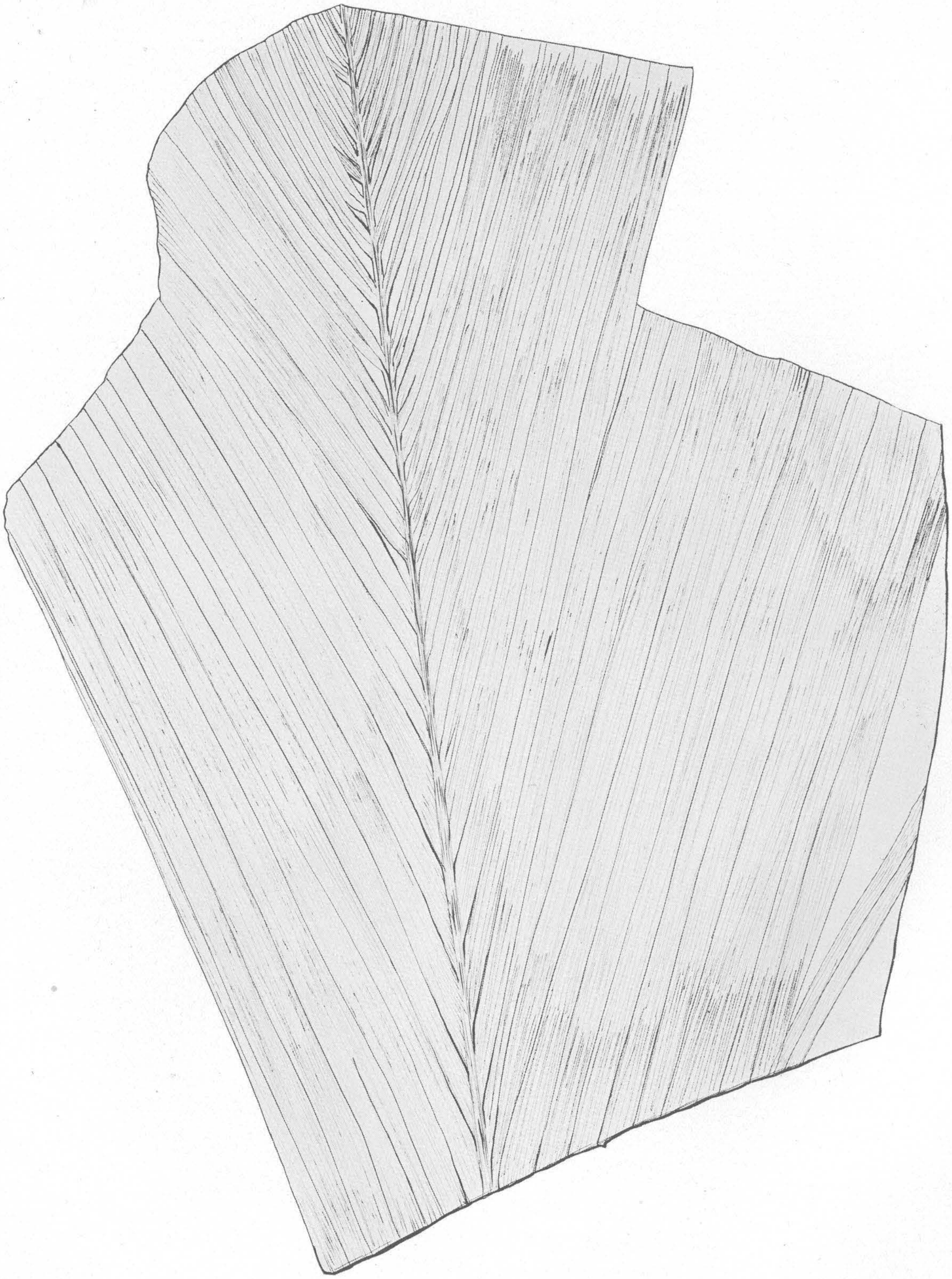
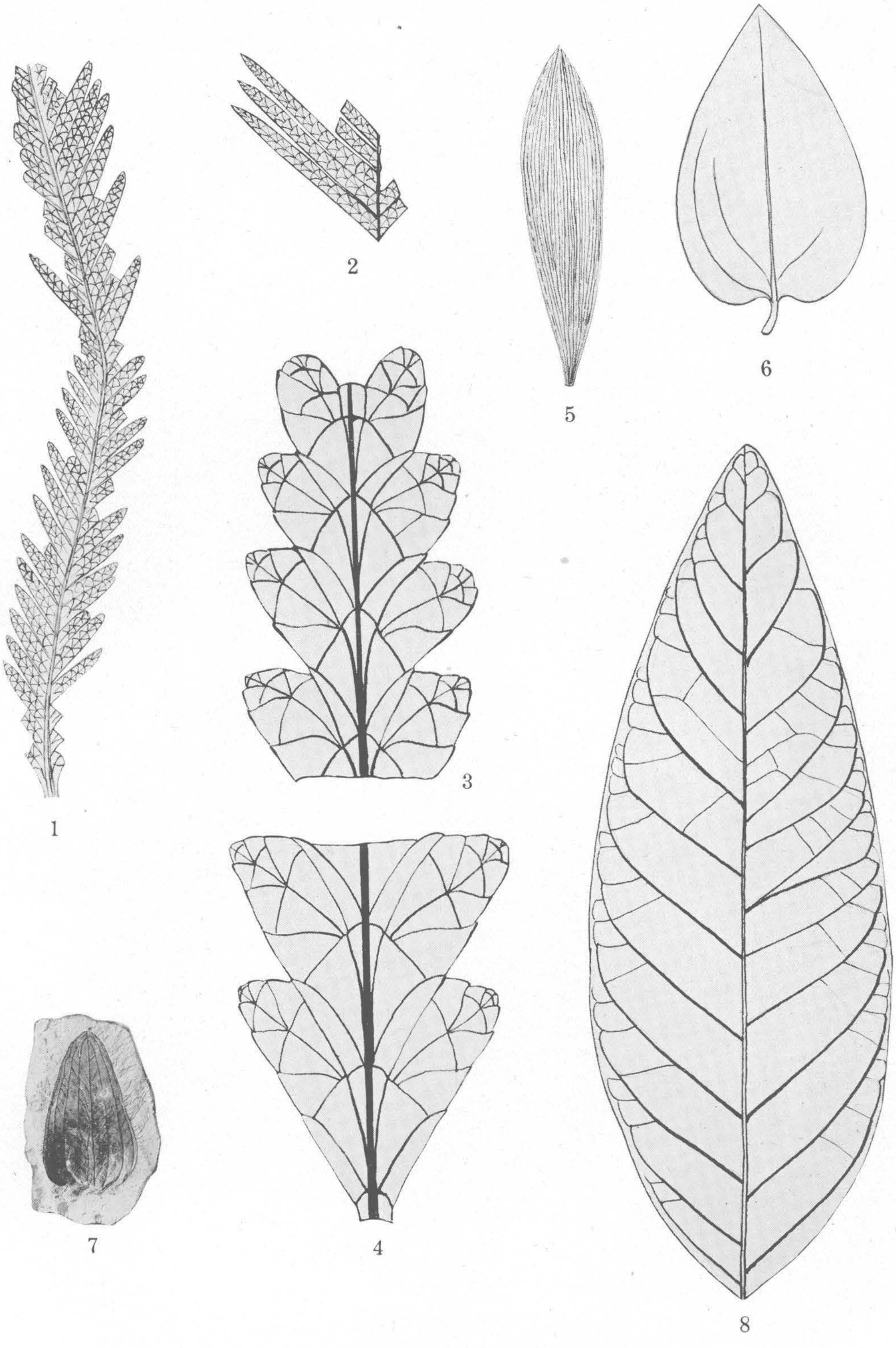


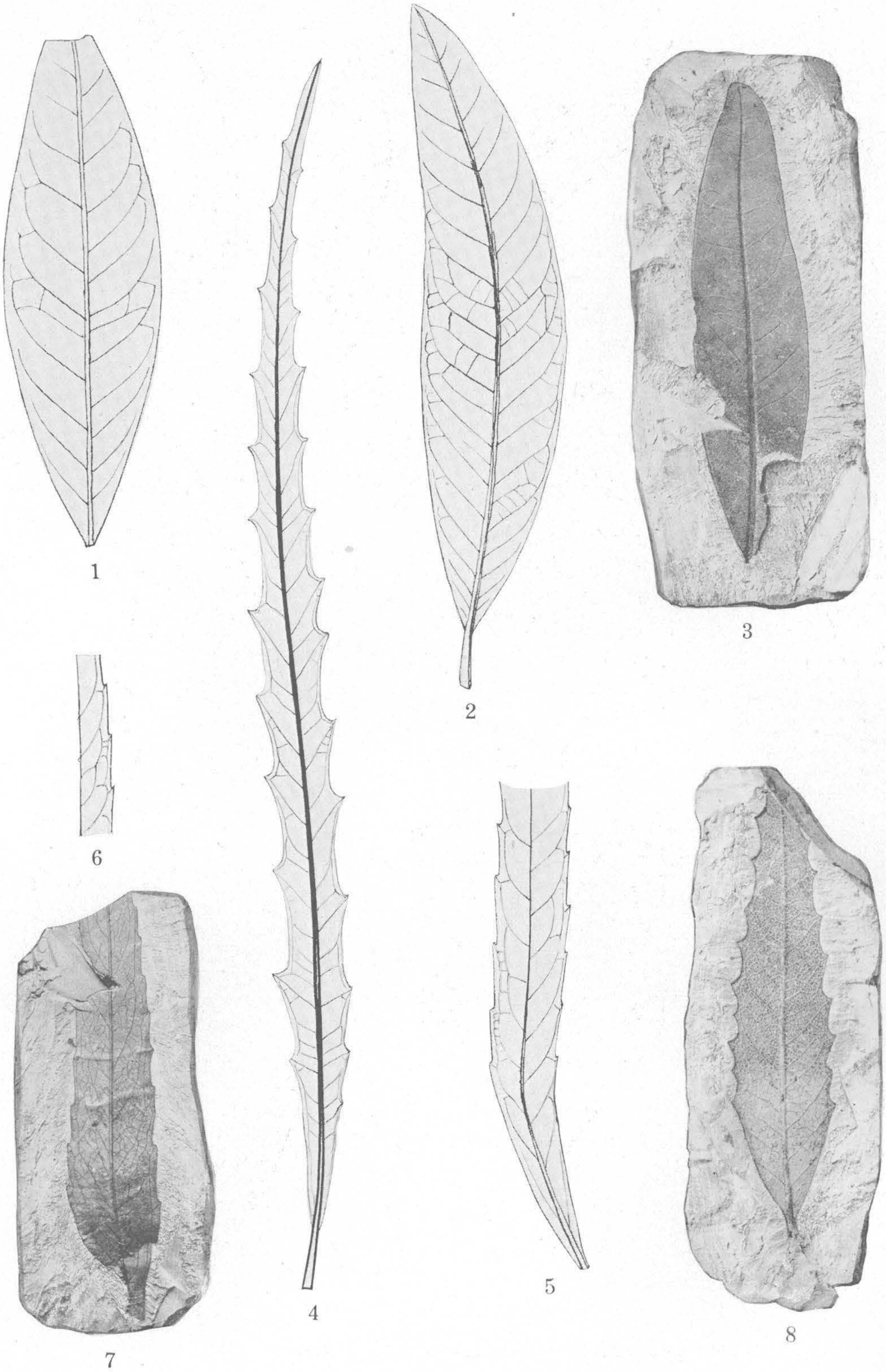
UPPER CRETACEOUS PLANT FROM THE RIPLEY FORMATION

Geonomites schimperi Lesquereux (p. 37). Perry place. One-third natural size.



