CONTRIBUTIONS TO PALÆONTOLOGY

UPPER CRETACEOUS FLORAS OF THE ROCKY MOUNTAIN REGION

II: FLORA OF THE LANCE FORMATION AT ITS TYPE LOCALITY, NIOBRARA COUNTY, WYOMING

By Erling Dorf

Princeton University

With seventeen plates and 3 text figures

[Preprinted from Carnegie Institution of Washington Publication No. 508, pages 79 to 159, October 2, 1942]

CONTRIBUTIONS TO PALÆONTOLOGY

UPPER CRETACEOUS FLORAS OF THE ROCKY MOUNTAIN REGION

II: FLORA OF THE LANCE FORMATION AT ITS TYPE LOCALITY, NIOBRARA COUNTY, WYOMING

By Erling Dorf

Princeton University

With seventeen plates and 3 text figures

[Issued October 2, 1942]

CONTENTS

FLORA OF THE LANCE FORMATION AT ITS TYPE LOCALITY, NIOBRARA COUNTY, WYOMING

INTRODUCTION

The flora of the Lance formation has been the subject of considerable discussion in the past because of its connection with the controversial Mesozoic-Cenozoic boundary problems. Several years ago it became apparent that many of the fossil plants supposed to have been collected from the Lance formation of Wyoming, Montana, and the Dakotas were in reality obtained from beds which are above and younger than the Lance formation as originally defined.[1] It has seemed wise, therefore, to limit the scope of this report to the description and discussion of plants known definitely to have come from the Lance formation at its type locality.

Although plants were collected by Knowlton from the type Lance (then called the "*Ceratops* beds of Converse County") as early as 1896,[2] they were only partially identified and have never been described or figured. These plants are now in the

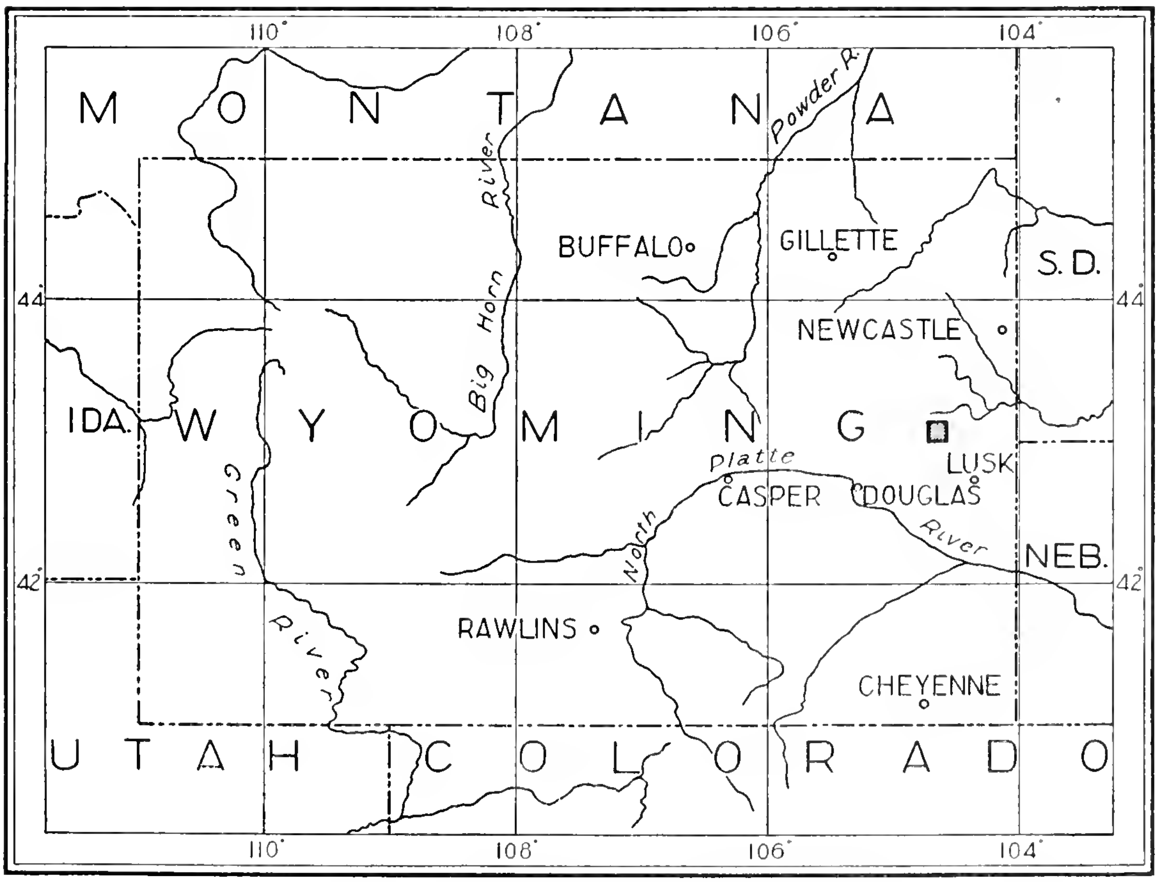


Fig. 1—Index map showing location of Lance Creek area

[1] Dorf, E., Carnegie Inst. Wash. Pub. No. 508, pt. I, 33, 35, 1938.
[2] Stanton, T. W., and Knowlton, F. H., Bull. Geol. Soc. Amer., vol. 8, 128, 1897.

collections of the U. S. National Museum, where they were kindly made available to me for the present study. My own larger collections of plants from the type Lance were obtained during two weeks of the field season of 1936 and five weeks of 1938.

As is shown in figure 1, the type locality of the Lance formation is in eastern Wyoming in the north-central part of Niobrara County (formerly the eastern part of Converse County). It is referred to generally as the Lance Creek area and is the location of the well-known Lance Creek oil field.[1] The area lies within a radius of 5 miles northward of the town of Lance Creek and is 25 miles north-northwest of Lusk, Wyoming.

The study of the Lance flora is a continuation of my program on Upper Cretaceous floras of the Rocky Mountain region, conducted under the auspices of the Carnegie Institution of Washington and Princeton University. For their competent assistance in the field I am indebted to H. H. Sharkey, K. M. Waagé, F. D. Boice, and J. S. Shirk, students at Princeton University, and J. S. Eddy, of Lawrenceville School. Suggestions and technical advice have been given by Dr. John B. Reeside and Dr. Roland W. Brown, of the U. S. Geological Survey. Herbarium material has been freely consulted at the New York Botanical Garden, whose staff has been most helpful in offering suggestions regarding the systematic position of the fossil plants. For his constructive criticism of the manuscript I am particularly indebted to Dr. Ralph W. Chaney, of the University of California.

EARLIER WORK IN THE AREA

The Lance Creek area was first brought to scientific attention by Hatcher,[2] who had collected a large suite of dinosaur remains there between 1889 and 1895. Before the publication of Hatcher's paper Marsh had described several species of *Triceratops* (originally called *Ceratops*) and other vertebrates from Hatcher's collections; he had failed, however, to specify the locality from which these specimens had been obtained, other than that they were "from the Laramie" or "from the *Ceratops* beds of Wyoming." [3] It remained for Hatcher to locate the area, and to describe in detail the lithologic characters and sketch the areal boundaries of the beds which had yielded dinosaur remains. Regarding the stratigraphic position of the "*Ceratops* beds," Hatcher stated: "All the beds of the entire section are conformable, and bear evidence of a continuous deposition, from the Fort Pierre shales up through the Fox Hills sandstones and the overlying fresh-water *Ceratops* beds." [4] Hatcher subsequently published two other short papers [5] which mentioned the Lance Creek area, but did not add any data pertinent to the present report.

At about the same time, Stanton and Knowlton visited the Lance Creek area and made collections of invertebrates and plants from both the "*Ceratops* beds" and

[1] Hancock, E. T., U. S. Geol. Surv. Bull. 716, 91-122, 1921. Emery, W. B., Amer. Assoc. Petroleum Geologists, *Structure of Typical American Oil Fields*, vol. 2, 604-613, 1929.

[2] Hatcher, J. B., Amer. Jour. Sci., 3d ser., vol. 45, 135-144, 1893.

[3] Marsh, O. C., Amer. Jour. Sci., 3d ser., vol. 37, 334, 1889; ibid., vol. 38, 81, 177, 501, 1889; ibid., vol. 39, 422, 1890; ibid., vol. 41, 167, 1891; ibid., vol. 43, 249, 1892.

[4] Hatcher, J. B., op. cit., 139, 1893.

[5] Hatcher, J. B., Amer. Naturalist, vol. 30, 112-120, 1896; Amer. Geologist, vol. 31, 369-375, 1903.

adjacent strata. The report on this visit was published in 1897.[1] At this time Knowlton regarded the plants as indicative of the "true Laramie" age of the "*Ceratops* beds," that is, equivalent to the Upper Cretaceous Laramie formation of the Denver basin, and of the same age as the plant-bearing "Black Buttes beds" of southwestern Wyoming. The fresh-water invertebrates and the dinosaurs corroborated this conclusion. The stratigraphic section, as observed by Stanton and Knowlton, showed a conformable sequence from the Pierre shales up through the Fox Hills sandstone, the "*Ceratops* beds," and finally the "Fort Union group." The "Fort Union" age of the beds overlying the "*Ceratops* beds" was determined on plant evidence and on the absence of dinosaur remains.[2]

The complete descriptions and discussions of the ceratopsian dinosaurs, including those of the Lance Creek area, were published by Hatcher and Lull a decade later.[3] The map (plate 51) accompanying that report showed both the exact localities where the dinosaurs had been collected and the areal limits of the beds, which were here called the "Converse County beds" and the "Lance Creek beds."[4] The fauna was regarded as of true Laramie (Cretaceous) age, and at least in part contemporaneous with the dinosaurs from near Black Buttes, Wyoming and from the "Hell Creek beds" of Montana.

Up to 1909 there was apparent unanimity of published opinion for the Cretaceous age of the "*Ceratops* beds" of the Lance Creek area. In that year, however, Knowlton changed his opinion concerning both their stratigraphic relations and their age. He concluded:

> "Conformably below the beds by some geologists considered as the true Fort Union occur dark-colored sandstones, clays and shales, which have often been incorrectly referred to the Laramie, or its equivalent, but which are stratigraphically and paleontologically distinct from the Laramie, and the contention is here made that these beds, which include the 'Hell Creek beds' and so-called 'somber beds' of Montana, the 'Ceratops beds' or 'Lance Creek beds' of Wyoming, and their stratigraphic and paleontologic equivalents elsewhere, are to be regarded as constituting the lower member of the Fort Union formation, and are Eocene in age."[5]

In this paper Knowlton included a revised list of the plants collected from the "*Ceratops* beds" of the Lance Creek area; this differed considerably from the one previously published.[6] Of 48 recognized forms, only 16 species were specifically identified; of 14 species having an outside distribution, 9 were reported known from the Fort Union. In view of the fact that 6 of these 9 species were not mentioned in Knowlton's previous lists and have not been seen in any of my own larger collections from the "*Ceratops* beds," I have been much concerned about their validity. An examination of Knowlton's collections at the U. S. National Museum has revealed that the specimens representing 4 of the species were actually collected from the acknowledged Fort Union beds above the top of the "*Ceratops* beds," and those representing 3 species are not to be found. The remaining 2 species, *Sequoia norden-*

[1] Stanton, T. W., and Knowlton, F. H., Bull. Geol. Soc. Amer., vol. 8, 127–156, 1897.
[2] Ibid., 134, 135.
[3] Hatcher, J. B., and Lull, R. S., U. S. Geol. Surv. Mon. 49, 1907.
[4] Ibid., 180, 184.
[5] Knowlton, F. H., Proc. Washington Acad. Sci., vol. 11, 180, 1909.
[6] Stanton, T. W., and Knowlton, F. H., op. cit., 136, 1897.

skiöldi Heer and *Trapa? microphylla* Lesquereux, were found to be valid; both of these species are, however, long-ranging forms of little value for correlation.

Although the obviously mixed collection of Lance Creek specimens did not add any appreciable weight to his argument, Knowlton was by this time thoroughly convinced by accumulated evidence from elsewhere that the flora of the "*Ceratops* beds" and their supposed equivalents elsewhere could not be distinguished from the Fort Union flora. The stratigraphic misconceptions which led him to this conclusion have been discussed elsewhere.[1]

The "*Ceratops* beds" of the Lance Creek area were discussed again in the same year by Stanton,[2] who reiterated his opinion regarding the Cretaceous age of the beds as determined by their stratigraphic relations, their vertebrates, and their invertebrates. In the following year, Stanton first applied the name Lance formation to the "*Ceratops* beds," as follows:

> "The name Lance formation has recently been adopted by the United States Geological Survey for the 'Ceratops beds' of eastern Wyoming and adjacent areas. It is an abbreviated form of the term 'Lance Creek beds' which J. B. Hatcher applied to these deposits . . . with the statement that the name is taken 'from the principal stream in the region where they are best represented in Converse County, Wyoming.'"[3]

In this report Stanton was primarily concerned with the stratigraphic relations of the Lance formation. In the Lance Creek area, and elsewhere, he observed that there was no evidence of an unconformity between the Lance and the underlying Fox Hills sandstone, such as had been postulated by some geologists. He pointed out also that the Fox Hills sandstone of the Lance Creek area was somewhat thicker than had previously been determined, and estimated the thickness of the Lance formation at 2100 to 2200 feet.