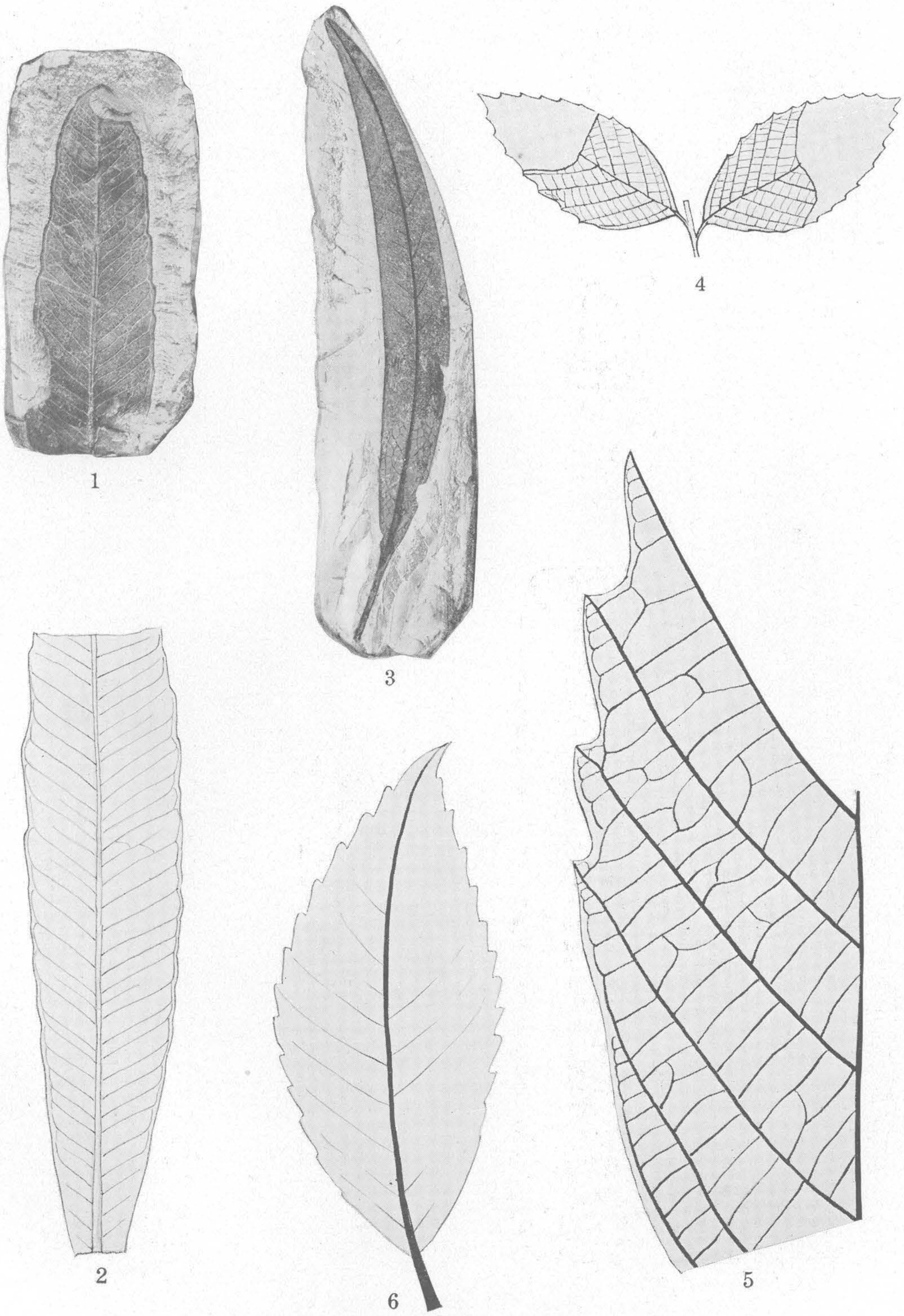
UPPER CRETACEOUS PLANTS FROM THE RIPLEY FORMATION

1, 2. *Moriconia cyclotoxon* Debey and Ettingshausen (p. 30). Figure 1, Cooper pit; Figure 2, Perry place.
3, 4. *Moriconia americana* Berry (p. 31). Perry place. × 2.
5. *Potamogeton ripleyensis* Berry (p. 34). Cooper pit.
6. *Alismaphyllum cretaceum* Berry (p. 35). Cooper pit.
7. *Dioscorites cretaceus* Berry (p. 36). Perry place.
8. *Juglans tennesseensis* Berry (p. 39). Perry place.



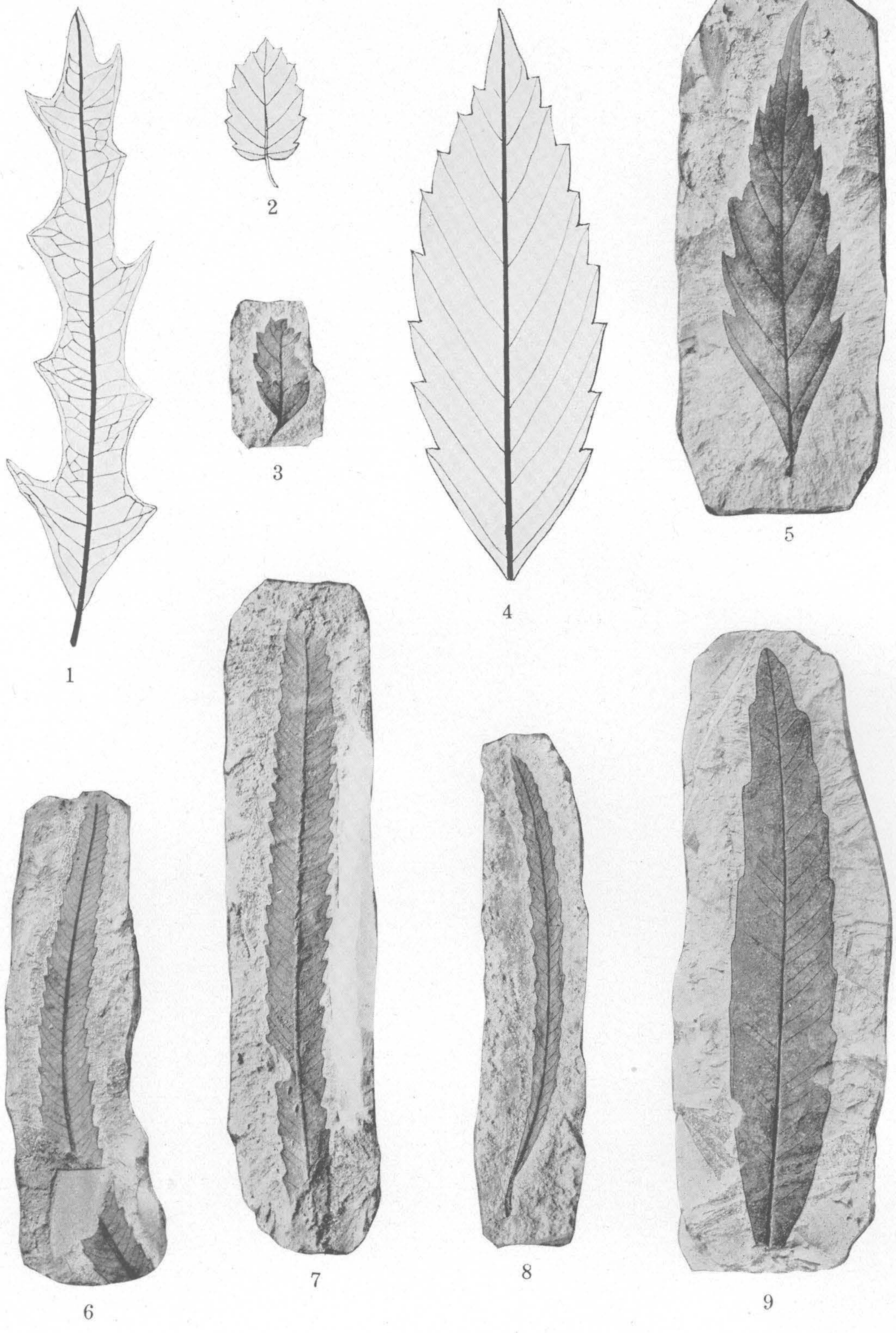
UPPER CRETACEOUS PLANTS FROM THE RIPLEY FORMATION

1, 2, 3. *Juglans wadii* Berry (p. 40). Perry place.
4, 5. *Myrica wadii* Berry (p. 40). Perry place.
6, 7, 8. *Myrica wadii minor* Berry (p. 41). Perry place.



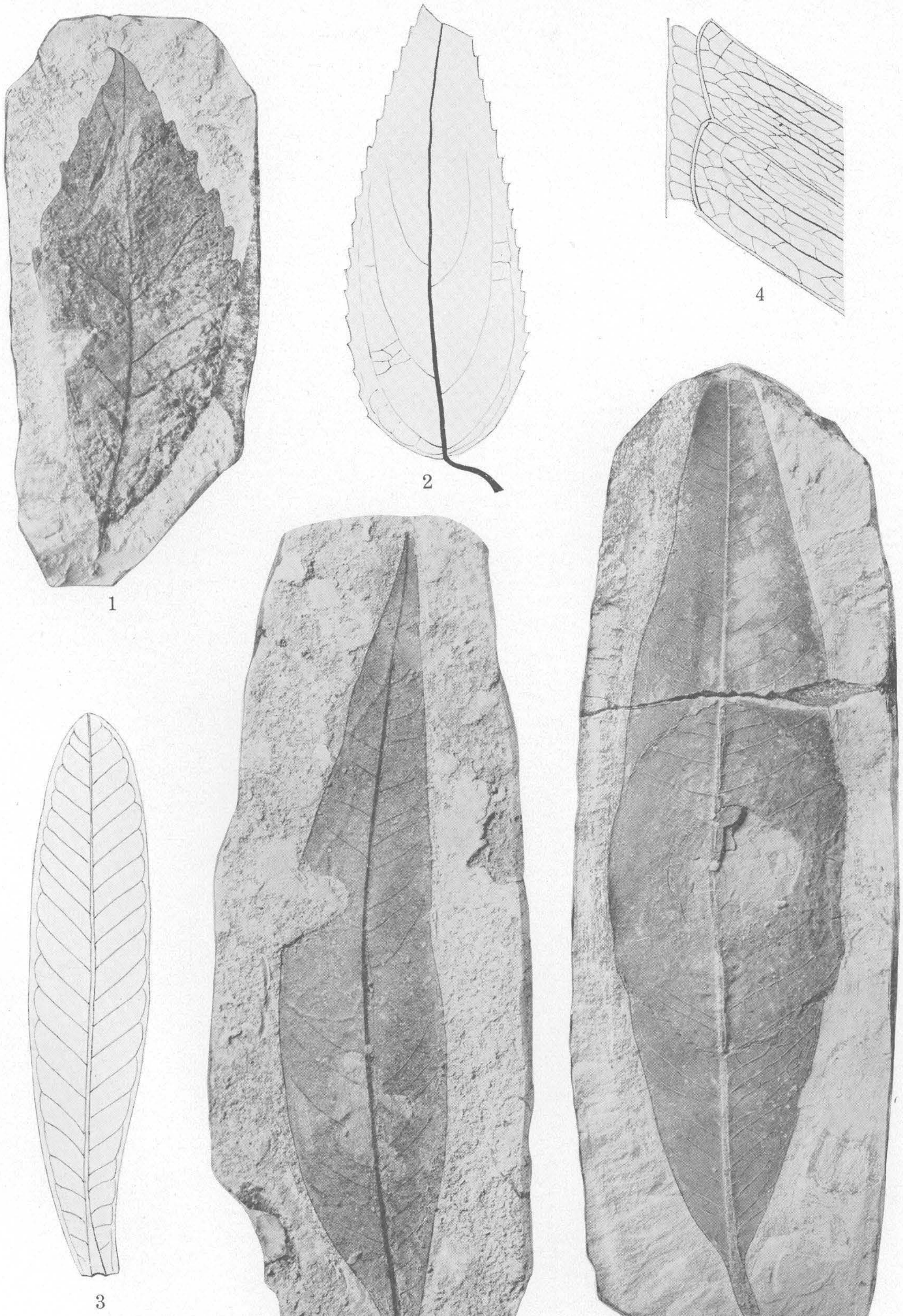
UPPER CRETACEOUS PLANTS FROM THE RIPLEY FORMATION

1, 2. *Myrica brittoniana obtusata* Berry (p. 45). Perry place.
3. *Salix gardneri* Knowlton (p. 46). Perry place.
4, 5. *Dryophyllum protofagus* Berry (p. 46). Cooper pit.
6. *Fagus ripleyensis* Berry (p. 47). Cooper pit.



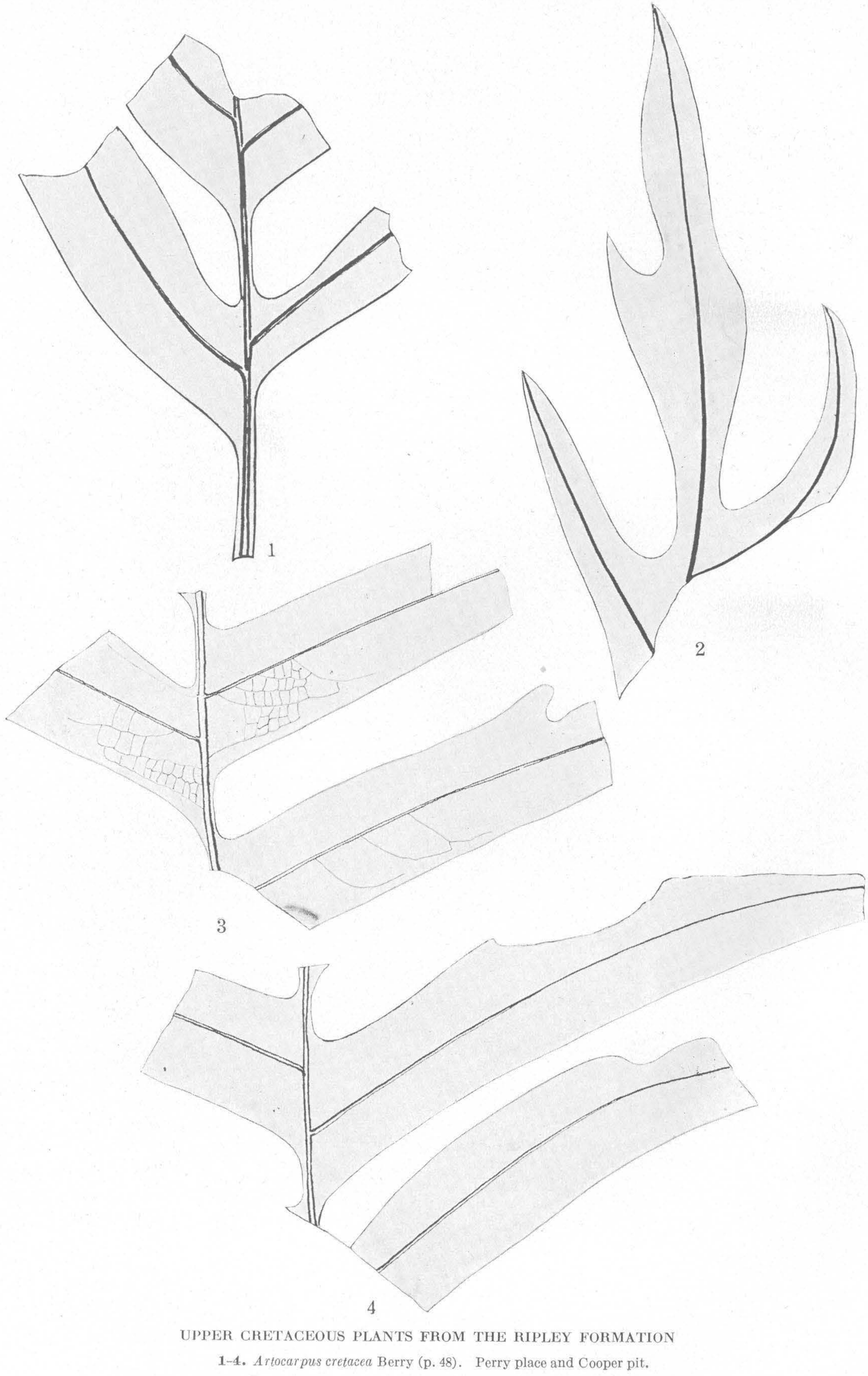
UPPER CRETACEOUS PLANTS FROM THE RIPLEY FORMATION

1. *Myrica cooperensis* Berry (p. 42). Cooper pit.
2, 3. *Myrica minor* Berry (p. 43). Cooper pit.
4, 5. *Myrica ornata* Berry (p. 44). Cooper pit.
6, 7. *Myrica torreyi* Lesquereux (p. 44). Cooper pit.
8. *Myrica torreyi obtusata* Berry (p. 45). Cooper pit.
9. *Myrica brittoniana* Berry (p. 45). Perry place.



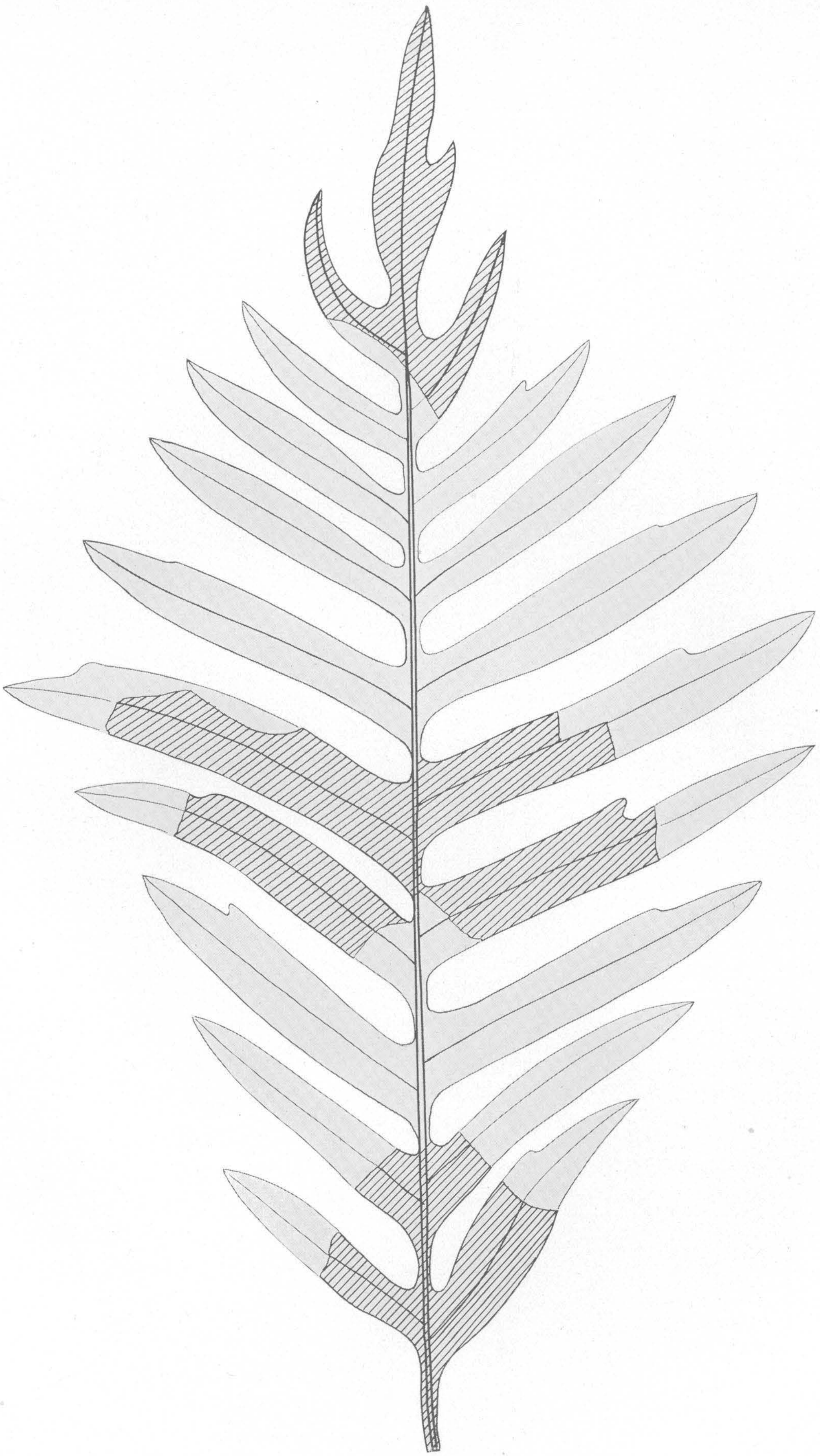
UPPER CRETACEOUS PLANTS FROM THE RIPLEY FORMATION

1. *Fagus ripleyensis* Berry (p. 47). Cooper pit.
2. *Celtis cretacea* Berry (p. 47). Cooper pit.
3, 4. *Ficus obtusa-sessilia* Berry (p. 51). Perry place.
5. *Ficus crassipes* (Heer) Heer (p. 51). Perry place.
6. *Ficus ripleyana* Berry (p. 50). Cooper pit.



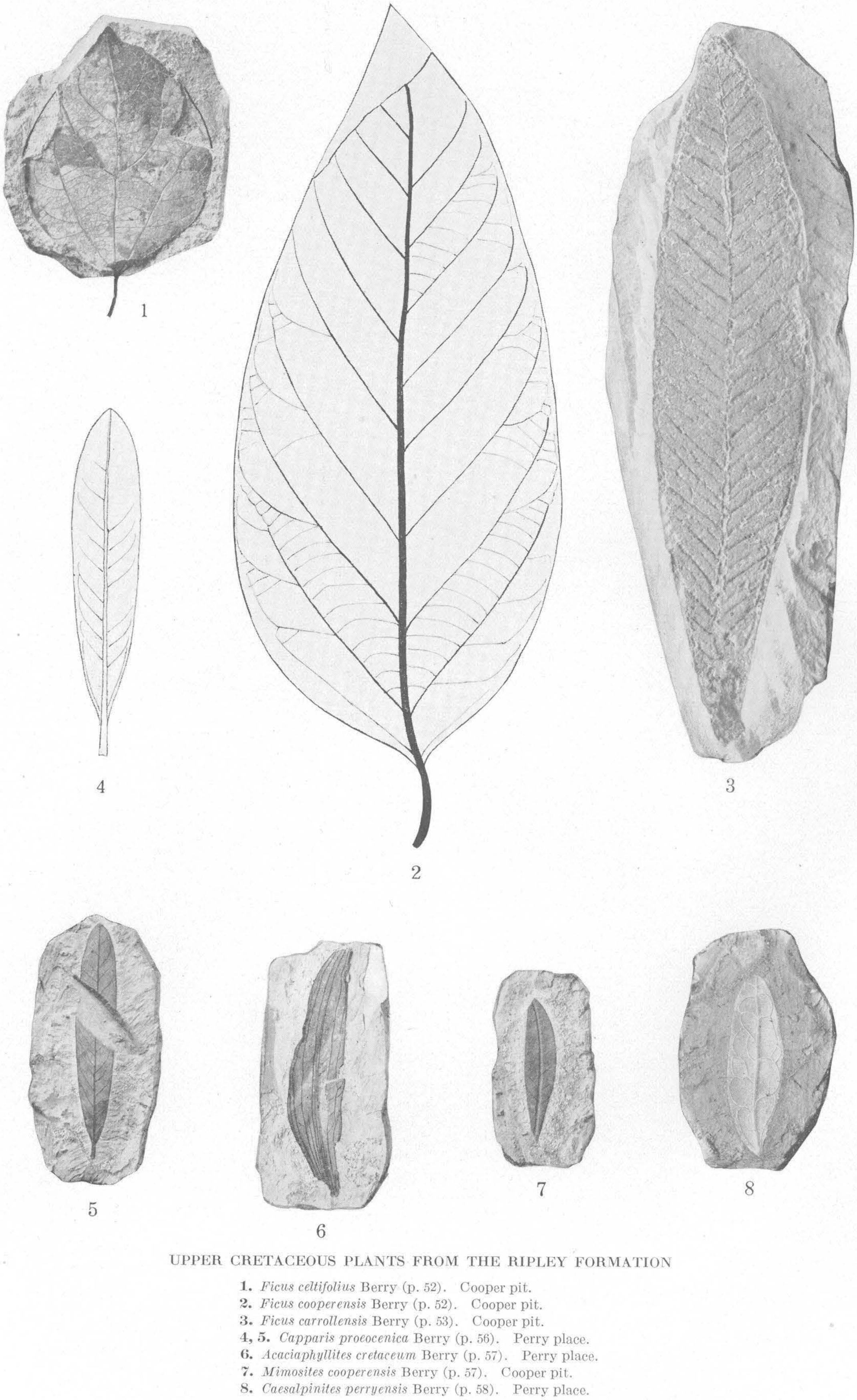
UPPER CRETACEOUS PLANTS FROM THE RIPLEY FORMATION

1-4. *Artocarpus cretacea* Berry (p. 48). Perry place and Cooper pit.