Within the next few years the controversy concerning the Cretaceous-Tertiary boundary in the western interior reached its climax. The Lance Creek area, however, was no longer the focus of attention. In 1911 Knowlton[4] described a new species from his Lance Creek collections but did not discuss further the question of the age of the flora. In 1912 Winchester[5] described a section from the Pierre shale to the Fort Union in the Lance Creek area, in which the Lance formation was estimated to be 2539 feet thick. Collections of invertebrates, vertebrates, and plants were obtained from a number of localities. Problems of correlation were not discussed. The area was only briefly mentioned in connection with the symposium on the "Close of the Cretaceous and Opening of Eocene Time in North America" of 1913–1914.[6]

In the summer of 1914 Lull visited the Lance Creek area, and subsequently he published an excellent summary of the known vertebrate remains, both mammalian and dinosaurian, which had by this time been collected from the Lance formation of

[1] Dorf, E., Bull. Geol. Soc. Amer., vol. 51, 213–236, 1940.
[2] Stanton, T. W., Proc. Washington Acad. Sci., vol. 11, 241–244, 1909.
[3] Stanton, T. W., Amer. Jour. Sci., 4th ser., vol. 30, 172, 184, 1910.
[4] Knowlton, F. H., Bull. Torrey Bot. Club, vol. 38, 389, 1911.
[5] Winchester, D. E., U. S. Geol. Surv. Bull. 471, 477, 1912.
[6] Osborn, H. F., Knowlton, F. H., et al., Bull. Geol. Soc. Amer., vol. 25, 321–402, 1914.

the region.[1] The chief contribution of this report was the observation that the mammalian remains had been collected from the same zone that had yielded the dinosaur remains, and were uniformly distributed throughout the entire Lance formation. Emphasizing the relationships of the mammals, Lull regarded these as substantiating the testimony of the dinosaurs for the Mesozoic age of the beds.

Reports on the structure and the oil and gas resources of the Lance Creek area were published in 1921 by Hancock,[2] and in 1929 by Emery.[3] The area between Lance Creek and Newcastle, Wyoming was visited at about this time by Dobbin and Reeside, who convincingly showed that here, as elsewhere, the contact of the Lance formation and the Fox Hills sandstone is essentially transitional.[4] This was an important observation, since by this time proponents of the contention that the Lance formation belongs in the Cenozoic had stressed the presence of a major unconformity at the top of the Fox Hills.

The report by Dobbin and Barnett [5] on the Gillette coal field, which lies just north of the Lance Creek area, contains observations of significance to the present report. The Lance formation in that region is subdivided by Dobbin and Barnett into two members, which "are respectively correlated with and are directly traceable northward into the Hell Creek and Tullock members of the Lance formation as recognized in eastern Montana. The Hell Creek member is also traceable southeastward into the '*Ceratops* beds' of the Lance Creek area, described by Hatcher and by Stanton and Knowlton." [6] This clearly implies, as I have also noted in a visit to the area, that the Tullock member of the Lance, which overlies the Hell Creek, is directly traceable southeastward into the well-recognized Fort Union beds of the Lance Creek area. This is in agreement with the evidence of the fossil plants, as discussed elsewhere in this report, that the Tullock is Paleocene "Fort Union," and not a part of the Lance formation as originally defined.

The mammalian remains of the Lance Creek area were included in Simpson's monograph on American Mesozoic mammals,[7] published in 1929. The Lance mammalian fauna is regarded (fig. 61 of Simpson) as of latest Cretaceous age. The dinosaurs of the area were again discussed in 1930 by Russell,[8] who listed the nineteen species known and discussed their relation to other faunas. He concluded that the Lance formation, as originally defined in the Lance Creek area, is equivalent in Montana and the Dakotas to only the Hell Creek beds, and that the Tullock and Cannonball should be provisionally included in the Paleocene. This opinion is now believed to be substantiated by the positive evidence of the fossil plants of the present report.

In the past decade the Lance Creek area has not often been the subject of discussion. In 1933 Lull included a systematic treatment and discussion of the dino-

[1] Lull, R. S., Amer. Jour. Sci., 4th ser., vol. 40, 319–348, 1915.
[2] Hancock, E. T., U. S. Geol. Surv. Bull. 716, 91–122, 1921.
[3] Emery, W. B., Amer. Assoc. Petroleum Geologists, *Structure of Typical American Oil Fields*, vol. 2, 604–613, 1929.
[4] Dobbin, C. E., and Reeside, J. B., Jr., U. S. Geol. Surv. Prof. Paper 158-B, 18–20, 1929.
[5] Dobbin, C. E., and Barnett, V. H., U. S. Geol. Surv. Bull. 796-A, 1–50, 1927.
[6] Ibid., 8.
[7] Simpson, G. G., Mem. Peabody Mus. Nat. Hist., vol. 3, pt. 1, 97–139, 146, 149, 150, 1929.
[8] Russell, L., Proc. Amer. Philos. Soc., vol. 69, 139–141, 1930.

saur species known from the area in his monograph on the revision of the Ceratopsia.[1] My own preliminary statements regarding the plants from the Lance and a discussion of their stratigraphic relationships have preceded the present comprehensive report.[2]

The palæobotanical conclusion that the Tullock and Ludlow beds, generally regarded as the upper member of the Lance formation in regions to the north of the Lance Creek area, are of early Paleocene age has recently been substantiated by the study of the foraminifera of the marine Cannonball beds, which interfinger westward into the Ludlow.[3]

STRATIGRAPHY

General Section

The sedimentary rocks exposed in the Lance Creek area, as shown in figure 2, are of Upper Cretaceous, Paleocene, and Oligocene age. The generalized section of formations is as follows:

- Tertiary
  - Oligocene:
    - *White River group* (nonmarine)
  - Unconformity
  - Paleocene:
    - *Fort Union group* (nonmarine)
- Upper Cretaceous
  - *Lance formation* (nonmarine)
  - *Fox Hills sandstone* (marine)
  - *Pierre shale* (marine)

From the Pierre shale up into the Fort Union group the succession is one of apparently continuous deposition. All these formations crop out as a result of erosion on the steep to gently dipping northwestern limb of an asymmetrical anticline. The sediments of the White River group lie essentially horizontally on the dipping, eroded Pierre shale in the southern part of the region. The best exposures of the formations are to be seen in the banks of the main streams and their numerous tributaries, all of which are practically dry during the summer months. In the descriptions which follow, details concerning the Pierre shale and the White River group are omitted, as these beds have no immediate bearing on the problems concerning the Lance formation.

Fox Hills Sandstone

From the typical dark-gray clay shales of the Pierre shale, exposures in the Lance Creek area show a gradual transition upward into a succession of light-gray and grayish-brown sandstones. These have been referred to the Fox Hills sandstone [4] on the basis of their stratigraphic position, their gross lithology, and their

[1] Lull, R. S., Mem. Peabody Mus. Nat. Hist., vol. 3, pt. 3, 1933.

[2] Dorf, E., Carnegie Inst. Wash. Pub. No. 508, pt. I, 33–36, 1938; Bull. Geol. Soc. Amer., vol. 51, 213–236, 1940.

[3] Fox, S. K., Jr., and Ross, R. J., Jr., Bull. Geol. Soc. Amer., vol. 51, no. 12, pt. 2, 1970, 1940.

[4] Stanton, T. W., and Knowlton, F. H., Bull. Geol. Soc. Amer., vol. 8, 128–132, 1897. Dobbin, C. E., and Reeside, J. B., Jr., U. S. Geol. Surv. Prof. Paper 158-B, 18–20, 1929. Waagé, K. M., *The Stratigraphy and Palæontology of the Fox Hills Formation in the Lance Creek Area, Niobrara County, Wyoming*, senior thesis, Princeton University, 4, 43–52, 1939.

abundant marine invertebrates, which include *Veniella humilis* Meek and Hayden, *Discoscaphites conradi* (Morton), *D. cheyennensis* (Owen), and the diagnostic zone index *Sphenodiscus lenticularis* (Owen).

The thickness of the Fox Hills sandstone in the region has been variously estimated at between 300 and 750 feet. Discrepancies in thickness appear to be the

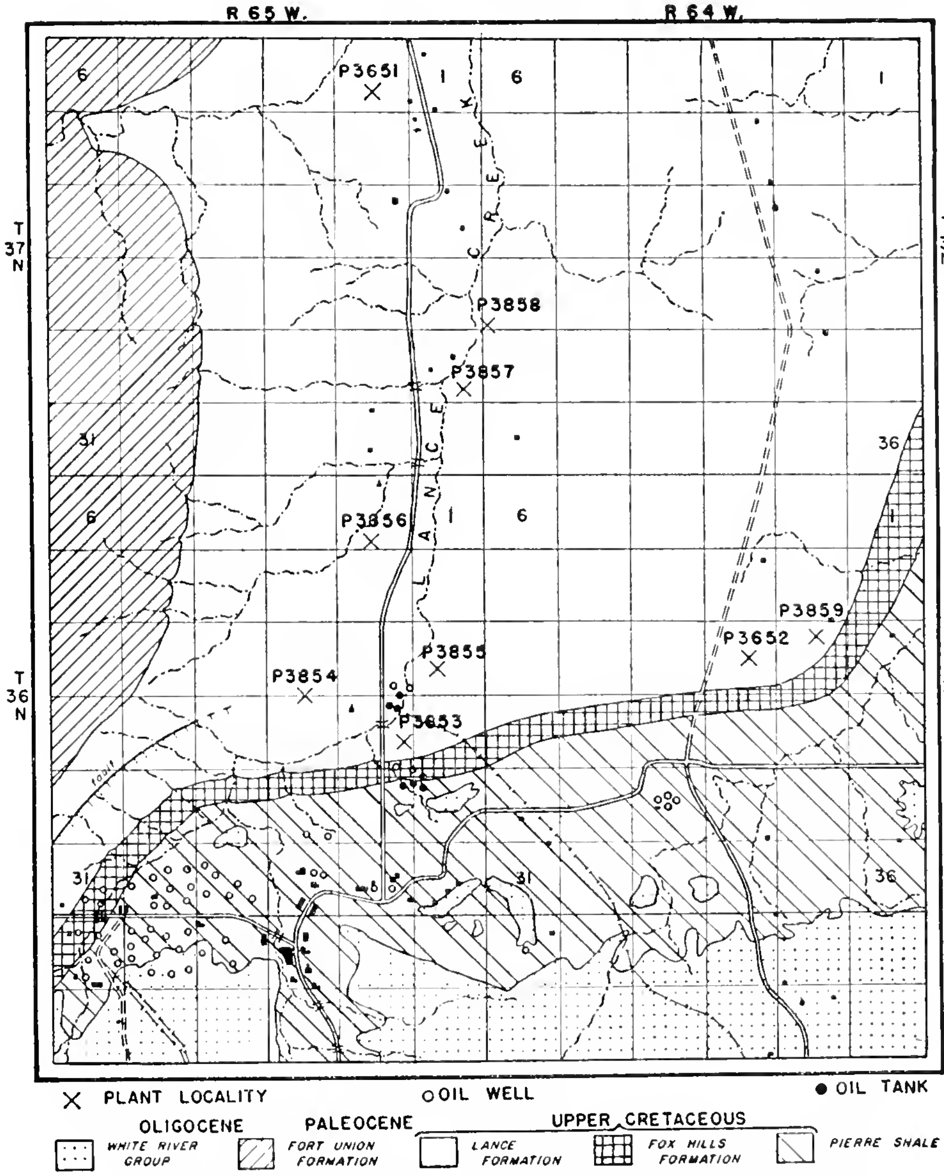


FIG. 2—Areal geology of Lance Creek area, showing locations of plant localities

result of difficulties involved in properly placing the contact with the overlying Lance formation. The practical solution to these difficulties has been ably stated by Dobbin and Reeside:

"In general, minor individual lithologic units are not persistent in either the Fox Hills or the Lance. On the other hand, larger lithologic units, aggregations of these smaller, variable units, persist over large areas and are trustworthy features for identification. In some places, however, there is little lithologic distinction between beds that contain characteristic Lance species and others that contain characteristic Fox Hills species, and in these places the fossils must be made the chief reliance for separating the formations." [1]

In keeping with these suggestions, the following criteria for the practical delimitation of the Fox Hills sandstone in northeastern Colorado were subsequently published by a committee of the Rocky Mountain Association of Petroleum Geologists after a field conference with Dr. Reeside:

"The base of the Fox Hills formation shall be considered as the horizon below which the section is predominantly gray marine clay shales and sandy shales of Pierre age, and above which the section changes rapidly to a buff to brown sandstone containing numerous large gray to brown, hard sandy concretions. This lower concretionary member is commonly overlain by a series of light gray to brown sandstones and sandy shales.

"The top of the Fox Hills formation shall be considered as the horizon above which the section is composed predominantly of fresh and brackish-water deposits accompanied by coals and lignitic shales, and below which it is predominantly marine." [2]

Attempts by our field party to apply these practical criteria to the section in the Lance Creek area showed that the Fox Hills sandstone, though somewhat variable in thickness, averages about 250 to 350 feet in thickness, as has also been shown by Dobbin and Reeside.[3] The greater thicknesses reported by earlier writers are apparently the result of the inclusion in the Fox Hills of several massive, gray sandstones (Colgate equivalent?) which in places lie above the typical, fossiliferous Fox Hills beds. These massive sandstones are locally present in the Lance Creek area, where they have the following characteristics: (1) they are lenticular bodies of sand, which were traced laterally along the strike from just east of Locality P3652 into the typical dull-gray sandy shales, lignites, and plant-bearing gray sandstones of the lower Lance formation at Locality P3853; (2) they contain a well-defined lignite bed above the lowest massive sandstone, as well as several lignite lenses higher up; (3) they contain no marine invertebrates; (4) locally they have yielded both dinosaur remains and impressions of land plants; and (5) they resemble more closely the lenticular sandstones of the overlying Lance succession than any beds of the true Fox Hills. On the basis of the criteria set forth above, these massive sandstones are not considered a part of the Fox Hills formation.