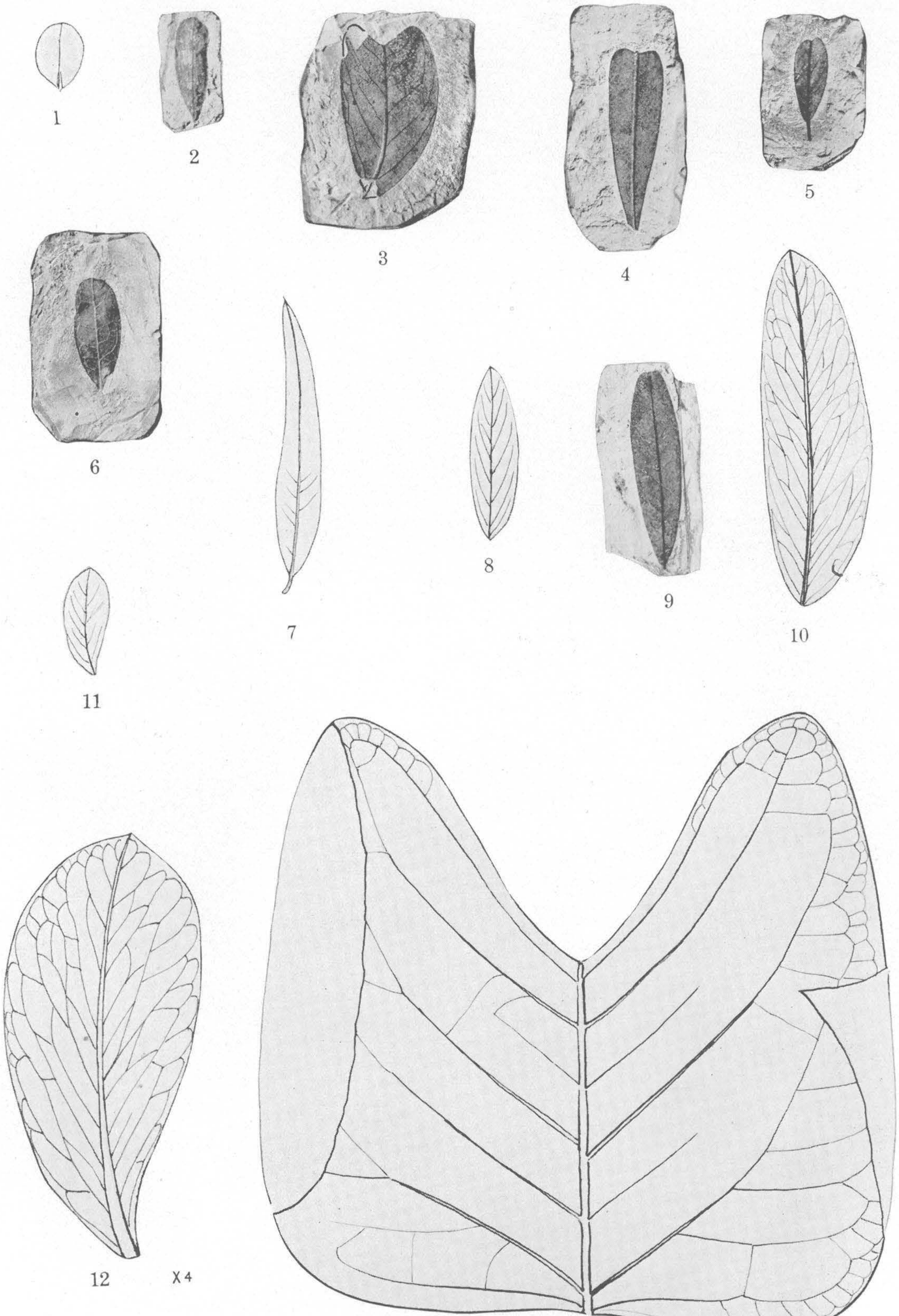
UPPER CRETACEOUS PLANT FROM THE RIPLEY FORMATION

Artocarpus cretacea Berry (p. 48). Restoration of the complete leaf from fragments, showing by cross lining the parts preserved. Three-fifths natural size.



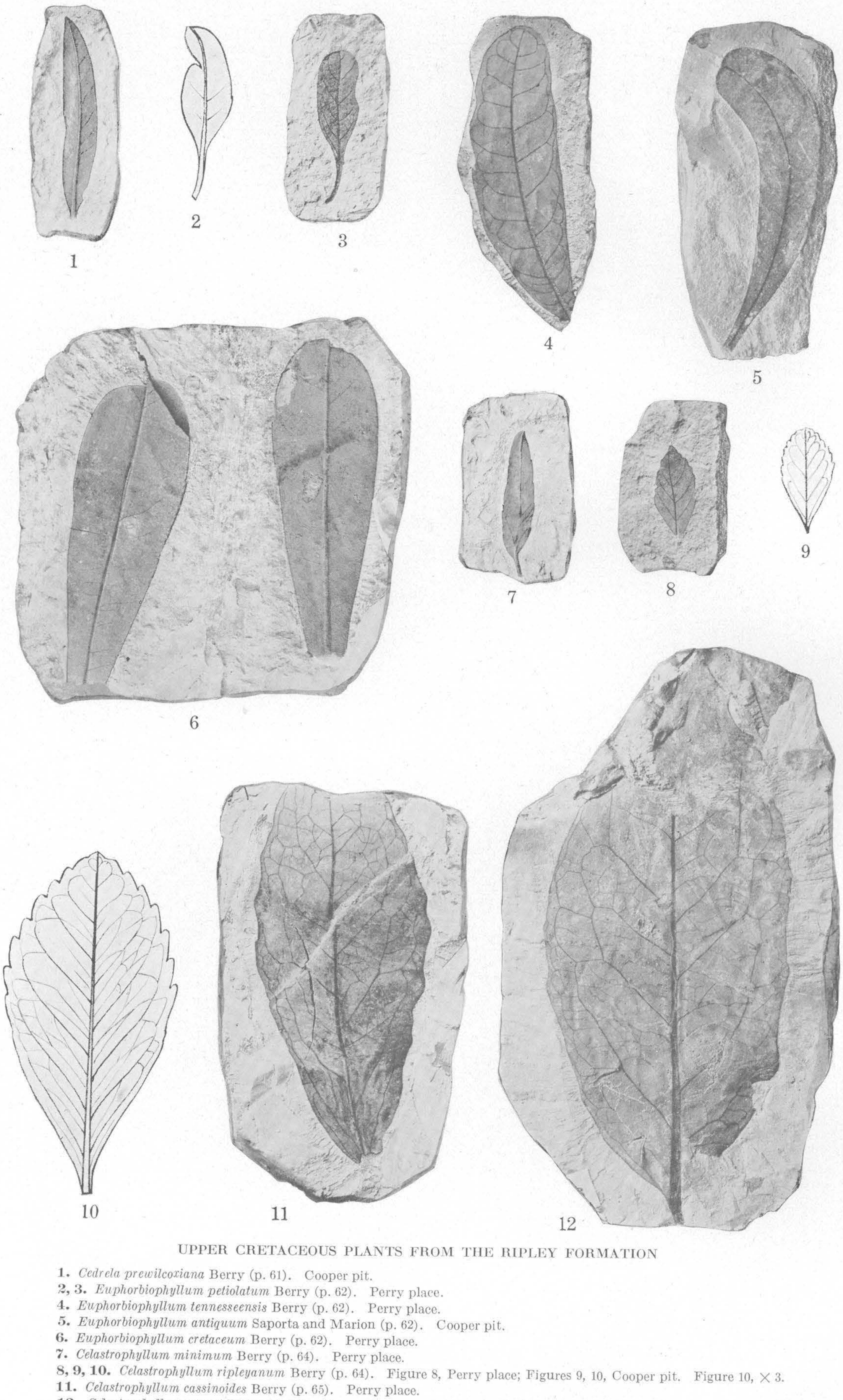
UPPER CRETACEOUS PLANTS FROM THE RIPLEY FORMATION

1. *Ficus celtifolius* Berry (p. 52). Cooper pit.
2. *Ficus cooperensis* Berry (p. 52). Cooper pit.
3. *Ficus carrollensis* Berry (p. 53). Cooper pit.
4, 5. *Capparis proeocenica* Berry (p. 56). Perry place.
6. *Acaciaphyllites cretaceum* Berry (p. 57). Perry place.
7. *Mimosites cooperensis* Berry (p. 57). Cooper pit.
8. *Caesalpinites perryensis* Berry (p. 58). Perry place.