The following section, measured by Stanton [4] at the mouth of Lance Creek, is typical of the Fox Hills sandstone in this region, and shows the relation of the massive sandstones, which were regarded by Stanton as upper Fox Hills, to the beds below.

Section of Fox Hills Sandstone at Mouth of Lance Creek, Sec. 11, T. 39 N., R. 62 W., Wyoming

	Thickness in feet
Lance formation [part]:	
White cross-bedded sandstone with irregular brown indurated bands, masses, and concretions	50.0
Soft sandy shale with bands of lignitic shale. Fragments of dinosaur bone were found on the surface here	50.0
[Both units above were included by Stanton in the Fox Hills]	

[1] Dobbin, C. E., and Reeside, J. B., Jr., op. cit., 11, 1929.
[2] Lovering, T. S., Aurand, H. A., Lavington, C. S., and Wilson, J. H., Bull. Amer. Assoc. Petroleum Geologists, vol. 16, 702, 1932.
[3] Dobbin, C. E., and Reeside, J. B., Jr., op. cit., 19, 1929.
[4] Stanton, T. W., Amer. Jour. Sci., 4th ser., vol. 30, 184, 1910.

Fox Hills sandstone:	Thickness in feet
Sandy shale full of *Corbicula cytheriformis*? and *Corbicula subelliptica* var. *moreauensis*	0.5–1.0
More or less carbonaceous shale	15.0
Soft, massive gray sandstone with many brown concretions	25.0
Gray sandstone and sandy shale with bands of sandstone containing Fox Hills fossils ... about	150.0
Cross-bedded, ripple-marked, reddish-brown sandstone with irregular base	8.0–10.0
Massive, soft, buff sandstone with many large and indurated masses and an abundant Fox Hills fauna	100.0
Total Fox Hills ... about	300
Pierre shale with only the top exposed	

Lance Formation

As exposed in the Lance Creek area, which is its designated type locality, the Lance formation consists of about 2600 feet of dull-gray sandy shales alternating irregularly with lenticular, light-colored sandstones and thin lignite beds. Along both Lance and Lightning creeks there are numerous good exposures which show that individual units are very irregular, sandstones passing laterally into shales and vice versa. Large, irregular concretions are prevalent at many horizons. The massive sandstones are generally friable, though occasionally well cemented, and are characteristically dull gray, weathering to light brown. The shaly beds are generally dull gray or purplish gray, occasionally yellowish gray, and usually weather to a somewhat lighter gray or pinkish gray. The lignite beds are thin, discontinuous, and of poor quality.

Although considerable time was spent in the field in search of a complete section of the Lance to be measured, none of the sections examined was found suitable. The following complete section was measured by Winchester and Barnett [1] in a traverse which cuts across the northwest corner of the region shown in figure 2 and ends at the mouth of Lance Creek:

Section of Lance Formation Measured between East Cow Creek Butte, Sec. 32, T. 38 N., R. 67 W., and the Mouth of Lance Creek, Sec. 11, T. 39 N., R. 62 W., Wyoming

	Thickness in feet
"Fort Union" formation [part]:	
Shale, carbonaceous, dark, sandy with a few thin beds of sandstone	200.0
Shale, dark, carbonaceous	40.0
Lance formation:	
Sandstone, yellowish, friable [may be "Fort Union"], with some light shale (bone fragments at 90 feet below top; *Triceratops* skull at 180 feet below top; shells at 229 and 250 feet below top)	320.0
Shale, sandy, with some hard brown, slightly carbonaceous bands and friable sandstone	147.0
Sandstone, massive, friable; shells at base [identified by T. W. Stanton]: Campeloma multilineata Meek and Hayden; Unio sp.; Sphærium sp.; Viviparus? sp.; Tulotoma thompsoni White	47.0
Sandstone, shaly, concretionary	3.0
Sandstone, massive, yellowish brown, friable; *Trachodon* skeleton at base	30.0
Shale, dark bluish gray, slightly carbonaceous	7.0
Shale, sandy	5.5

[1] Winchester, D. E., U. S. Geol. Surv. Bull. 471, 477, 1912.

	Thickness in feet
Sandstone, massive, yellowish brown	22.0
Shale, sandy, bluish gray	6.0
Sandstone, friable, yellowish, with soft, sandy light-colored shale	1150.0
Sandstone, friable, massive, concretionary, shaly in places, with some hard brown, slightly calcareous sandstone and a few bands of soft sandy shale; Unios found at top	570.0
Shale and sandstone, banded	30.0
Sandstone, massive, yellowish brown, with the following fossils [identified by C. W. Gilmore]: Tooth of *Triceratops*; Fragment of the carapace of a soft-shelled turtle, probably belonging to the genus *Aspiderates*	25.0
Sandstone, shaly, with some shale	25.0
Sandstone and shale; light colors prevailing	120.0
Sandstone, massive, yellowish brown, friable	12.0
Shale, carbonaceous, sandy, and sandstone, soft	20.0
Total Lance formation	2539.5

Fox Hills sandstone:

Sandstones, yellowish brown, soft, interbedded with sandy, light-colored shale [probably in part Lance]

The lower limit of the Lance formation has been discussed under the Fox Hills sandstone. The upper limit, following its original definition, has been conveniently drawn at the top of the dinosaur-bearing beds. This horizon coincides with a marked change, without a recognized erosional or structural unconformity, from the characteristic dull-gray shales and shaly sandstones of the typical Lance formation to a sequence of more persistent ridge-forming yellowish sandstones, yellowish sandy shales, and coal beds.

The Lance formation of the Lance Creek area has yielded abundant fossil remains of vertebrates, invertebrates, and plants. The dinosaur remains, most of which were collected from the area included in figure 2, have been discussed recently by Russell [1] and Lull.[2] The mammalian fauna has been thoroughly treated by Simpson,[3] and the invertebrates have been listed by both Stanton [4] and Henderson.[5] Up to the present report the plant remains have not been systematically treated, and only a provisional list of species has been published by Knowlton.[6]

Except for the few specimens kindly loaned to me by the U. S. National Museum, the plant remains described in the present report were collected by me from the Lance formation at the following localities, shown in figure 2:

Locality P3853. Base of low ridge, near center of SE. ¼ sec. 23, T. 36 N., R. 65 W. (See plate 1, figs. 1, 2.) Leaves occur in great numbers in a dull-gray, hard, calcareous sandstone, which is a lenticular unit within a thicker unit of gray, carbonaceous, sandy shales and thin lignite beds. The horizon is about 210 feet above the top of the Fox Hills sandstone. The following species of plants were obtained here:

Anona? robusta	Asplenites tenellum
Araucarites longifolia	Canna? magnifolia

[1] Russell, L., Proc. Amer. Philos. Soc., vol. 69, 139–141, 1930.
[2] Lull, R. S., Mem. Peabody Mus. Nat. Hist., vol. 3, pt. 3, 8, 15, 1933.
[3] Simpson, G. G., Mem. Peabody Mus. Nat. Hist., vol. 3, pt. 1, 97–139, 146, 149, 150, 1929.
[4] Stanton, T. W., and Knowlton, F. H., op. cit., 128–136, 1897.
[5] Henderson, J., Geol. Soc. Amer., Spec. Paper No. 3, 33, 1935.
[6] Knowlton, F. H., Proc. Washington Acad. Sci., vol. 11, 180, 1909.

Carpites lancensis
Cornophyllum wardii
Dombeyopsis trivialis
Equisetum sp.
Ficus planicostata
Fraxinus leii
Laurophyllum meeki
Menispermites belli
Menispermites cockerelli
Myrtophyllum torreyi
Nymphæites dawsoni
Phyllites sp.
Pistia corrugata
Quercophyllum gardneri
Quercus? viburnifolia
Sabalites eocenica
Sabalites montana
Salix lancensis
Selaginella? falcata
Trapa? microphylla
Typha sp.
Viburnum marginatum

Locality P3854. South bank of small valley, southwest corner of SE. ¼ sec. 15, T. 36 N., R. 65 W. (See plate 2, fig. 1.) A fair collection of leaves was obtained from a lens of dark-gray, hard, calcareous siltstone, estimated to lie about 1000 feet above the base of the Lance formation:

Aristolochites brittoni
Carpites sp.
Cercidiphyllum arcticum
Dombeyopsis colgatensis
Dombeyopsis obtusa
Dryophyllum subfalcatum
Ficus? trinervis
Fraxinus leii
Grewiopsis saportana
Laurophyllum coloradensis
Laurophyllum salicifolium
Palæoaster inquirenda
Phyllites sp.
Platanophyllum montanum
Quercus? viburnifolia
Salix lancensis
Trapa? microphylla
Viburnum montanum
Woodwardia? crenata

Locality P3855. North bank of small valley, near center of SW. ¼ sec. 13, T. 36 N., R. 65 W. The following species were obtained from a bed of dull-gray, thinly bedded siltstone, estimated to be about 1200 feet above the base of the Lance:

Anona? robusta
Carpites walcotti
Carpites sp.
Cissus? lobato-crenata
Dryophyllum subfalcatum
Grewiopsis saportana
Laurophyllum coloradensis
Magnoliophyllum cordatum
Phyllites sp.
Platanophyllum montanum
Quercus? viburnifolia
Sequoia dakotensis
Viburnum marginatum
Vitis stantoni

Locality P3856. Head of small valley, southeastern part of SW. ¼ sec. 2, T. 36 N., R. 65 W. Only a few species were obtained, from a massive, buff to light-gray, soft claystone, estimated to lie about 1600 feet above the base of the Lance. As nearly as can be determined, this is the same locality as U. S. Geological Survey Locality 1462, referred to as "a clay bed . . . one and a half miles southwest" of the U-L Ranch.[1] Only the following species were obtained:

Equisetum sp.
Filicites knowltoni
Trapa? microphylla
Typha sp.

Locality P3857. Middle of steep cliff along east bank of Lance Creek, center of SE. ¼ sec. 25, T. 37 N., R. 65 W. (See plate 2, fig. 2.) Numerous plant remains occur in an irregular stratum of dull-gray siltstone in direct association with numerous well-preserved but fragile shells of fresh-water invertebrates. This is the locality (U. S. Geological Survey Locality 1464) about which Stanton and Knowlton remarked, "one of the best localities is in a bluff on the right bank of the Lance Creek just below the U-L Ranch."[2] I obtained the following species from this horizon, estimated to be about 1700 feet above the base of the Lance:

Apeibopsis? discolor
Cyperacites sp.
Dombeyopsis trivialis
Dryophyllum subfalcatum
Fraxinus leii
Ginkgo adiantoides?
Grewiopsis saportana
Laurophyllum salicifolium
Magnoliophyllum cordatum
Platanophyllum montanum
Quercus? viburnifolia
Rhamnus? minutus

[1] Stanton, T. W., and Knowlton, F. H., op. cit., 133, 1897.
[2] Ibid., 132.

Saliciphyllum wyomingensis
Salix lancensis
Sequoia dakotensis
Typha sp.
Viburnum marginatum
Viburnum montanum
Vitis stantoni

Locality P3858. Base of steep east bank of Lance Creek, southwest corner of SW. ¼ sec. 19, T. 37 N., R. 64 W. (See plate 3, fig. 1.) Leaves occur in large dull-gray siltstone concretions embedded in beds of lighter-gray, sandy shales. Horizon estimated to be slightly above the stratigraphic level of Locality P3857, about 1800 feet above the base of the Lance:

Asplenites tenellum
Cercidiphyllum ellipticum
Dryophyllum subfalcatum
Equisetum sp.
Filicites knowltoni
Fraxinus leii
Laurophyllum coloradensis
Menispermites knightii
Phyllites sp.
Pistia corrugata
Quercophyllum gardneri
Trapa? microphylla
Typha sp.
Vitis stantoni
Woodwardia? crenata

Locality P3651. Sandstone outcrops in small badlands area, western edge of SE. ¼ sec. 2, T. 37 N., R. 65 W. Scattered plant remains occur in irregularly bedded, grayish-buff, hard siltstone, estimated to be about 2000 feet above the base of the Lance:

Apeibopsis? discolor
Araliæphyllum artocarpoides
Carpites lancensis
Carpites verrucosus
Celastrus? taurinensis
Cornophyllum wardii
Dillenites cleburni
Dryophyllum subfalcatum
Fraxinus leii
Pistacia eriensis
Sequoia dakotensis
Typha sp.

Locality P3652. West bank of deep gully, northwestern corner of SE. ¼ sec. 15, T. 36 N., R. 64 W. A small collection of excellent impressions was obtained from a grayish-buff, hard, fine-grained sandstone, which lies 450 feet above the base of the Lance:

Apeibopsis? discolor
Cercidiphyllum ellipticum
Dillenites cleburni
Dombeyopsis trivialis
Platanophyllum platanoides
Quercus? viburnifolia
Sequoia dakotensis
Viburnum marginatum
Viburnum montanum
Vitis stantoni

The following species were obtained from a massive, friable, coarse, buff sandstone just 26 feet stratigraphically below the horizon above:

Canna? magnifolia
Cinnamomum? affine
Salix lancensis

Locality P3859. North bank of wide gully, western edge of NE. ¼ sec. 14, T. 36 N., R. 64 W. (See plate 3, fig. 2.) Leaves occur in a thinly bedded, grayish-buff siltstone 2 feet above a layer of fine-grained gray sandstone concretions. Horizon lies 440 feet above the base of the Lance:

Araucarites longifolia
Carpites verrucosus
Cercidiphyllum ellipticum
Dombeyopsis obtusa
Dombeyopsis trivialis
Dryophyllum subfalcatum
Equisetum sp.
Ficus? trinervis
Grewiopsis saportana
Laurophyllum salicifolium
Laurophyllum wardiana
Pistacia eriensis
Platanophyllum montanum
Quercus? viburnifolia
Rhamnus? minutus
Salix lancensis
Sequoia dakotensis
Typha sp.
Viburnum marginatum

In addition to the species obtained from these localities, the following species were borrowed from the U. S. National Museum:

U. S. Geol. Survey Locality 1462. Ravine 1½ miles southwest of U-L Ranch (apparently same as Locality P3856 of the present report):

Filicites knowltoni
Nymphæites browni
Phyllites trifoliatus
Salvinia? sp.
Trapa? microphylla

U. S. Geol. Survey Locality 1464. East bank of Lance Creek, just below U-L Ranch (same as Locality P3857 of present report):

Myrtophyllum torreyi

U. S. Geol. Survey Locality 1469. East bank of Lance Creek, 2 miles above the mouth of Lightning Creek:

Salix lancensis

U. S. Geol. Survey Locality 1479. Near Buck Creek corrals, Converse County, Wyoming. Collected by T. W. Stanton, July 17, 1896:

Carpites ulmiformis

U. S. Geol. Survey Locality 1485. East side of Lance Creek, 1 mile north of the Pierre shale:

Nelumbo tenuifolia

U. S. Geol. Survey Locality. No number given; Lance formation ("*Ceratops* beds"), Lance Creek, Converse County, Wyoming. Collected by J. B. Hatcher, June 1881:

Ficus? ceratops

Fort Union Group

The deposits above the Lance formation have been generally referred to the Fort Union "formation" on the basis of stratigraphic position, lithology, absence of dinosaurs, and the presence of a typical Lower Eocene (Paleocene) flora.[1] The contact between the typical Lance formation and the lowest unit of the Fort Union group has been discussed under the Lance formation. This contact is traceable northward into the Gillette coal field region, where it coincides, so far as I can determine, with the contact between the Hell Creek and Tullock formations.[2] The Tullock formation was regarded by Dobbin and Barnett, as elsewhere by others, as the upper member of the Lance formation. In the Gillette coal field, as well as at its type locality and elsewhere, the Tullock formation is now known to contain plant remains of typical Paleocene Fort Union aspect.[3] This conclusion is substantiated by the southward extension of the Tullock of the Gillette coal field into the Fort Union beds above the top of the Lance formation, as defined, in the Lance Creek area. It is evident, therefore, that the lower unit of the Fort Union group of the Lance Creek area is equivalent to the Tullock formation, which is traceable from its type locality in eastern Montana into the area of the Gillette coal field.[4]

The lithologic characters of the "Tullock" formation in the Lance Creek area are in distinct contrast with those of the type Lance. Sandstones are thin, yellowish, fine-grained, and fairly hard. They are more persistent than the sandstones of the Lance formation and form a fairly prominent succession of low scarps which stand above the rolling, subdued lowlands developed on the Lance formation. The

[1] Stanton T. W., and Knowlton, F. H., op. cit., 134, 1897. Dorf, E., Bull. Geol. Soc. Amer., vol. 51, 216, 232, 1940.
[2] Dobbin, C. E., and Barnett, V. H., U. S. Geol. Surv. Bull. 796-A, 8, 9, 1927.
[3] Dorf, E., op. cit., 223-232, 1940.
[4] Dobbin, C. E., and Barnett, V. H., op. cit., 8, 1927.

interbedded shales are also yellowish, and are soft and sandy, and non-concretionary. The coal beds are generally thin but are of better quality than the lignites of the Lance formation. The thickness of the "Tullock" formation in this region is roughly estimated at about 400 feet.

The beds above the "Tullock" were not examined in the Lance Creek area. In the Gillette coal field Dobbin and Barnett divided these beds into the Lebo shale member and the Tongue River member of the Fort Union "formation." [1]

The various units of the Fort Union group of the Lance Creek area and contiguous areas have yielded a considerable number of fossil plants. The following identified species were reported by Knowlton from the lower 200 feet of the Fort Union "formation" of the region shown in figure 2: [2]

Ampelopsis montanensis Cockerell
(Vitis cuspidata of Knowlton)
Celastrus pterospermoides Ward
Celastrus? taurinensis Ward
(C. curvinervis of Knowlton)
Cornus newberryi Hollick?
(C. acuminata? of Knowlton)
Diospyros brachysepala Al. Braun
Grewia celastroides Ward
Grewia crenata (Unger) Heer
Parottia cuneata (Newberry) Berry
(Viburnum cuneatum of Knowlton)
Platanus raynoldsii Newberry
Sequoia nordenskiöldi Heer
Zizyphus serrulatus Ward

Only 1 of these species, *Celastrus? taurinensis*, is known also from the underlying type Lance formation. *Sequoia nordenskiöldi* is known elsewhere from beds of Lance age, but is of no correlative significance, as it represents a type of conifer foliage of extended stratigraphic range from the Upper Cretaceous into the Cenozoic. Of the remaining 9 species, 5 are known elsewhere only in the type Fort Union or other undoubted Paleocene beds, and the remaining 4 species are known only in beds of Paleocene and Eocene age. This analysis leaves little doubt as to the Paleocene age of the beds.

During the summer of 1938 I collected, on the basis of information received from Dr. William W. Rubey, of the U. S. Geological Survey,[3] a number of fossil plants from the lower 100 feet of the Tullock formation of the Gillette coal field area. These were obtained from an old coal prospect on Coal Draw, 11 miles south by east of Moorcroft, Wyoming, SE. ¼ sec. 28, T. 48 N., R. 67 W. The following species have been identified:

Anemia lanceolata Knowlton
Celastrus? taurinensis Ward
Glyptostrobus dakotensis Brown
Hicoria antiquora (Newberry) Knowlton
Onoclea sensibilis fossilis Newberry
Platanus coloradensis Knowlton
Sapindus affinis Newberry
Sequoia nordenskiöldi Heer
Thuja interrupta Newberry

In this assemblage, the 2 species which occur also in the type Lance or equivalent beds (*Celastrus? taurinensis* and *Sequoia nordenskiöldi*) are elsewhere known to extend from late Cretaceous into Paleocene time and were discussed above. Of the remaining 7 species, 5 are known definitely only in undoubted Paleocene beds, and

[1] Ibid., 9–11.
[2] Stanton, T. W., and Knowlton, F. H., op. cit., 134–136, 1897.
[3] Written communication, May 11, 1936.

the remaining 2 species (*Aneimia lanceolata* and *Platanus coloradensis*) occur elsewhere only in the Middle Park formation (Paleocene?) of Grand County, Colorado.

In addition to these typical Paleocene floral assemblages from the lower Fort Union group of the Lance Creek area, Knowlton has identified another collection of typical Paleocene species from somewhat higher beds of the Fort Union group a few miles southwest of the Lance Creek area.[1]

COMPOSITION OF THE FLORA

SYSTEMATIC RELATIONSHIPS

The flora of the type Lance formation, as described in the present report, is composed of 70 recognizable forms distributed among 32 families. The major divisions of the plant kingdom are represented in the flora as follows: Dicotyledones, 55 species; Monocotyledones, 6 species; Coniferales, 2 species; Ginkgoales, 1 species; Lycopodiales, 1 species; Equisetales, 1 species; Filicales, 4 species. There are 56 forms referred to species previously known, 5 are described as new species, and 9 are given generic designation but are not specifically determinable.

The task of allocating Upper Cretaceous species to their proper botanical genera continues to be a difficult one. Many of the Lance species are still of very uncertain systematic position. Others are believed to show only a family relationship to existing forms. Not many can be shown to have a marked resemblance to living genera. The systematic position of the Lance species, in so far as it is believed to be determinable, is shown in the following list:

- Pteridophyta
  - Filicales
    - Polypodiaceæ
      - *Asplenites tenellum* (Knowlton) Dorf, n. comb.
      - *Woodwardia? crenata* Knowlton
    - Salviniaceæ?
      - *Salvinia?* sp.
    - Position uncertain
      - *Filicites knowltoni* Dorf, n. sp.
  - Equisetales
    - Equisetaceæ
      - *Equisetum* sp.
  - Lycopodiales
    - Selaginellaceæ?
      - *Selaginella? falcata* Lesquereux
- Spermatophyta
  - Gymnospermæ
    - Ginkgoales
      - Ginkgoaceæ
        - *Ginkgo adiantoides* (Unger) Heer ?
    - Coniferales
      - Taxodiaceæ
        - *Sequoia dakotensis* Brown
      - Araucariaceæ
        - *Araucarites longifolia* (Lesquereux) Dorf, n. comb.
- Angiospermæ
  - Monocotyledones
    - Typhaceæ
      - *Typha* sp.
    - Cyperaceæ
      - *Cyperacites* sp.
    - Palmæ
      - *Sabalites coccnica* (Lesquereux) Dorf
      - *Sabalites montana* (Knowlton) Dorf
    - Araceæ
      - *Pistia corrugata* Lesquereux
    - Cannaceæ
      - *Canna? magnifolia* Knowlton
  - Dicotyledones
    - Salicaceæ
      - *Salix lancensis* Berry
      - *Saliciphyllum wyomingensis* (Knowlton and Cockerell) Dorf, n. comb.
    - Fagaceæ
      - *Dryophyllum subfalcatum* Lesquereux
      - *Quercophyllum gardneri* (Knowlton) Dorf, n. comb.
    - Moraceæ
      - *Ficus planicostata* Lesquereux
    - Platanaceæ
      - *Platanophyllum montanum* (Brown) Dorf, n. comb.

[1] Winchester, D. E., op. cit., 481–483, 1912.

Platanaceæ—*continued*
Platanophyllum platanoides (Lesquereux) Dorf, n. comb.
Aristolochiaceæ
Aristolochites brittoni (Knowlton) Dorf, n. comb.
Lauraceæ
Laurophyllum coloradensis (Knowlton) Dorf, n. comb.
Laurophyllum meeki Dorf
Laurophyllum salicifolium (Lesquereux) Dorf, n. comb.
Laurophyllum wardiana (Knowlton) Dorf, n. comb.
Cercidiphyllaceæ
Cercidiphyllum arcticum (Heer) Brown
Cercidiphyllum ellipticum (Newberry) Brown
Nymphæaceæ
Nelumbo tenuifolia (Lesquereux) Knowlton
Nymphæites browni Dorf, n. sp.
Nymphæites dawsoni (Hollick) Dorf, n. comb.
Menispermaceæ
Menispermites belli Berry
Menispermites cockerelli (Knowlton) Dorf, n. comb.
Menispermites knightii Knowlton
Magnoliaceæ
Magnoliophyllum cordatum Dorf
Anacardiaceæ
Pistacia eriensis Knowlton
Vitaceæ
Vitis stantoni (Knowlton) Brown
Tiliaceæ
Grewiopsis saportana Lesquereux
Dilleniaceæ
Dillenites cleburni (Lesquereux) Dorf, n. comb.
Myrtaceæ
Myrtophyllum torreyi (Lesquereux) Dorf, n. comb.
Araliaceæ
Araliæphyllum artocarpoides (Lesquereux) Dorf, n. comb.
Cornaceæ
Cornophyllum wardii Dorf
Oleaceæ
Fraxinus leii Berry
Bignoniaceæ
Dombeyopsis colgatensis Brown
Dombeyopsis obtusa Lesquereux
Dombeyopsis trivialis Lesquereux
Caprifoliaceæ
Viburnum marginatum Lesquereux
Viburnum montanum Knowlton
Position uncertain
Anona? robusta Lesquereux
Apeibopsis? discolor (Lesquereux) Lesquereux
Celastrus? taurinensis Ward
Cinnamomum? affine Lesquereux
Cissus? lobato-crenata Lesquereux
Ficus? ceratops Knowlton
Ficus? trinervis Knowlton
Quercus? viburnifolia Lesquereux
Rhamnus? minutus Knowlton
Trapa? microphylla Lesquereux
Phyllites trifoliatus Dorf, n. sp.
Phyllites sp.
Phyllites sp.
Phyllites sp.
Carpites lancensis Dorf, n. sp.
Carpites ulmiformis Dorf, n. sp.
Carpites verrucosus Lesquereux
Carpites walcotti Dorf
Carpites sp.
Carpites sp.
Palæoaster inquirenda Knowlton

QUANTITATIVE ANALYSIS

The dominant species of an assemblage may be said to include both those species whose remains are most abundant and those whose remains are most persistently present at the various horizons within the deposit. The most useful results of quantitative studies are obtained from localities where several thousand specimens can be collected.[1] Unfortunately, none of the localities in the Lance Creek area has yielded more than 280 specimens. Failure to secure large collections is a result of the limited extent, both horizontally and vertically, of the lenticular beds containing the plant remains.