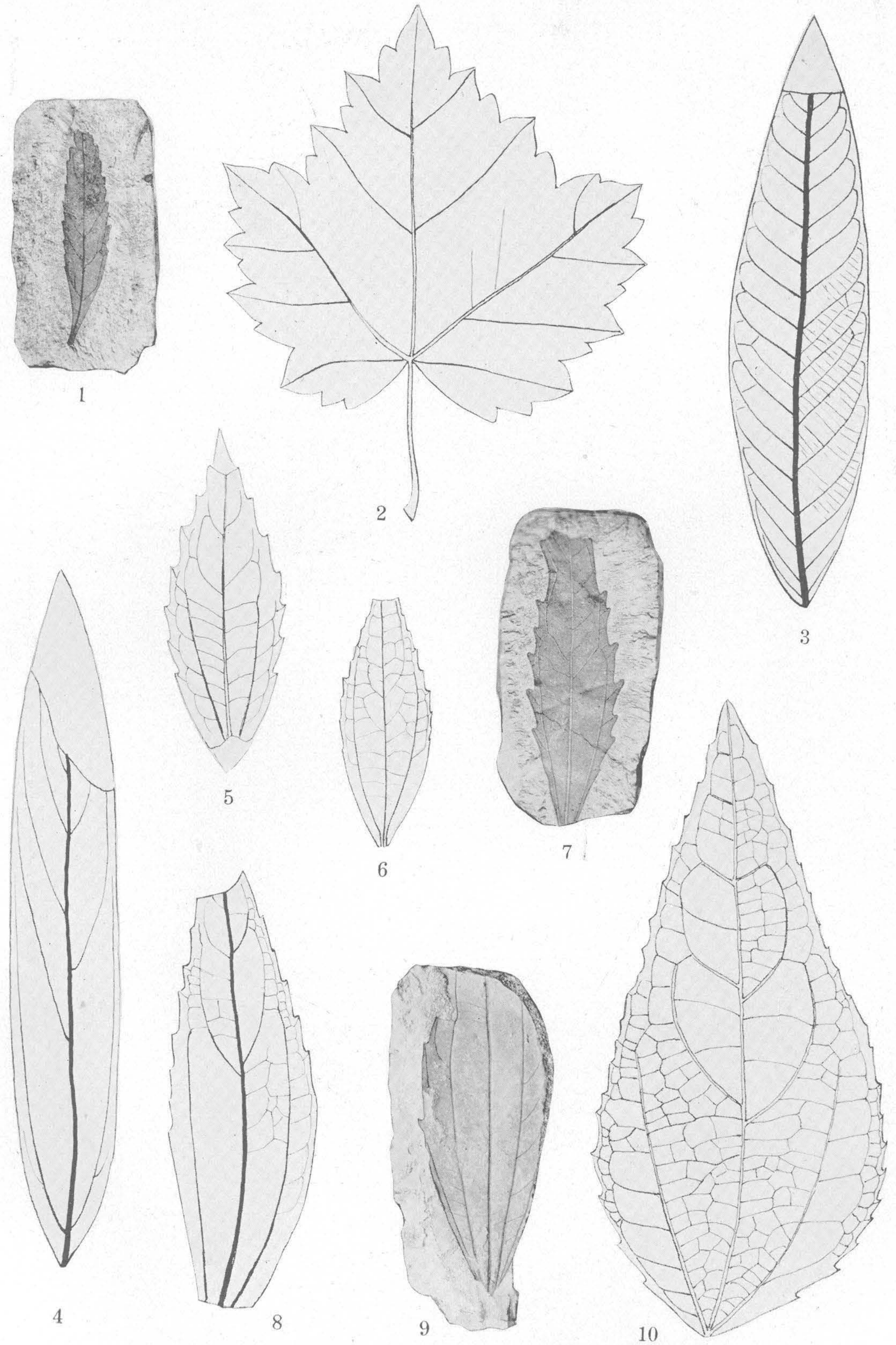
UPPER CRETACEOUS PLANTS FROM THE RIPLEY FORMATION

1. *Leguminosites carrollensis* Berry (p. 60). Cooper pit.
2. *Leguminosites perryensis* (p. 60). Perry place.
3. *Dalbergia cretacea* Berry (p. 59). Perry place.
4. *Dalbergia perryana* Berry (p. 59). Perry place.
5. *Dalbergia prewilcoxiana* Berry (p. 59). Perry place.
6. *Caesalpinites ripleyensis* Berry (p. 58). Perry place.
7. *Gleditsiophyllum aristatum* Berry (p. 61). Cooper pit.
8, 9, 10. *Gleditsiophyllum proeocenicum* Berry (p. 61). Perry place. Figure 10, × 2.
11, 12. *Gleditsiophyllum preovatum* Berry (p. 60). Perry place.
13. *Liriodendron laramiense* Ward (p. 53). Perry place.



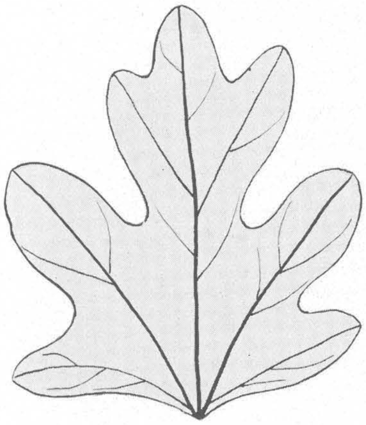
UPPER CRETACEOUS PLANTS FROM THE RIPLEY FORMATION

1. *Cedrela prewilcoxiana* Berry (p. 61). Cooper pit.
2, 3. *Euphorbiophyllum petiolatum* Berry (p. 62). Perry place.
4. *Euphorbiophyllum tennesseensis* Berry (p. 62). Perry place.
5. *Euphorbiophyllum antiquum* Saporta and Marion (p. 62). Cooper pit.
6. *Euphorbiophyllum cretaceum* Berry (p. 62). Perry place.
7. *Celastrophyllum minimum* Berry (p. 64). Perry place.
8, 9, 10. *Celastrophyllum ripleyanum* Berry (p. 64). Figure 8, Perry place; Figures 9, 10, Cooper pit. Figure 10, × 3.
11. *Celastrophyllum cassinoides* Berry (p. 65). Perry place.
12. *Celastrophyllum perryi* Berry (p. 65). Perry place.



UPPER CRETACEOUS PLANTS FROM THE RIPLEY FORMATION

1. *Celastrophyllum variabilis* Berry (p. 65). Perry place.
2. *Acer cretaceum* Berry (p. 66). Cooper pit.
3. *Rhamnus ripleyensis* Berry (p. 67). Perry place.
4. *Zizyphus laurifolius* Berry (p. 67). Cooper pit.
5, 6, 7, 8, 9. *Zizyphus ripleyensis* Berry (p. 68). Perry place.
10. *Zizyphus perryi* Berry (p. 69). Perry place.



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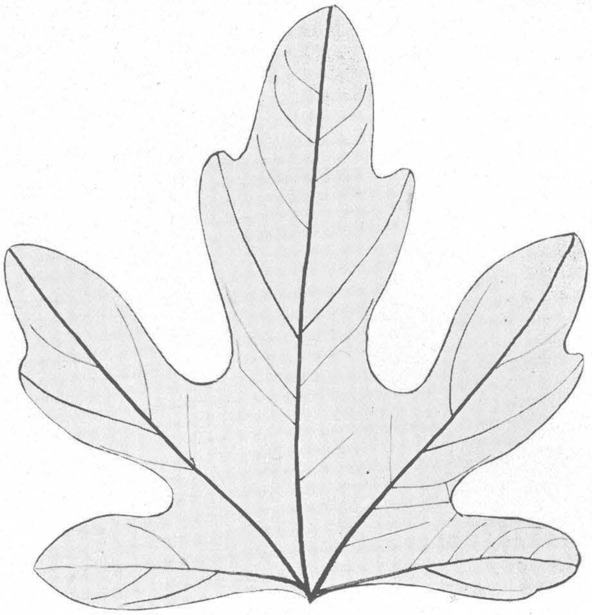

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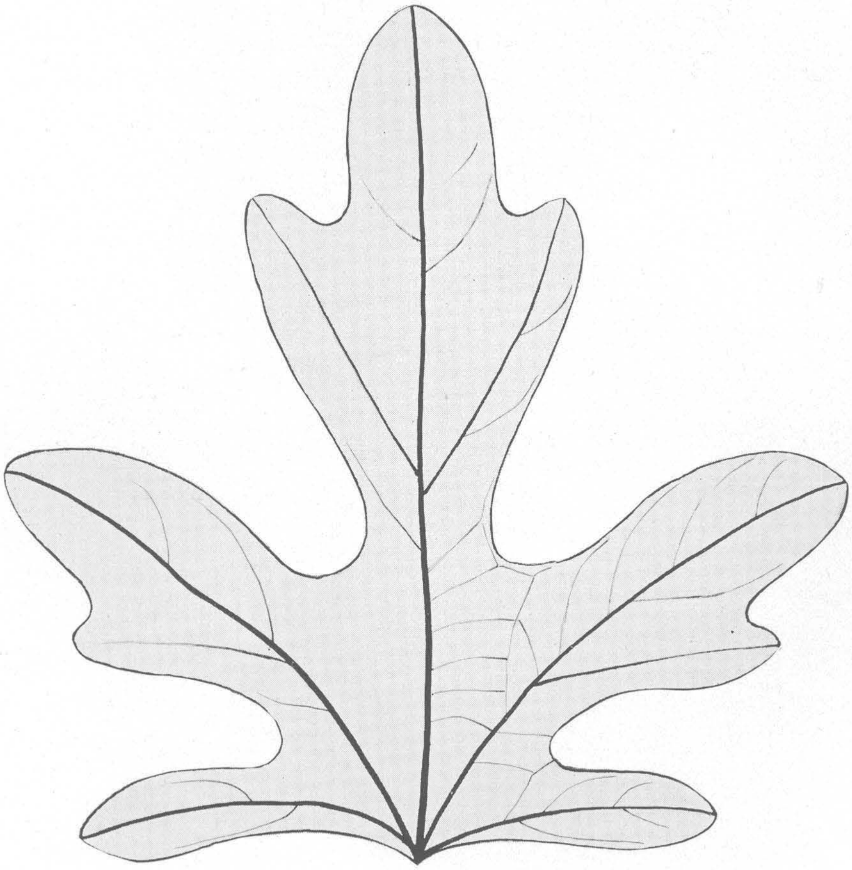