At each locality quarrying was continued as long as the plant remains continued to appear. Leaf counts at Localities P3853 and P3857 were made in the field, and species not definitely identified were temporarily designated by letters. All the

[1] Chaney, R. W., Amer. Jour. Sci., 5th ser., vol. 8, 127–144, 1925.

specimens obtained at the remaining localities were shipped and leaf counts were made in the laboratory. In the following lists the species are shown in the order of dominance at each locality, the numbers referring to the actual number of specimens of each species counted. Species represented by less than 5 specimens are omitted.

Locality P3853 (280 specimens counted)

Araucarites longifolia	182	Trapa? microphylla	6
Pistia corrugata	24	Nymphæites dawsoni	5
Menispermites cockerelli	8	Sabalites eocenica	5
Ficus planicostata	7	Salix lancensis	5
Equisetum sp.	6		

Locality P3854 (146 specimens counted)

Platanophyllum montanum	74	Dryophyllum subfalcatum	6
Salix lancensis	29	Ficus? trinervis	6
Fraxinus leii	7	Dombeyopsis colgatensis	5

Locality P3855 (57 specimens counted)

Viburnum marginatum	16	Grewiopsis saportana	5
Sequoia dakotensis	15	Quercus? viburnifolia	5
Dryophyllum subfalcatum	5		

Locality P3856 (22 specimens counted)

Trapa? microphylla	14	Filicites knowltoni	5

Locality P3857 (193 specimens counted)

Salix lancensis	43	Viburnum marginatum	6
Fraxinus leii	35	Viburnum montanum	6
Vitis stantoni	34	Dombeyopsis trivialis	5
Dryophyllum subfalcatum	28	Platanophyllum montanum	5
Sequoia dakotensis	8		

Locality P3858 (42 specimens counted)

Cercidiphyllum ellipticum	6	Fraxinus leii	5
Menispermites knightii	6		

Locality P3651 (88 specimens counted)

Sequoia dakotensis	44	Celastrus? taurinensis	5
Cornophyllum wardii	25		

Locality P3652 (61 specimens counted)

Vitis stantoni	25	Apeibopsis? discolor	6
Viburnum marginatum	7	Viburnum montanum	6

Locality P3859 (72 specimens counted)

Salix lancensis	19	Sequoia dakotensis	6
Dryophyllum subfalcatum	15	Viburnum marginatum	5

On the basis of the above leaf counts, in which a total of 951 specimens were examined and counted, the following species are considered the dominants of the type Lance flora as a whole:

- Araucarites longifolia
- Platanophyllum montanum
- Salix lancensis
- Sequoia dakotensis
- Vitis stantoni
- Dryophyllum subfalcatum
- Fraxinus leii
- Viburnum marginatum
- Cornophyllum wardii
- Pistia corrugata

These 10 species represent about 69 per cent of all the specimens encountered in the collections from the nine localities listed.

As regards frequency of occurrence, the following 13 species are recorded from four or more of the type Lance localities:

Dryophyllum subfalcatum	6	Viburnum marginatum	5
Quercus? viburnifolia	6	Dombeyopsis trivialis	4
Salix lancensis	6	Equisetum sp.	4
Typha sp.	6	Platanophyllum montanum	4
Fraxinus leii	5	Vitis stantoni	4
Sequoia dakotensis	5	Grewiopsis saportana	4
Trapa? microphylla	5		

A comparison of this list with that of the 10 species which are of greatest individual abundance shows that 7 of the latter are also among the 13 most persistent species of the Lance flora, as at present known. The remaining 3 species are very abundant locally but are each restricted to two of the nine Lance Creek localities.

CLIMATIC CONDITIONS INDICATED BY THE LANCE FLORA

There are in my opinion two reliable methods of employing fossil plants as indicators of climatic conditions of the past; both methods apply only to floras of late Mesozoic or Cenozoic time, and each method is wholly independent of the other. These are (1) an analysis of the structural characters of the dicotyledonous leaves (chiefly size, venation, texture, and marginal characters) as compared with modern leaves of known climatic requirements; and (2) a generic and specific comparison of fossil species with living forms whose climatic requirements are known, on the assumption that the past conditions were analogous to those under which the majority of the closely related living species grow.

The application of these methods to early and middle Tertiary floras has been described by Chaney and Sanborn,[1] MacGinitie,[2] and Potbury.[3] The details of their application to Upper Cretaceous floras are contained in my report on the Medicine Bow flora.[4] Although neither of these methods is strictly quantitative, they are considered much more accurate than conclusions based on individual species or genera, particularly since each method may be used as a check against the other.

The analyses of the leaf characters of the dicotyledonous Lance species are shown in table 1. For purposes of comparison the table also includes analyses of various modern and fossil assemblages studied by the authors mentioned above or by me. In each category in the table the Lance flora stands between the warm temperate to subtropical floras and the subtropical to tropical. The percentage of entire-leaved species in the Lance flora (54 per cent) is similar to the highest figure obtained by Bailey and Sinnott for warm temperate forests.[5] This is in agreement with the intermediate position of this flora, in respect to this character, between the warm temperate Weaverville flora and the subtropical Goshen flora. In their comparative lengths the Lance species are between the warm temperate La Porte flora

[1] Chaney, R. W., and Sanborn, E. I., Carnegie Inst. Wash. Pub. No. 439, 18, 1933.
[2] MacGinitie, H. D., Carnegie Inst. Wash. Pub. No. 465, 113, 1937.
[3] Potbury, S. S., Carnegie Inst. Wash. Pub. No. 465, 52, 1935.
[4] Dorf, E., Carnegie Inst. Wash. Pub. No. 508, pt. I, 25–31, 1938.
[5] Bailey, E. W., and Sinnott, I. W., Science, n. s., vol. 41, 832, 1915.

TABLE 1—*Leaf characters of dicotyledons, showing relative percentages in each category*

Flora	Margin		Length		Venation		Texture	
	Entire	Non-entire	Over 10 cm.	Under 10 cm.	Pinnate	Palmate	Thick	Thin
Temperate:								
Muir Woods, 22 species (modern)	23	77	27	73	77	23	64	36
Bridge Creek, 20 species	15	85	30	70	70	30	55	45
Warm temperate to subtropical:								
Weaverville, 36 species	47	53	60	40	60	40	57	43
La Porte, 35 species	71	29	35	65	65	35	83	17
Hell Creek, 28 species	54	46	36	64	64	36	64	36
Lance, 46 species	54	46	41	59	54	46	67	33
Medicine Bow, 42 species	67	33	45	55	60	40	71	29
Subtropical to tropical:								
Laramie, 55 species	71	29	45	55	64	36	73	27
Goshen, 49 species	61	39	53	47	82	18	98	2
Panama, 41 species (modern)	88	12	56	44	83	17	98	2

and the essentially subtropical Medicine Bow. In texture and venation characters they are only 4 per cent and 6 per cent, respectively, out of accord with the Medicine Bow flora. In their combined characters the Lance species are closest to those of the Medicine Bow flora, which is considered intermediate between warm temperate and subtropical, more nearly approaching the latter. In view of the usual difficulties of definition it may be said that the leaf characters of the Lance species indicate climatic conditions intermediate between warm temperate and subtropical, more nearly approaching the former.

As the data of table 1 were being arranged, it became apparent that the percentages representing the Lance, Medicine Bow, and Laramie leaf characters fall rather precisely into a steady progression. In terms of climatic conditions this is interpreted to mean that the Lance conditions were somewhat more temperate than those of the Medicine Bow, which in turn were somewhat more temperate (or less subtropical) than those of the Laramie. Since these three floras are essentially contemporaneous and occupy progressively more southerly positions in latitude, such an observation is rather to be expected in view of latitudinal control of vegetational zones. It was consequently a natural step to determine whether or not the contemporaneous Colgate–Hell Creek flora, from a region lying north of the Lance deposits, would fit into this progression. This it does to a large degree, as is shown in table 1. In length, texture, and marginal characters the Colgate–Hell Creek species indicate, as anticipated, a slightly more temperate aspect than the Lance species. A considerable discrepancy is to be noted, however, in venation characters, which are the same in the Colgate–Hell Creek species as in the more subtropical Laramie species. I can offer no suggestion as to the real meaning of this discrepancy. It must be noted, however, that there is another inexplicable anomaly in this column of table 1, namely, the abnormally high percentage of pinnately veined leaves in the temperate Muir Woods and Bridge Creek floras.

The use of modern correlatives in attempting to determine the climatic requirements of the Lance species is indicated in table 2. The modern genera or families which are considered most closely related to the Lance species are listed with their modern distribution, so far as it is determinable. Fossil species whose modern relationships are unknown or in doubt have been omitted; in the case of species which show an equally close relationship to two modern genera, both genera are listed. It

TABLE 2

Fossil species	Modern correlatives	Modern distribution			
		Cool temp.	Warm temp.	Sub-tropical	Tropical
Aralaephyllum artocarpoides	Araliaceæ	x	x	x	x
Araucarites longifolia	Araucaria	x	x		
Aristolochites brittoni	Aristolochaceæ	x	x	x	x
Canna? magnifolia	Canna		x	x	x
	Thalia		x	x	x
Cercidiphyllum arcticum	Cercidiphyllum	x	x	x	
Cercidiphyllum ellipticum	Cercidiphyllum	x	x	x	
Cornophyllum wardii	Cornus	x	x	x	
Dillenites cleburni	Dilleniaceæ		x	x	x
Dombeyopsis colgatensis	Menispermaceæ	x	x	x	x
Dombeyopsis obtusa	Menispermaceæ	x	x	x	x
Dombeyopsis trivialis	Cocculus (Cebatha)			x	x
Dryophyllum subfalcatum	Quercus	x	x	x	
	Castanea	x	x		
Equisetum sp.	Equisetum	x	x	x	x
Ficus planicostata	Ficus		x	x	x
Fraxinus leii	Fraxinus	x	x	x	
Ginkgo adiantoides?	Ginkgo	x	x		
Grewiopsis saportana	Grewiopsis			x	x
	Callichlamys			x	x
Laurophyllum coloradensis	Lauraceæ		x	x	x
Laurophyllum meeki	Lauraceæ		x	x	x
Laurophyllum salicifolium	Lauraceæ		x	x	x
Laurophyllum wardiana	Lauraceæ		x	x	x
Magnoliophyllum cordatum	Magnoliaceæ	x	x	x	x
Menispermites belli	Menispermaceæ	x	x	x	x
Menispermites cockerelli	Menispermaceæ	x	x	x	x
Menispermites knightii	Menispermaceæ	x	x	x	x
Myrtophyllum torreyi	Myrtaceæ		x	x	x
Nelumbo tenuifolia	Nelumbo	x	x	x	x
Nymphaeites browni	Nymphaeaceæ	x	x	x	x
Nymphaeites dawsoni	Nymphaeaceæ	x	x	x	x
Pistacia eriensis	Pistacia		x	x	
Pistia corrugata	Pistia		x	x	x
Platanophyllum montanum	Platanaceæ	x	x	x	
Platanophyllum platanoides	Platanaceæ	x	x	x	
Quercophyllum gardneri	Quercus	x	x	x	
Sabalites eocenica	Sabaleæ		x	x	x
Sabalites montana	Sabaleæ		x	x	x
Salix lancensis	Salix	x	x	x	
Sequoia dakotensis	Sequoia	x	x		
Typha sp.	Typha	x	x		
Viburnum marginatum	Viburnum	x	x	x	
Viburnum montanum	Viburnum	x	x	x	
Vitis stantoni	Vitis	x	x	x	x
	Totals	29	42	40	28

may at once be observed from the totals of this table that the floral assemblage is neither strictly cool temperate nor strictly tropical. Without exception, moreover, the cool temperate and tropical distributions belong to genera which are known to thrive—often thrive best—also under warm temperate or subtropical conditions. In contrast, the table shows that 16 of the modern correlatives do not grow under cool temperate conditions and 17 do not grow under tropical conditions, whereas all the species are apparently at home in warm temperate or subtropical regions. The slightly higher number of warm temperate correlatives would imply that the Lance assemblage is more nearly warm temperate than subtropical. This conclusion is precisely the conclusion reached on the basis of the leaf characters of the Lance species. In this connection it should be noted that the dominants of the Lance flora (p. 99) belong to genera which are warm temperate rather than subtropical in modern distribution.

The above inferences regarding climate are supported by the fact that there are a number of genera or families whose presence together in the Lance flora indicates a lowland coastal-plain environment. These include *Canna*?, *Trapa*?, *Sabalites*, and *Pistia*, all of whose modern relatives are typically restricted to or best developed in the humid coastal lowlands of subtropical to warm temperate regions.

In summary it may be stated that the leaf characters and the distribution of modern correlatives of the Lance species, as well as the absence or scarcity of typically cool temperate genera, point to humid lowland conditions of growth under a warm temperate to subtropical climate, more nearly approaching the former.

CORRELATION

General principles and methods—It must, I believe, be admitted that there is no empirical quantitative means of exact correlation between rocks of different regions. Certain fundamentals have, to be sure, gradually developed as guiding principles.[1] But each investigator must carefully weigh, qualify, and modify each principle in the light of his own experience to suit the facts and conditions which he encounters.

In the present analysis, the principles which have been most applicable and useful in the correlation of certain Upper Cretaceous deposits of the Rocky Mountain region are as follows:

1. If two or more fossil assemblages are essentially identical, the rocks from which they were obtained are considered contemporaneous. This principle is not considered infallible. In the first place, it must be remembered that a fossil assemblage is neither more nor less than a recovered sample of the remains of the living organisms which inhabited the region at the time of fossilization. All samples are not necessarily fair samples; for example, some may be too small. A small assemblage of 20 species which are identical with 20 out of 30 species of a second assemblage is not necessarily contemporaneous with the second assemblage, if the 20 species happen to be long-ranging types. In the second place, in view of the element of chance involved both in the preservation of organisms and in the re-

[1] Berry, E. W., Maryland Geol. Surv., Lower Cretaceous, 153, 1911. Clark, W. B., U. S. Geol. Surv. Bull. 141, 47–53, 1896. Neaverson, E., *Stratigraphical Palæontology*, 1–14, 1928.

covery of a fair sample, it would indeed be rare to find absolute 100 per cent identity between two or more sets of fossil assemblages. Moreover, slight differences in environmental conditions, which may follow each other in short spaces of time or in short distances, may be expected to have produced slight or even marked differences in various assemblages of organisms. Finally, it must be recognized that similar assemblages may be homotaxial rather than synchronous. For most problems of correlation, however, this qualification is not necessary, since the span of time needed for the migration of newly evolved organisms from one region to another is negligible as compared with the time required for the deposition of the average geological formation. If barriers to migration are known to have existed, however, homotaxis must be considered.

2. The most useful index fossils are those which are abundant, easily identified, and of wide geographic range and short stratigraphic range. Although generally understood and usually reliable in application, this principle needs some qualification. Each investigator, for example, is entitled to an opinion as to the exact meaning of such terms as "abundant," "easily," "wide," and "short." Moreover, fossils that seem reliable today may become unreliable tomorrow as a result of new discoveries extending their stratigraphic range. Furthermore, a short stratigraphic range of a species or genus cannot be established unless its position in time can be determined at several stations by clear stratigraphic relations and by associations with other organisms. It is also considered more satisfactory for correlation to use index associations of as many species as possible, rather than merely a single or a few index species. Finally, in cases where index fossils present conflicting evidence, careful consideration must be given to such possibilities as mixed collections, incorrect identifications, and inadequate delimitation of zones.

3. The earliest appearance of new forms in abundance is a valuable criterion for correlation.

4. The latest appearance of old forms is sometimes an important guide, particularly when they are accompanied by other organisms of restricted range. The earliest appearance of new forms is, I believe, a safer criterion than the latest appearance of old forms, since the latter may be surviving relicts of long-ranging organisms, whereas the incoming of abundant new forms to a region is generally a result of invasion or major environmental change, either of which would result in widespread biotic changes which would be useful in exact correlation within that region.

5. The dominance of certain genera or species is a reliable adjunct to other palæontological methods of correlation. Dominance is here meant to include both abundance of individuals and widespread occurrence at many localities. It is often found that dominance of a form or group of forms may be of time significance even though the form or forms occur in more limited numbers in both older and younger rocks. In cases where a single form or several forms are dominant, a "zone" may be defined and named for the dominant form or forms.

6. Similarities of stratigraphic succession, though often unreliable criteria, may contribute materially to conclusions reached by palæontological methods of correla-

tion. This principle is best applied to unfossiliferous rocks occurring above, below, or between rocks containing datable fossil assemblages. It does not imply that dissimilarities of stratigraphic succession preclude the possibility of correlation.

7. Exact correlation of fossil assemblages does not necessarily include exact age determination unless one or another of the assemblages has been properly placed in the geologic time scale. Although sometimes forgotten, this principle is obviously fundamental in all problems of correlation, since the geologic time scale is an arbitrary and empirical classification based in the first instance on superposition rather than on fossil content. There are known instances in which diverse fossil assemblages have been proved synchronous yet cannot be accurately assigned to a definite position in the time scale because of their isolation from rocks of known age.

8. Accuracy in palæontological correlation depends largely on the validity of the identifications of the fossils used.

Lance flora as a standard—The Lance flora, herein described, is an excellent standard flora with which to compare and contrast other late Cretaceous and early Tertiary floras of the Rocky Mountain region. It is composed of specimens which were all collected from the type locality of the Lance formation. It is a comparatively large flora, comprising 70 species, of which 57 have an outside distribution. It is accurately dated in terms of the geologic time scale (aside from its own floral testimony), since it occurs in beds which have yielded abundant remains of dinosaurs of the *Triceratops* zone of latest Cretaceous age and which are conformably above the *Sphenodiscus* zone of true Fox Hills (latest Montanan) age. It also contains a sufficient number of index species of short stratigraphic range elsewhere to be reliable for correlation. Finally, the stratigraphic succession and the relation of the floral assemblage to the *Triceratops* zone and to the *Sphenodiscus* zone in this region are strictly comparable with the conditions observed in several other regions.

Definition of Lancian age—There does not exist at present a clearly defined temporal term for the latest Cretaceous of the Rocky Mountain region. For the practical purposes of clarity and precision it is here proposed to use Lancian age as a convenient provincial time term, based on the Lance formation at its type locality near Lance Creek, Niobrara County, Wyoming. This time unit is delimited below by true Fox Hills time (i.e., latest Montanan age, characterized by marine sandstones comprising the well-defined *Sphenodiscus* zone), and delimited above by the beginning of Paleocene time. The terrestrial sediments of Lancian age carry the characteristic mammals[1] and dinosaurs[2] of the *Triceratops* zone, as well as the plants here described.

Lance flora—As is shown in table 3, there are 57 species of the Lance flora which are known elsewhere in the late Cretaceous and to some extent the early Tertiary deposits of North America, chiefly the Rocky Mountain region. In the analysis of the relation of this assemblage to other assemblages, the stratigraphic range of species elsewhere is determined on the following basis: species restricted to Montanan age are those whose occurrences, where stratigraphic and palæontologic relations are

[1] Wood, H. E., et al., Bull. Geol. Soc. Amer., vol. 52, 8, 1941.
[2] Russell, L. S., Proc. Amer. Philos. Soc., vol. 69, 139–141, 1930.

TABLE 3—*Outside distribution of the type Lance species*

Type Lance species / Formations	Judith River, Mont.	Belly River, Can.	Mesaverde, SE. Wyo.	Ericson-Almond, SW. Wyo.	Fruitland-Kirtland, New Mex. & Colo.	Trinidad-Vermejo, Colo.	Adaville, W. Wyo.	Fox Hills, Mont. & Colo.	Colgate, Mont.	"Laramie," Black Buttes, Wyo.	Laramie, Colo.	Medicine Bow, Wyo.	Hell Creek, Mont. & Daks.	Whitemud-l. Ravenscrag, Can.	Denver-Dawson, Colo.	Animas, New Mex. & Colo.	Raton, Colo.	Tullock-Ludlow, Mont. & Daks.	Fort Union, Mont. & Daks.	M. & u. Ravenscrag-Paskapoo, Can.	Wilcox, Gulf coast
Anona? robusta											x		x				x				
Apeibopsis? discolor									x	x		?									
Araliaephyllum artocarpoides													x					?	x	?	
Araucarites longifolia	x		?	x		x				x	x	x	x					?			
Aristolochites brittoni											x										
Asplenites tenellum			x						x												
Canna? magnifolia						x						x	x								
Carpites lancensis													x								
Carpites verrucosus										x											
Carpites walcotti												x									
Celastrus? taurinensis									x	x		x	x					x	x	x	x
Cercidiphyllum arcticum																		?	x	x	
Cercidiphyllum ellipticum	x								x	x	x	x	x		x			x	?		
Cinnamomum? affine			?						x		x	x									
Cissus? lobato-crenata										x	x				x						
Cornophyllum wardii				x								x			x		x				
Dillenites cleburni						x				x	x	x		x	x	x	x				?
Dombeyopsis colgatensis									x												
Dombeyopsis obtusa						x					x	x			x						
Dombeyopsis trivialis											x	x									
Dryophyllum subfalcatum				x		x	x	?	x	x	x	x	x				x				
Ficus? ceratops													x	x							
Ficus planicostata				?	x	x				x	x	x			x	x	x				
Ficus? trinervis				x	x	x				x	x	x	x		x		x				
Fraxinus leii													x	x						?	
Ginkgo adiantoides?				x					x				x	x				x	x	x	
Grewiopsis saportana										x		x	x								
Laurophyllum coloradensis											x	x			x						
Laurophyllum meeki					?					x	x	x									
Laurophyllum salicifolium			x			x			x	x	x	x									
Laurophyllum wardiana											x	?	x		?						
Magnoliophyllum cordatum												x									
Menispermites belli				x						x				x	?						
Menispermites cockerelli										x	x	x					?				
Menispermites knightii			x																		
Myrtophyllum torreyi			x	x	x	x		x		x	x	x			x						
Nelumbo tenuifolia											x			x	x		x			?	
Nymphaeites dawsoni		x		x		x			x					x							
Palaeoaster inquirenda						x					x	x	x				x				
Pistacia eriensis											x	x									
Pistia corrugata	x	x	x	x	x			?	x	x		?		x							
Platanophyllum montanum													x								
Platanophyllum platanoides								?		x											
Quercophyllum gardneri						x															
Quercus? viburnifolia										x	x	x	x		x			x			
Rhamnus? minutus									x		x										
Sabalites eocenica										x	x	x					x				
Sabalites montana				x		x					x	x	?		x			?			
Saliciphyllum wyomingensis										x	x										
Salix lancensis													x								
Selaginella? falcata				x																	
Sequoia dakotensis													x					?			
Trapa? microphylla	x	x		x										x				x	x	x	
Viburnum marginatum						x				x	x	x	x	x	x		x				
Viburnum montanum				x		x						x									
Vitis stantoni	x		?			x		x	x			x	x	x	x						
Woodwardia? crenata				x		x						?									
Totals	5	3	5	14	4	17	1	2	13	22	27	28	21	11	14	2	10	5	5	4	1

clear, are known only from deposits ranging from the top of the Colorado group below to the top of the true *Sphenodiscus*-bearing Fox Hills above—i.e., Judith River, Belly River, Ericson-Almond (Mesaverde), and Fox Hills; species restricted to Lancian age are those known only from beds lying between the top of the true *Sphenodiscus*-bearing Fox Hills and the top of the *Triceratops*-bearing beds—i.e., Colgate, Hell Creek, Medicine Bow, Laramie, Whitemud–lower Ravenscrag, Arapahoe–lower Denver, and lower Dawson; those restricted to Paleocene age are those known only from beds lying between the *Triceratops*-bearing beds below and the true Lower Eocene Wasatchian above—i.e., Tullock, Ludlow, Fort Union and equivalents, middle and upper Ravenscrag, and Paskapoo.

Formations whose position in Montanan, Lancian, or Paleocene time is uncertain because of lack of convincing stratigraphic or palæontologic data are disregarded for the present. The correlation of most of these formations, including the Fruitland, Kirtland, Vermejo, Whitemud, and "Laramie" (Black Buttes) of southwestern Wyoming, is made below on the basis of their floral assemblages.

An analysis of table 3 gives the following summary of data regarding the outside distribution of the type Lance species of plants:

No outside distribution	13
Outside distribution	57
Total number of species	70

Short-ranging species:		Long-ranging species:		Species of uncertain range	2
Montanan	3	Montanan-Lancian-Paleocene	3		
Lancian	28	Montanan-Lancian	17		
Paleocene	1	Lancian-Paleocene	3		
	32		23		

The short-ranging species, which are considered most reliable for correlation purposes, are as follows:

Short-ranging species restricted elsewhere to Paleocene age:

Cercidiphyllum arcticum

Short-ranging species restricted elsewhere to Lancian age:

Anona? robusta
Apeibopsis? discolor
Aristolochites brittoni
Carpites lancensis
Carpites verrucosus
Carpites walcotti
Cinnamomum? affine
Cissus? lobato-crenata
Dombeyopsis colgatensis
Dombeyopsis trivialis
Ficus? ceratops
Fraxinus leii
Grewiopsis saportana
Laurophyllum coloradensis
Laurophyllum meeki
Laurophyllum wardiana
Magnoliophyllum cordatum
Menispermites cockerelli
Nelumbo tenuifolia
Palæoaster inquirenda
Pistacia eriensis
Platanophyllum montanum
Rhamnus? minutus
Sabalites eocenica
Saliciphyllum wyomingensis
Salix lancensis
Sequoia dakotensis
Viburnum marginatum

Short-ranging species restricted elsewhere to Montanan age:

Menispermites knightii
Selaginella? falcata
Woodwardia? crenata

This analysis of the Lance flora is not introduced in order to ascertain its age, since it is obviously of Lancian age as defined. The data will be useful, however, in comparing the analyses of other floras with that of the Lance.

The question may be raised as to the significance of the small Paleocene and Montanan elements in the Lance flora. In view of the overwhelming majority of species restricted elsewhere to floras of known Lancian age, it is evident that the 4 species previously thought to be restricted in stratigraphic range can no longer be so considered, unless, of course, other investigators should disagree with my identifications of these species. Moreover, it is to be expected that future work with floras of Paleocene and Montanan age will extend the stratigraphic range of species now known only in floras of Lancian age.

As will be amplified below in the discussion of the Paleocene "Fort Union" flora, the analysis above shows that the flora of the type Lance formation is distinctly not a "Fort Union" assemblage, but is closely related to floras obtained from beds lying between the true Fox Hills formation and the top of the *Triceratops* zone. These comprise the Colgate–Hell Creek, Laramie, and Medicine Bow floras, whose analyses follow. These are presented in order to determine the reliability of floral assemblages in the correlation of deposits whose contemporaneity is already rather definitely established on the basis of similar stratigraphic position, similar relations to underlying marine invertebrates, and similar associations with dinosaur remains.