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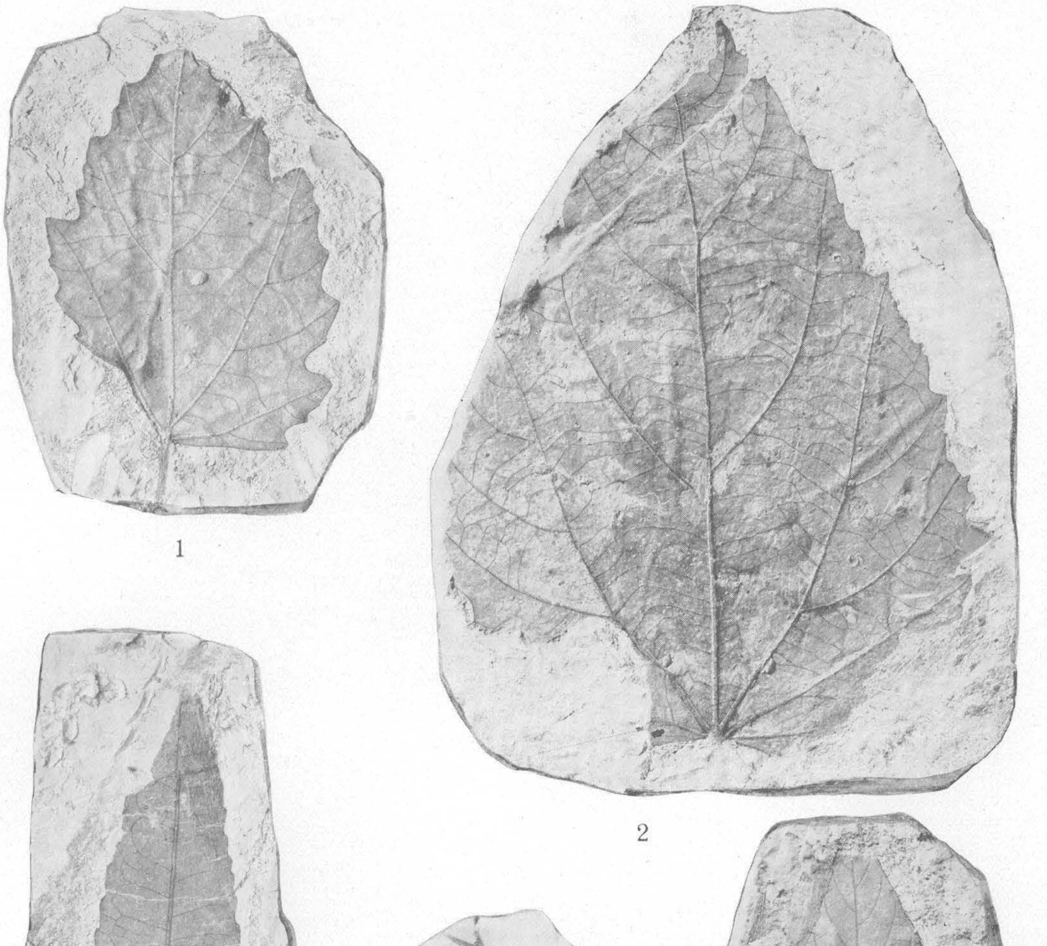
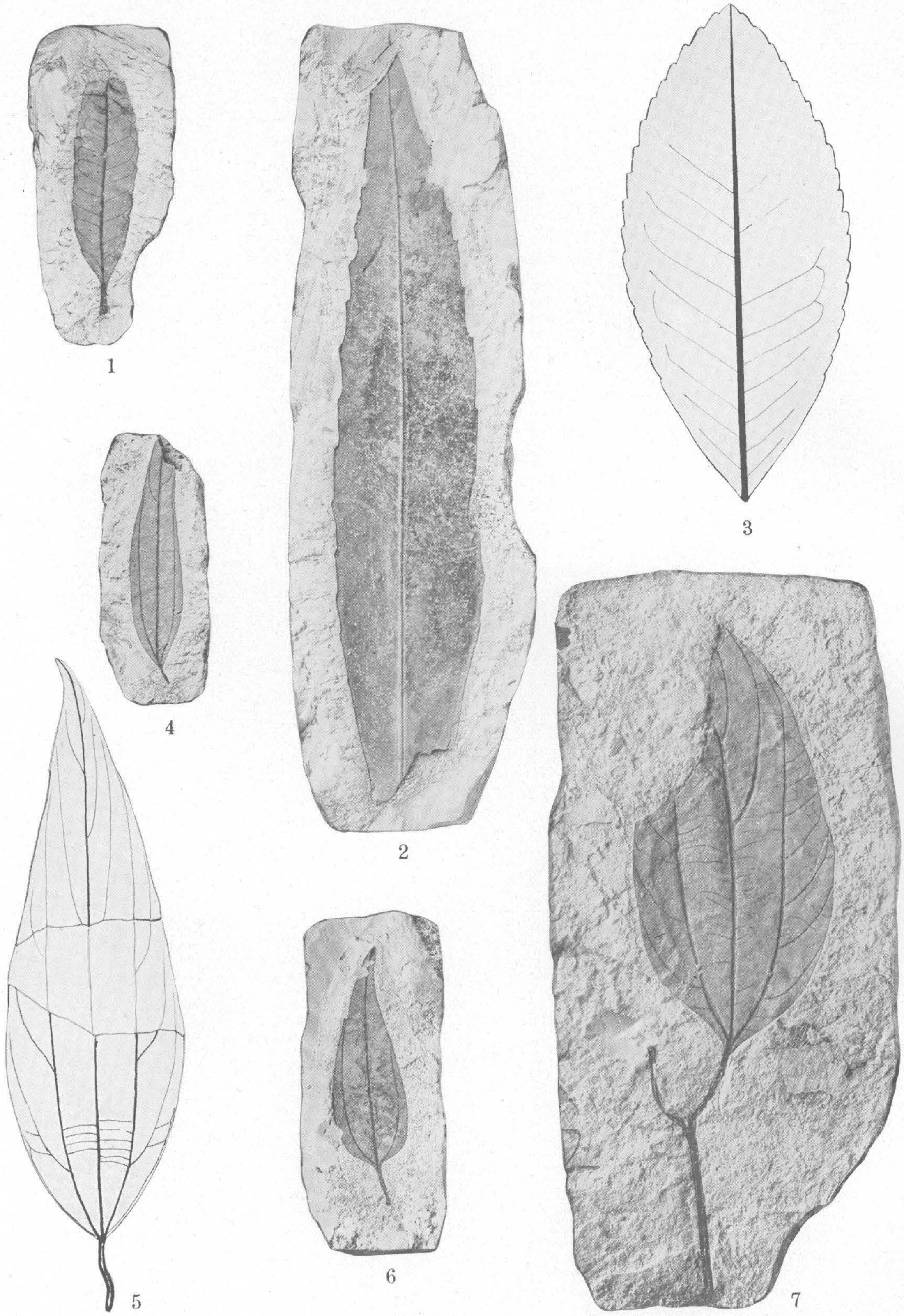
UPPER CRETACEOUS PLANTS FROM THE RIPLEY FORMATION

1, 2, 3. *Cissites panduratus* Knowlton (p. 70). Perry place.



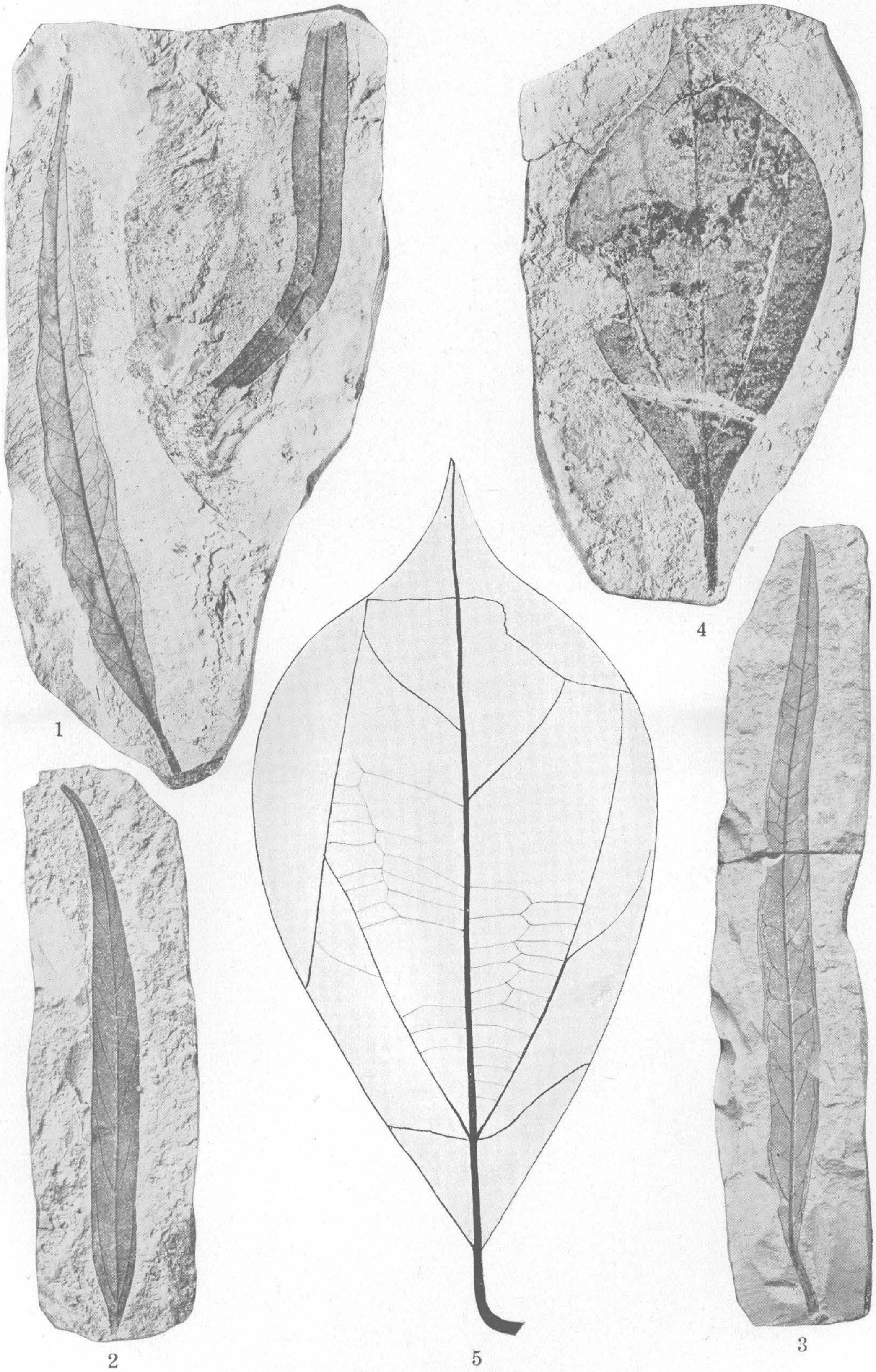
UPPER CRETACEOUS PLANTS FROM THE RIPLEY FORMATION

1. *Grewiopsis inequilateralis* Berry (p. 73). Perry place.
2. *Grewiopsis ripleyensis* Berry (p. 72). Cooper pit.
3, 4. *Ternstroemites ripleyensis* Berry (p. 74). Perry place.
5. *Dillenites cretaceus* Berry (p. 74). Cooper pit.



UPPER CRETACEOUS PLANTS FROM THE RIPLEY FORMATION

1. *Ternstroemites ripleyensis* Berry (p. 74). Perry place.
2. *Ternstroemites cretaceus* Berry (p. 75). Perry place.
3. *Ternstroemites tennesseensis* Berry (p. 74). Cooper pit.
4. *Cinnamomum newberryi lanceolatum* Berry (p. 76). Cooper pit.
5. *Cinnamomum newberryi* Berry (p. 75). 2½ miles south of Mifflin, Chester County.
6. *Cinnamomum newberryi minimum* Berry (p. 77). Cooper pit.
7. *Cinnamomum newberryi ellipticum* Berry (p. 77). Cooper pit.



UPPER CRETACEOUS PLANTS FROM THE RIPLEY FORMATION

1, 2, 3. *Nectandra prolifica* Berry (p. 78). Cooper pit.
4, 5. *Cinnamomum praespectabile* Berry (p. 77). Cooper pit.