Colgate–Hell Creek floras—The Colgate flora of eastern Montana and western South Dakota [1] is here combined with the Hell Creek flora of the same region for three reasons: (1) Since the Colgate beds lie above the *Sphenodiscus*-bearing Fox Hills marine sandstone, they obviously are of Lancian age as defined. (2) The Colgate beds are laterally discontinuous and are seen to interfinger along the strike with the lower beds of the Lance formation as originally defined at its type locality. (3) The flora of the Colgate beds is distinctly a Lancian flora, containing 13 species, out of 17 species with outside distribution, in common with the type Lance flora; of these 17, 8 are long-ranging species, 6 are restricted elsewhere to Lancian age, and 3 are at present of uncertain range but probably Lancian. In this connection it seems significant to mention that the Colgate beds were originally defined as the lower member of the Lance formation.[2] Their redefinition as a member of the Fox Hills sandstone [3] does not seem supported by conclusive facts, particularly in view of the criteria now used elsewhere for the recognition of the upper limit of the Fox Hills sandstone.[4] It is felt, however, that whatever the allocation of the Colgate beds as a lithologic unit, there should be no confusion as to their temporal position.

The Colgate and Hell Creek floras have been described by Brown,[5] and a small Hell Creek flora from South Dakota has been described by Berry.[6] In the Sayen collection of Colgate plants at Princeton University there are, besides most of Brown's recorded species, also specimens of *Celastrus? taurinensis* Ward and

[1] Brown, R. W., U. S. Geol. Surv. Prof. Paper 189-I, 242, 1939.
[2] Calvert, W. R., U. S. Geol. Surv. Bull. 471, 194–195, 1910.
[3] Thom, W. T., Jr., and Dobbin, C. E., Bull. Geol. Soc. Amer., vol. 35, 490, 1924.
[4] Lovering, T. S., et al., Bull. Amer. Assoc. Petroleum Geologists, vol. 16, 702, 1932.
[5] Brown, R. W., op. cit., 244, 1939.
[6] Berry, E. W., U. S. Geol. Surv. Prof. Paper 185-F, 127–132, 1934.

Rhamnus? minutus Knowlton.[1] The Corbin collection of Hell Creek plants at Princeton University contains excellent specimens of *Quercus? viburnifolia* Lesquereux and *Ficus? trinervis* Knowlton, which have not been previously recorded.[2]

An analysis of the Colgate–Hell Creek flora gives the following summary:

No outside distribution	3
Outside distribution	38 (29 in common with type Lance)
Total number of species	41

Short-ranging species:		Long-ranging species:		Species of uncertain range	4
Montanan	0	Montanan-Lancian-Paleocene	2		
Lancian	18	Montanan-Lancian	10		
Paleocene	0	Lancian-Paleocene	4		
	18		16		

The short-ranging Lancian species, restricted elsewhere to deposits lying between the *Sphenodiscus* zone and the top of the *Triceratops* zone, are as follows:

Anona? robusta	Laurophyllum wardiana
Carpites lakesii	Magnolia dakotana
Carpites lancensis	Magnolia lakesii
Cinnamomum? affine	Palæoaster inquirenda
Diospyros berryana	Platanophyllum montanum
Dombeyopsis colgatensis	Rhamnus? minutus
Ficus? ceratops	Salix lancensis
Fraxinus leii	Sequoia dakotensis
Grewiopsis saportana	Viburnum marginatum

This analysis shows that the Colgate–Hell Creek flora is closely comparable with the flora of the type Lance and has a majority of species restricted elsewhere exclusively to beds of Lancian age. As a test case the analysis indicates perfect agreement between plants, vertebrates, marine invertebrates, and stratigraphy in the correlation of the Colgate–Hell Creek beds with those of the Lance formation at its type locality.

The close relationship of the Colgate–Hell Creek flora to that of the type Lance is seen in the fact that of 38 species with outside distribution, 29 (76 per cent) are known in the type Lance flora. This is a high degree of resemblance and is perhaps somewhat higher than could normally be expected in view of the factors, mentioned above, which contribute toward preventing absolute identity of contemporaneous fossil assemblages.

The time relations here believed to exist between the Colgate–Hell Creek deposits and those of the Lance formation at its type locality are shown in figure 3.

Medicine Bow flora—In southern Wyoming and adjacent Colorado the Medicine Bow formation has yielded a flora of 64 species.[3] The plant horizons lie in the lower third of the formation, above *Sphenodiscus*-bearing Fox Hills sandstone and

[1] Sayen, W. H., III, *The Pierre–Fort Union Succession near Glendive, Montana*, senior thesis, Princeton University, 14, 32, 41, 59, 1938.

[2] Corbin, R. S., *Stratigraphy and Paleontology of the Pierre, Fox Hills, and Lance Formations in Southwestern North Dakota*, senior thesis, Princeton University, 19, 20, 97, 115, 1938.

[3] Dorf, E., Carnegie Inst. Wash. Pub. No. 508, pt. 1, 22–38, 1938.

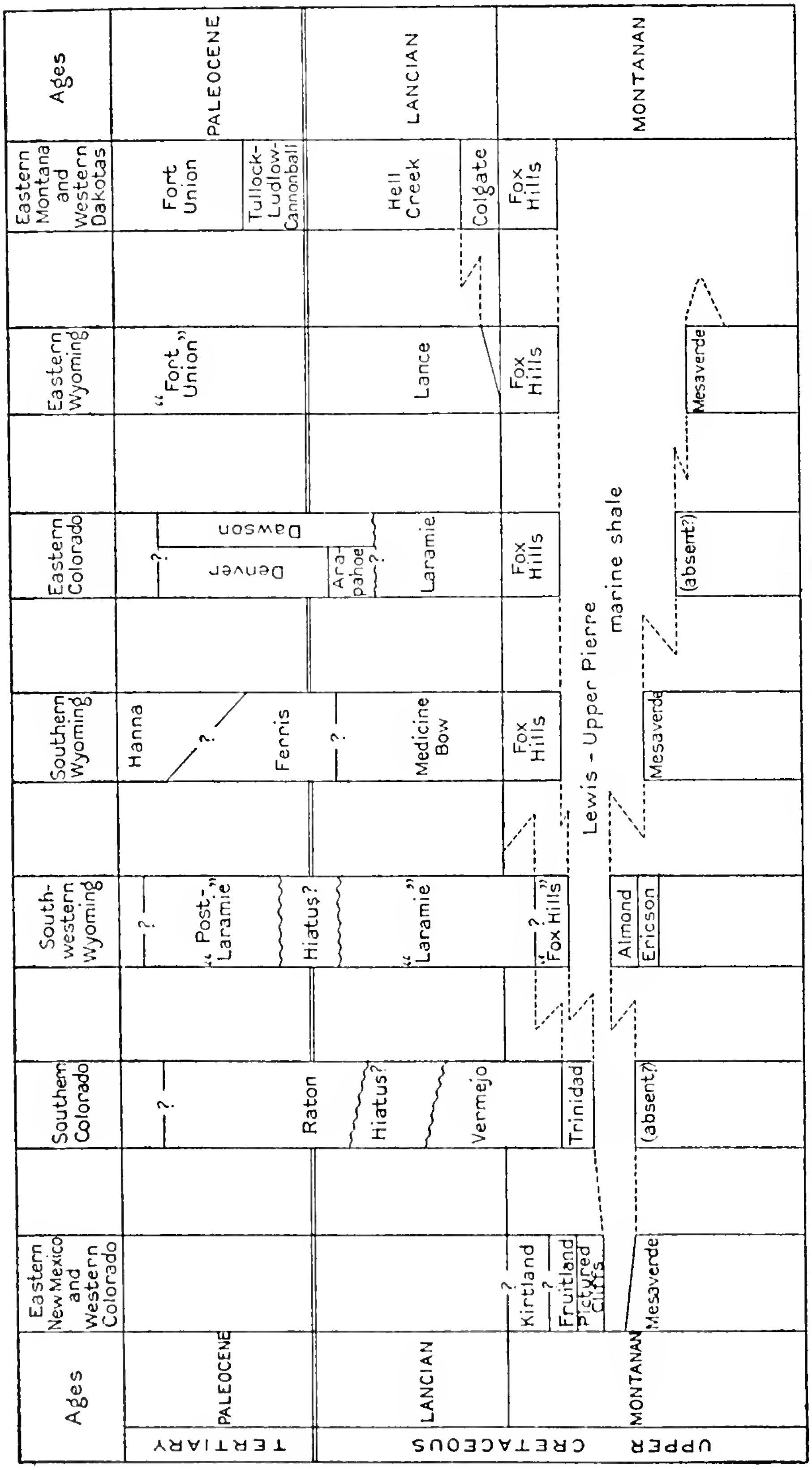


FIG. 3—Correlation chart showing relations of plant-bearing formations to Montanan, Lancian, and Paleocene ages

below the top of the *Triceratops* zone. The analysis of the floral assemblage is as follows:

No outside distribution	13	
Outside distribution	51	(28 in common with type Lance)
Total number of species	64	

Short-ranging species:		Long-ranging species:		Species of uncertain range	4
Montanan	0	Montanan-Lancian-Paleocene	1		
Lancian	26	Montanan-Lancian	17		
Paleocene	0	Lancian-Paleocene	3		
	26		21		

As has already been pointed out in my report on the Medicine Bow flora, its resemblance to the Lance flora is striking. Out of a total of 51 species with outside distribution, it has 28 species (55 per cent) in common with the type Lance flora. Its reference to Lancian age is amply corroborated by a study of its component short-range species. Not a single species has previously been known only from deposits of Montanan or Paleocene age. In contrast, there are 26 (51 per cent) which have been found previously only in deposits of Lancian age, as follows:

Apeibopsis? laramiensis
Carpites walcotti
Cinnamomum? affine
Cinnamomum linifolium
Cissites lobatus
Dombeyopsis trivialis
Dryopteris? carbonensis
Ficus coloradensis
Ficus cowanensis
Grewiopsis saportana
Juglans leconteana
Juglans newberryi
Juglans prærugosa
Laurophyllum coloradensis
Laurophyllum meeki
Magnolia dakotana
Magnolia lakesii
Magnoliophyllum cordatum
Menispermites cockerelli
Palæoaster inquirenda
Pisonia? racemosa
Pistacia eriensis
Sabalites eocenica
Viburnum marginatum
Zingiberites dubius
Zizyphus hendersoni

The temporal relations of the Medicine Bow formation, as here interpreted, are shown in figure 3. The inclusion of the upper Medicine Bow and overlying lower Ferris in the Lancian age is based entirely on the reported presence of *Triceratops* remains in these beds. No plants are now known from this part of the sequence.

Laramie-Denver-Dawson floras—The flora of the Laramie formation of the Denver basin of Colorado has been described by Knowlton.[1] Although I believe it is somewhat overspeciated, there are apparently about 100 recognizable species. The plant-bearing beds lie between the *Sphenodiscus*-bearing Fox Hills sandstone below and the top of the *Triceratops* zone of the overlying Arapahoe and lower Dawson formations,[2] and are thus clearly of Lancian age. The testimony of the floral assemblage, even without other evidence, supports the same conclusion on

[1] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 130, 1–168, 1922.
[2] Lull, R. S., Mem. Peabody Mus. Nat. Hist., vol. 3, pt. 3, 3, 7, 1933. Hatcher, J. B., and Lull, R. S., U. S. Geol. Surv. Mon. 49, 182–184, 1907.

the basis of its correlation with the Lance, Colgate–Hell Creek, and Medicine Bow floras, as is shown in the following analysis:

No outside distribution	57	
Outside distribution	43	(27 in common with type Lance)
Total number of species	100	

Short-ranging species:		Long-ranging species:		Species of uncertain range	4
Montanan	1	Montanan-Lancian-Paleocene	0		
Lancian	22	Montanan-Lancian	13		
Paleocene	0	Lancian-Paleocene	3		
	23		16		

Of the 23 short-ranging species, only 1, *Ancimia elongata* (Newberry) Knowlton, has elsewhere been known only from deposits of Montanan age. This single discordance is minimized by the serious doubt which Knowlton cast on the identification of the specimen from the Laramie formation.[1] The remaining restricted species, all of which are known elsewhere only from rocks of true Lancian age, are as follows:

Anona? robusta
Apeibopsis? laramiensis
Aristolochites brittoni
Asplenium? coloradensis
Carpites lakesii
Cinnamomum? affine
Diospyros berryana
Dombeyopsis trivialis
Dryopteris? carbonensis
Ficus cowanensis
Juglans leconteana
Juglans newberryi
Juglans prærugosa
Laurophyllum coloradensis
Laurophyllum wardiana
Magnolia lakesii
Menispermites cockerelli
Palæoaster inquirenda
Pistacia eriensis
Rhamnus? minutus
Salicíphyllum wyomingensis
Zizyphus hendersoni

In regard to the Arapahoe-Denver and Dawson formations, which overlie the Laramie formation, the Lancian age of at least their lowest part has already been established, on the basis of both *Triceratops* dinosaurs[2] and Lancian species of plants.[3] Many of the older plant collections of the Denver region were obtained without due regard to their exact stratigraphic position. As a consequence it is often difficult to determine whether or not a species is restricted to the lower beds of the Arapahoe-Denver or Dawson. Pending further work in the region, it can be said at present that at least the following dominant or typical Montanan and Lancian species are known from the lower part of the Denver-Dawson, and not from the upper part, which is believed to be of Paleocene age:

Cercidiphyllum ellipticum
Cinnamomum linifolium
Cissus? lobato-crenata
Cornophyllum wardii
Dillenites cleburni
Dombeyopsis obtusa
Ficus coloradensis
Ficus planicostata
Ficus? trinervis
Laurophyllum coloradensis
Myrtophyllum torreyi
Nelumbo tenuifolia
Quercus? viburnifolia
Sabalites montana
Viburnum marginatum
Vitis stantoni

[1] Knowlton, F. H., op. cit., 112, 1922.
[2] Lull, R. S., op. cit., 3, 7, 1933.
[3] Dorf, E., op. cit., 34, 1938.