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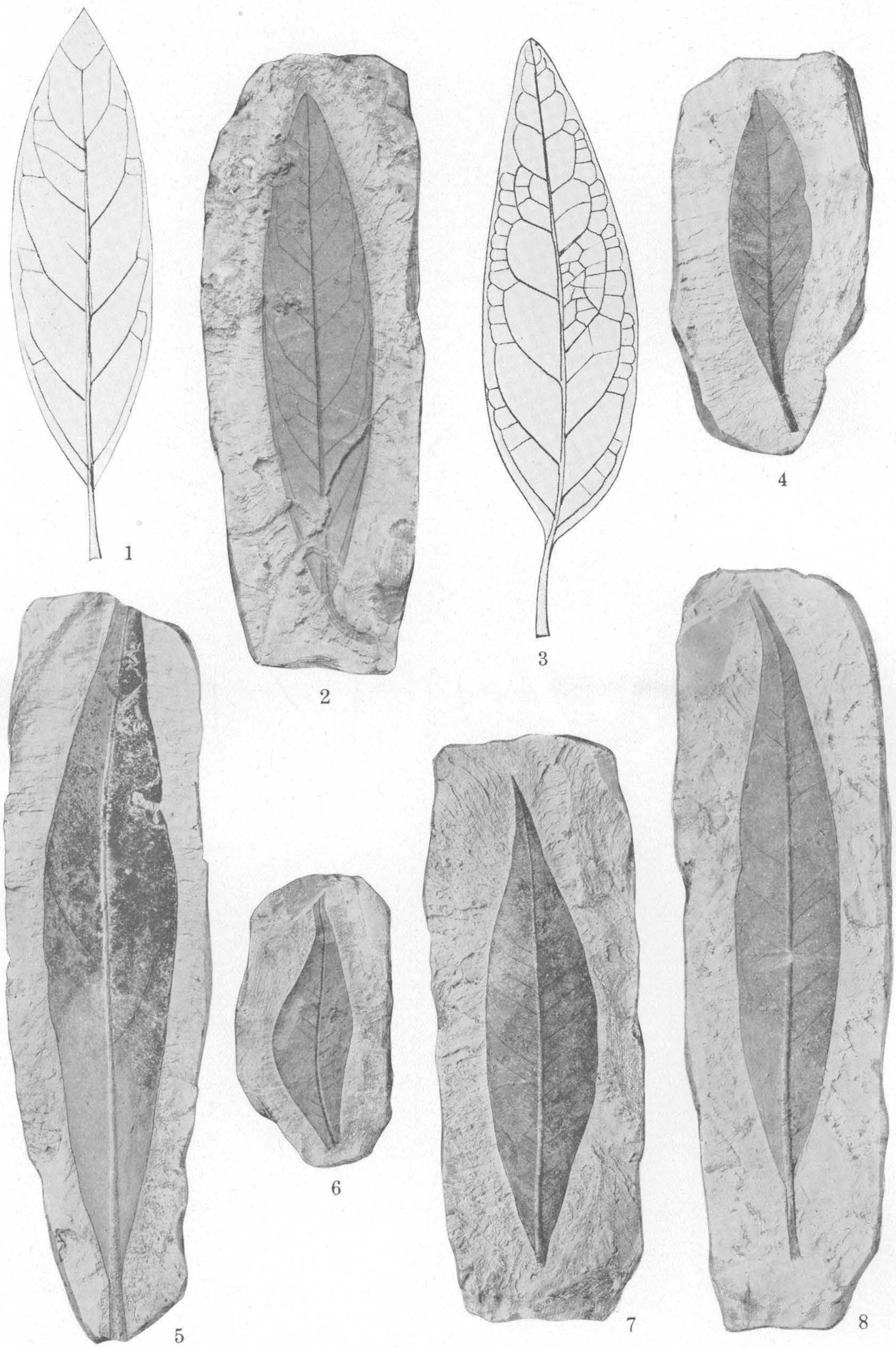
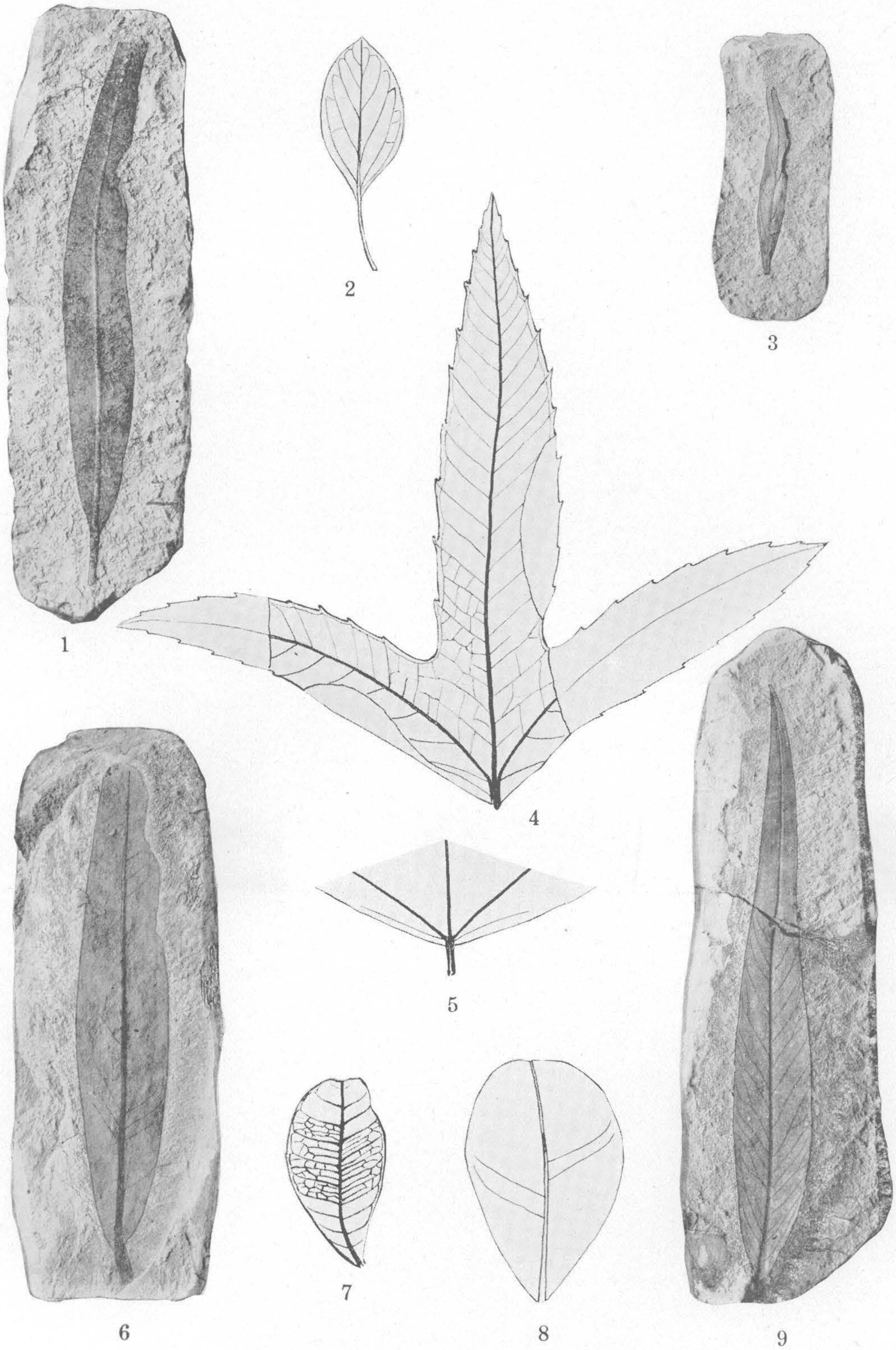


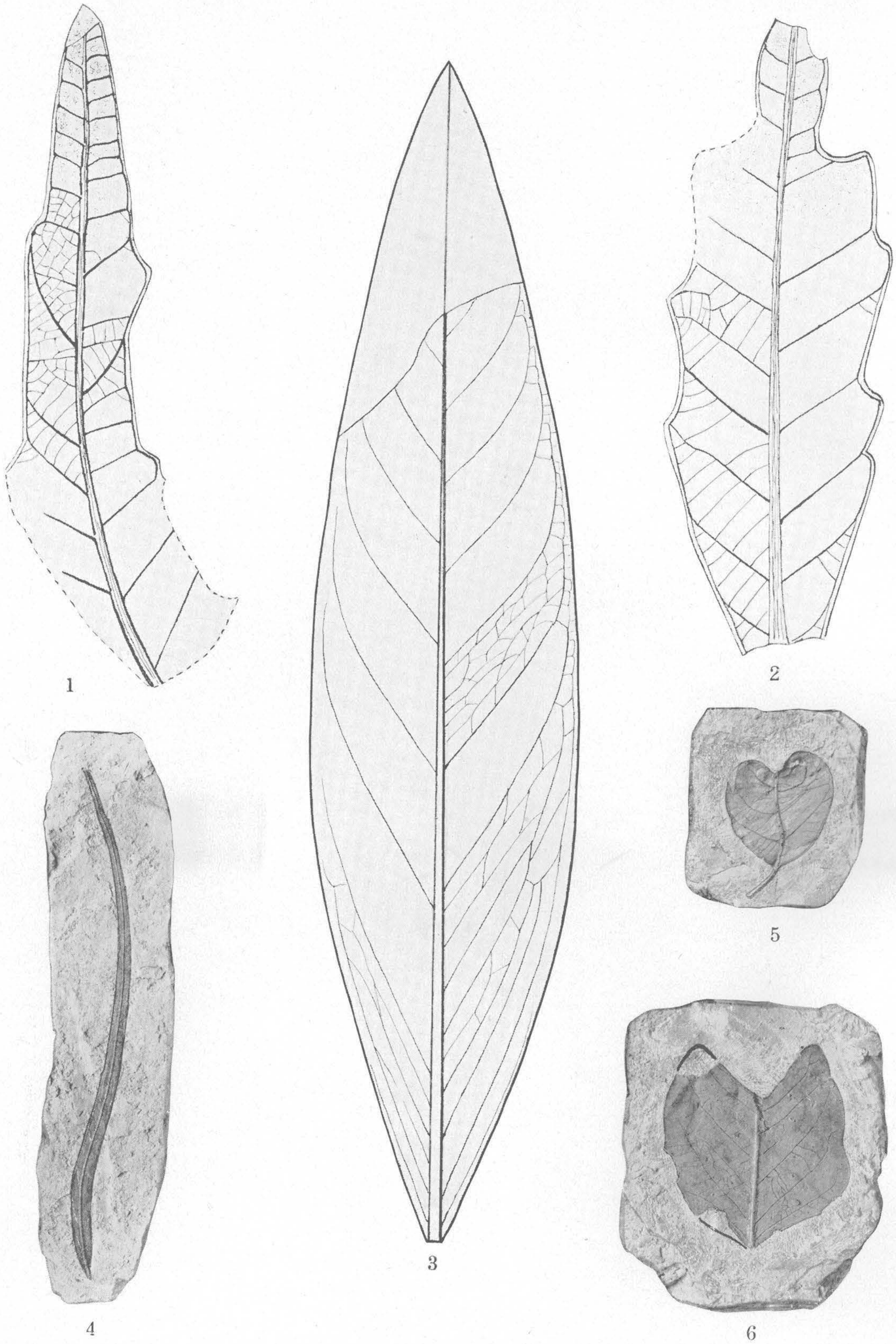
UPPER CRETACEOUS PLANTS FROM THE RIPLEY FORMATION

1, 2. *Laurus asiminoides* Berry (p. 79). Perry place.
3. *Laurus ripleyensis* Berry (p. 80). Perry place.
4, 5, 6, 7, 8. *Laurophyllum ripleyensis* Berry (p. 80). Perry place.



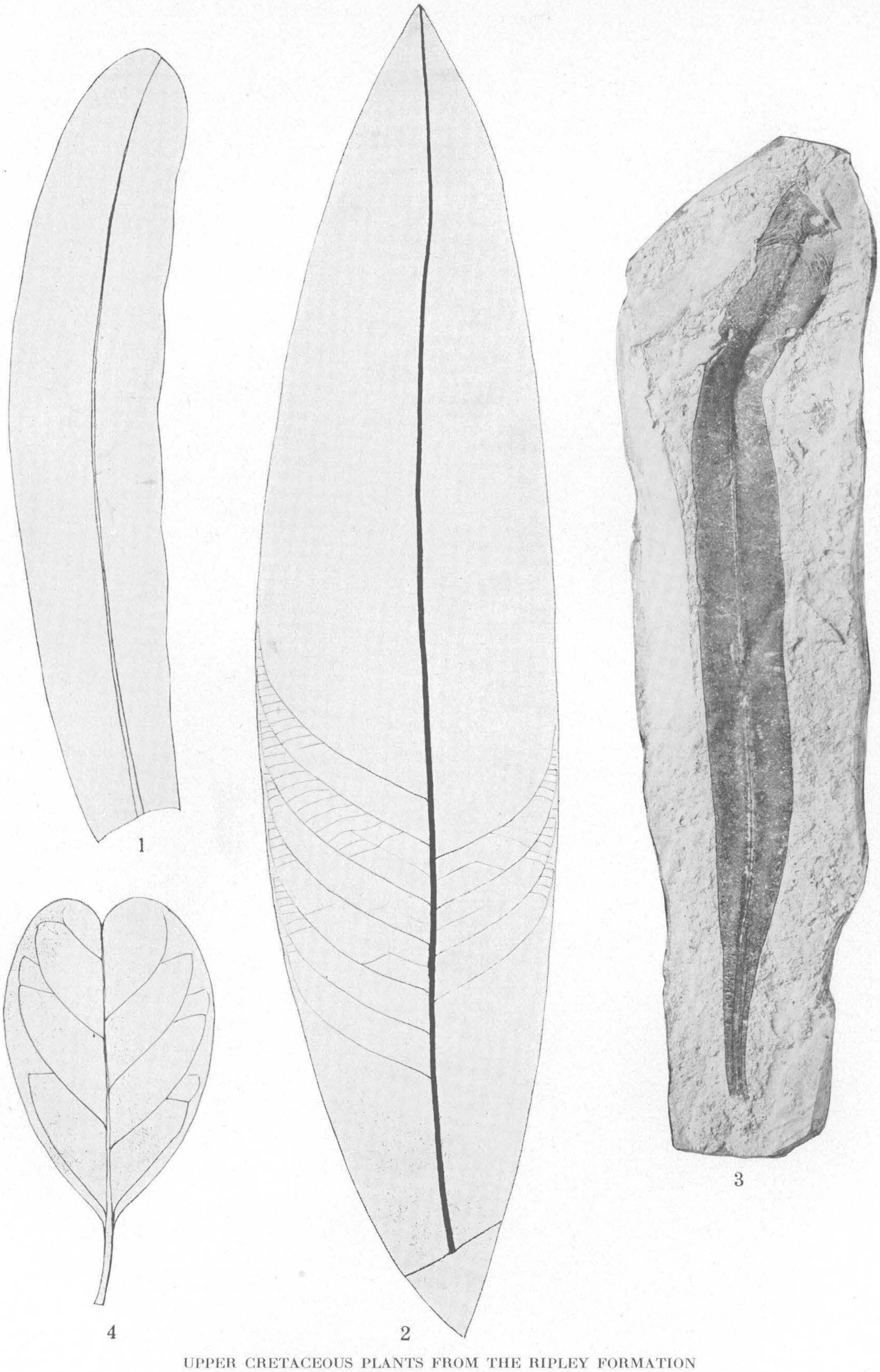
UPPER CRETACEOUS PLANTS FROM THE RIPLEY FORMATION

1. *Myrtophyllum angustum* (Velenovsky) Berry (p. 82). Cooper pit.
2. *Cornophyllum minimum* Berry (p. 84). Cooper pit.
3. *Myrcia dubia* Berry (p. 81). Cooper pit.
4, 5. *Aralia wellingtoniana minor* Berry (p. 82). Perry place.
6. *Eugenia? anceps* Berry (p. 82). Cooper pit.
7, 8. *Chrysophyllum parvum* Berry (p. 84). Cooper pit.
9. *Myrcia havanensis* Berry (p. 81). Cooper pit.



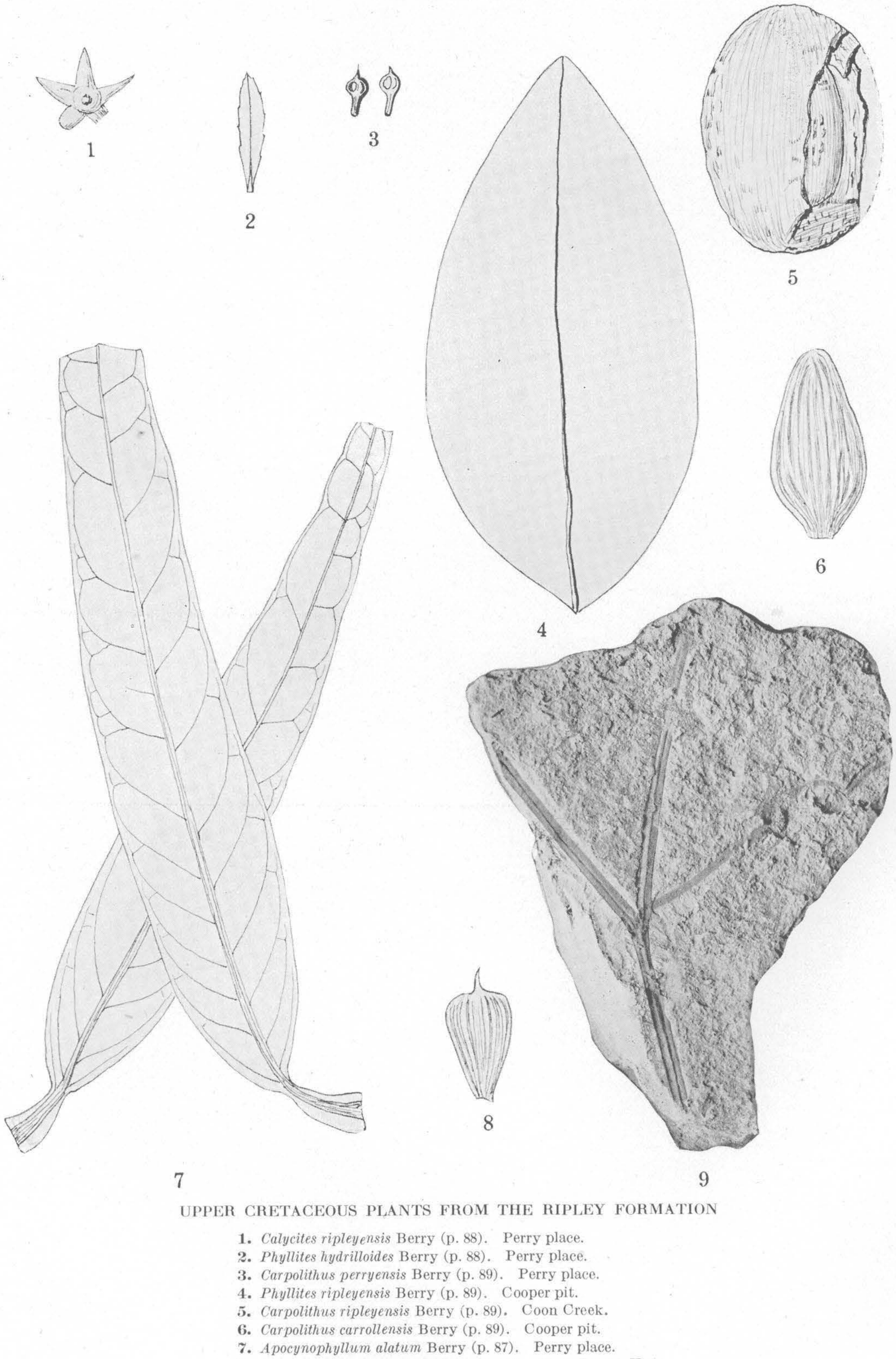
UPPER CRETACEOUS PLANTS FROM THE RIPLEY FORMATION

1, 2. *Aralia problematica* Berry (p. 83). Perry place.
3. *Andromeda anceps* Berry (p. 84). Perry place.
4. *Acerates cretacea* Berry (p. 83). Cooper pit.
5. *Bumelia prewilcoxiana* Berry (p. 85). Perry place.
6. *Bumelia ripleyana* Berry (p. 85). Perry place.



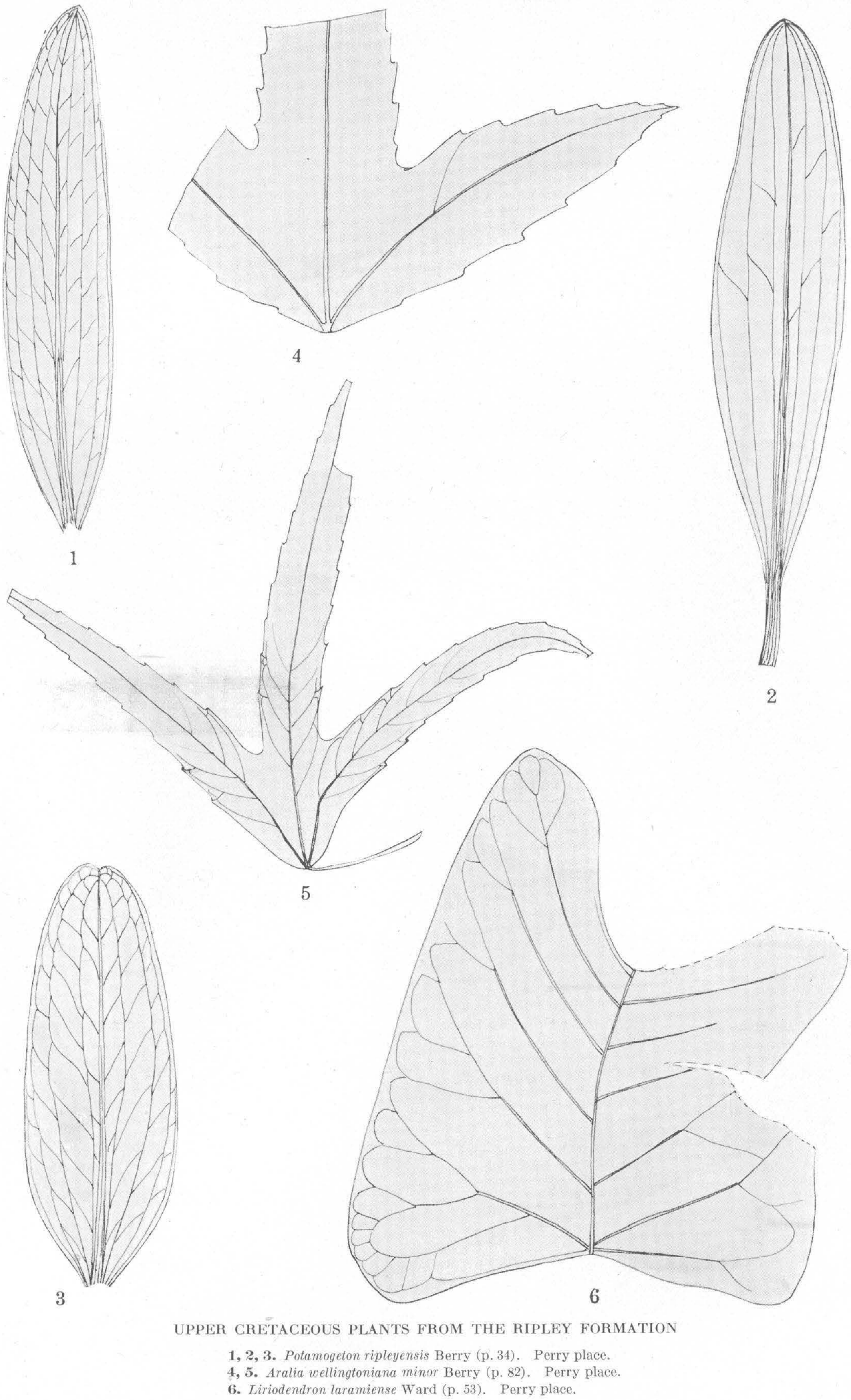
UPPER CRETACEOUS PLANTS FROM THE RIPLEY FORMATION

1. *Apocynophyllum perryensis* Berry (p. 87). Perry place.
2. *Apocynophyllum giganteum* Berry (p. 86). Cooper pit.
3. *Apocynophyllum ripleyensis* Berry (p. 87). Cooper pit.
4. *Bumelia prewilcoxiana* Berry (p. 85). Perry place.



UPPER CRETACEOUS PLANTS FROM THE RIPLEY FORMATION

1. *Calycites ripleyensis* Berry (p. 88). Perry place.
2. *Phyllites hydrilloides* Berry (p. 88). Perry place.
3. *Carpolithus perryensis* Berry (p. 89). Perry place.
4. *Phyllites ripleyensis* Berry (p. 89). Cooper pit.
5. *Carpolithus ripleyensis* Berry (p. 89). Coon Creek.
6. *Carpolithus carrollensis* Berry (p. 89). Cooper pit.
7. *Apocynophyllum alatum* Berry (p. 87). Perry place.
8. *Dammara acicularis* Knowlton (p. 34). Near Buena Vista.
9. *Phyllites hydrocharitoides* Berry (p. 88). Cooper pit.



UPPER CRETACEOUS PLANTS FROM THE RIPLEY FORMATION

1, 2, 3. *Potamogeton ripleyensis* Berry (p. 34). Perry place.
4, 5. *Aralia wellingtoniana minor* Berry (p. 82). Perry place.
6. *Liriodendron laramiense* Ward (p. 53). Perry place.

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