The representation in figure 3 of the age relations of the Laramie and the overlying Arapahoe-Denver and Dawson formations is based on an opinion derived from combination of the evidence of the vertebrates, the plants, and the stratigraphic succession. The placing of the exact horizon marking the Upper Cretaceous–Paleocene boundary in the Denver and Dawson beds, if it is determinable at all, must await further work in the region.

Black Buttes "Laramie" flora—The flora from near Black Buttes in southwestern Wyoming has been discussed [1] in my report on the Medicine Bow flora, to which it is closely related. The plant-bearing beds near Black Buttes overlie a massive coarse sandstone tentatively called "Fox Hills." Diagnostic invertebrates of true Fox Hills age are lacking, however, although the fauna of the underlying Lewis shale is clearly of late Montanan age.[2] Remains of a single species of dinosaur, *Agathaumas sylvestris* Cope, were collected from the same beds that contain the plant horizons.[3] The unique characters of this ceratopsian dinosaur make it rather unreliable for exact age determination, except, of course, as it places the beds in the Upper Cretaceous and not the Paleocene. The floral assemblage must therefore be the chief basis for correlation at the present time.

The latest complete floral list of plant species from the Black Buttes "Laramie" was given by Knowlton in 1919.[4] Allowing for subsequent synonymies, this assemblage may be analyzed as follows:

No outside distribution	19	
Outside distribution	31	(22 in common with type Lance)
Total number of species	50	

Short-ranging species:		Long-ranging species:		Species of uncertain range	7
Montanan	0	Montanan-Lancian-Paleocene	1		
Lancian	13	Montanan-Lancian	6		
Paleocene	0	Lancian-Paleocene	4		
	13		11		

With a total of 22 species (71 per cent), out of 31 species with outside distribution, in common with the type Lance flora, the Black Buttes "Laramie" is clearly of true Lancian age. This is further corroborated by the 13 short-ranging species, all of which are elsewhere restricted to deposits of known Lancian age. These species are as follows:

Apeibopsis? discolor
Carpites glumæformis
Carpites verrucosus
Cissus? lobato-crenata
Grewiopsis saportana
Laurophyllum coloradensis
Laurophyllum meeki
Menispermites cockerelli
Pisonia? racemosa
Platanophyllum platanoides
Sabalites eocenica
Saliciphyllum wyomingensis
Viburnum marginatum

[1] Ibid.
[2] Stanton, T. W., and Knowlton, F. H., Bull. Geol. Soc. Amer., vol. 8, 146, 147, 1897.
[3] Hatcher, J. B., and Lull, R. S., op. cit., 104, 1907. Lull, R. S., op. cit., 15, 1933. Stanton, T. W., Proc. Washington Acad. Sci., vol. 11, 270, 1909.
[4] Knowlton, F. H., U. S. Geol. Surv. Bull. 696, 767, 1919.

The time relations between the Black Buttes "Laramie" and other deposits of Lancian age are shown in figure 3. The transition between the so-called "Fox Hills" and the overlying "Laramie" is tentatively placed somewhat earlier than in eastern Colorado because of the absence of diagnostic invertebrates of the *Sphenodiscus* zone in the "Fox Hills" of this region. It is suggested that in the future the Black Buttes "Laramie" be referred either to the Lance formation or to the Medicine Bow formation, to either of which it is both nearer geographically and more nearly synchronous in its entirety than it is to the true Laramie of the Denver basin.

Vermejo-Raton floras—In south-central Colorado the terrestrial beds overlying the late Montanan marine deposits have been separated rather arbitrarily into two formations, the Vermejo and the overlying Raton. No vertebrates are known from either of these formations, so their age determinations must be based primarily on the fossil plants and on the evidence from the underlying marine rocks. The latter are the Trinidad sandstone, whose fauna appears to be late Montanan, probably somewhat older than true Fox Hills.[1] The Vermejo flora, adequately described by Knowlton, was referred by him to Montanan age.[2] The present study agrees in part with such an age assignment, as is shown in the following analysis of the Vermejo species:

No outside distribution	45
Outside distribution	43 (17 in common with type Lance)
Total number of species	88

Short-ranging species:		Long-ranging species:		Species of uncertain range	2
Montanan	8	Pre-Montanan-Montanan	1		
Lancian	11	Montanan-Lancian	18		
Paleocene	0	Lancian-Paleocene	3		
	19		22		

This is a more difficult analysis to evaluate than any of the others presented. In the first place there are, out of 43 species with outside distribution, 17 species (40 per cent) in common with the flora of the type Lance formation. This is 15 to 36 per cent less than in any of the floras known to be of true Lancian age. Yet there are 11 out of 19 short-ranging species which are restricted elsewhere to Lancian age, and 3 long-ranging species which are not known earlier than Lancian time. These are as follows:

Lancian age only:

Aneimia supercretacea
Artocarpus dissecta
Asplenium? coloradensis
Canna? magnifolia
Cissites panduratus
Credneria protophylloides
Ficus tessellata
Magnolia nervosa
Palæoaster inquirenda
Quercophyllum gardneri
Viburnum marginatum

Not known previous to Lancian age:

Dillenites cleburni
Quercus? viburnifolia
Sabal? ungeri

[1] Lee, W. T., and Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 101, 50, 1917.
[2] Ibid., 230, 231.

There is no alternative but to conclude that at least a part of the Vermejo deposits are of Lancian age. This at once suggests that it may be possible to show that the typical Lancian species occur only in the upper part of the Vermejo formation. The stratigraphic position of some of the plant horizons in the Vermejo formation has not been recorded. It is clear, however, that of the 14 species listed above, the stratigraphic positions of 11 are known: all the 11 are in the upper Vermejo and only 3 (*Artocarpus dissecta, Cissites panduratus*, and *Palæoaster inquirenda*) are reported also in beds which are questionably in the lower Vermejo. I believe it just as significant to point out that the majority of the restricted Lancian species listed above as occurring in the Vermejo are known elsewhere only in beds of lower rather than upper Lancian age.

With respect to the restricted Montanan and pre-Montanan species present in the Vermejo flora, it is difficult to determine whether these are relicts in a flora of early Lancian age or are actually indicative of Montanan age for the lower part of the formation. These species are as follows:

Brachyphyllum cf. B. macrocarpum
Ficus regularis
Ficus rhamnoides
Ficus? starkvillensis
Ficus wardii
Liriodendron alatum
Pterospermites undulatus
Pterospermites wardii
Widdringtonia? complanata

Disregarding *Liriodendron alatum*, whose stratigraphic position in the Vermejo formation is very much in doubt, 3 species (*Ficus regularis, Ficus rhamnoides*, and *Brachyphyllum* cf. *B. macrocarpum*) are confined to the lower Vermejo, 2 species (*Pterospermites wardii* and *Widdringtonia? complanata*) are confined to the upper Vermejo, and the remaining 3 are known in both the lower and the upper Vermejo. This leads me to the conclusion that the lower Vermejo is of latest Montanan age, as shown in figure 3, and that the upper Vermejo is of early Lancian age, during which time a few Montanan species survived as relicts.

The Raton flora is a large flora of about 135 species which is Paleocene in general aspect. It contains, however, an element (20 out of a total of about 70 species with outside distribution) which is elsewhere restricted to Lancian age or older. This element includes the following species, of which those marked by an asterisk are definitely known only from the Raton and the *Triceratops*-bearing Arapahoe-Denver or lower Dawson:

Allantodiopsis erosa
Anona? robusta
*Artocarpus similis
*Castanea intermedia?
Cinnamomum linifolium
*Cissus coloradensis
*Cissus grosse-dentata
Cornophyllum wardii
Dryophyllum subfalcatum
*Ficus aquilar
Ficus planicostata
Ficus? trinervis
*Geonomites tenuirachis
Nelumbo tenuifolia
Palæoaster inquirenda
*Paloreodoxites plicatus
*Platanus rhomboidea
Pteris russelli
Sabalites eocenica
Viburnum marginatum

It has been possible to determine, from the report of Lee and Knowlton,[1] the approximate position in the Raton formation of all but 4 of the species listed. Of

[1] Lee, W. T., and Knowlton, F. H., op. cit., 66–161, 1917.

the total of 18 species, 13 are known only from the lower 500 feet of the Raton, 2 (*Artocarpus similis* and *Ficus planicostata*) are known from both the lower and the upper Raton, and only 2 (*Cornophyllum wardii* and *Platanus rhomboidea*) are known only from the middle or upper Raton. These facts seem to me to indicate that a part of the lower Raton formation is of Lancian age, specifically upper Lancian age, corresponding to the *Triceratops*-bearing beds of the Arapahoe–lower Denver and the lower Dawson.

Whitemud-lower Ravenscrag floras—The Whitemud formation of southern Saskatchewan has yielded a flora of 26 species, described by Berry.[1] Omitting 4 species which Berry says are only questionably determined, the analysis of this flora is as follows:

No outside distribution	4	
Outside distribution	18	(8 in common with type Lance)
Total number of species	22	

Short-ranging species:		Long-ranging species:		Species of uncertain range	4
Montanan	0	Montanan-Lancian-Paleocene	3		
Lancian	5	Montanan-Lancian	4		
Paleocene	1	Lancian-Paleocene	1		
	6		8		

Out of a total of 18 species with outside distribution, 8 (44 per cent) are also found in the type Lance flora. This percentage is somewhat lower than that seen in typical Lancian floras, and is of the same order as in the Vermejo flora, of late Montanan and early Lancian age. Yet in the appraisal of the short-ranging species it is noted that no Whitemud species are restricted elsewhere to Montanan age, 6 are restricted to Lancian age, and 1 is restricted to the Paleocene. These are as follows:

Restricted elsewhere to Lancian age:

- Leguminosites arachioides minor
- Nelumbo tenuifolia
- Smilax? inquirenda
- Viburnum marginatum
- Zizyphus coloradensis

Restricted elsewhere to Paleocene age:

- Viburnum antiquum

The overwhelming preponderance of restricted Lancian species in the Whitemud should cast suspicion on the identification of the single restricted Paleocene species, which is not figured in Berry's report. The conclusion from the analysis is definitely that the Whitemud flora is of Lancian age. From occurrences of its species elsewhere its assemblage seems also to be early rather than late Lancian.

The flora of the lower Ravenscrag formation of southern Saskatchewan comprises only 9 species, of which 2 are of doubtful validity.[2] Of 6 species with outside distribution, 2 (*Ficus? ceratops* and *Fraxinus leii*) are restricted to Lancian age, 2 (*Ginkgo adiantoides* and *Dillenites cleburni*) are more abundant in Lancian floras than in the Paleocene, and 1 (*Aralia notata*) is known elsewhere only in the Paleo-

[1] Berry, E. W., Canada Geol. Surv. Mem. 182, 3–4, 1935.
[2] Ibid., 4.

cene. This analysis is, of course, very suggestive of Lancian age, but cannot be considered conclusive because of the small number of species in the assemblage. Fortunately, the suggestive floral testimony is made rather conclusive by the occurrence of the typical Lancian dinosaur *Triceratops* in the lower Ravenscrag deposits.

The floras of the middle and upper Ravenscrag beds, also described by Berry, are so clearly Paleocene that they do not need further analysis here.

Fruitland-Kirtland floras—The flora of the Fruitland formation of northwestern New Mexico has been described by Knowlton.[1] From his analysis of the floral assemblage he concluded that the beds were of Montanan age. This conclusion is supported by the following analysis:

No outside distribution	17
Outside distribution	14 (3 in common with type Lance)
Total number of species	31

Short-ranging species:		Long-ranging species:		Species of uncertain range	0
Montanan	4 (+2?)	Pre-Montanan-Montanan	1		
Lancian	0	Montanan-Lancian	6		
Paleocene	0	Pre-Montanan-Montanan-Lancian	1		
	6 (?)		8		

From the fact that 3 of the short-ranging species are known elsewhere only in the lower Vermejo and that the 2 species questioned in the list are also restricted to the Vermejo, but of unknown stratigraphic position, it can be concluded that the Fruitland is not younger than Vermejo, and most likely synchronous with the lower Vermejo.

The Kirtland flora, described by Knowlton as an integral unit of the Fruitland flora, comprises at present only 7 species. Such a small assemblage is, in my opinion, not a fair sample for reliable correlation, particularly in view of the fact that only 3 of the species have an outside distribution. Until a larger floral assemblage is known, it can only be said that from its relation to overlying and underlying beds the Kirtland shale is either late Montanan or early Lancian in age.

Ericson-Almond flora—Fossil plants collected near Point of Rocks in southwestern Wyoming have been described by Ward,[2] Lesquereux,[3] and Knowlton.[4] These specimens were collected at a time when neither stratigraphic nor geographic position could be easily determined. From the published reports and my visit to the area, however, it seems reasonably certain that most of the plants were obtained from the massive sandstone and overlying shale exposed $\frac{1}{4}$ to $\frac{1}{2}$ mile north and east of the Point of Rocks station on the Union Pacific railroad. The massive sandstone has since been called the Ericson sandstone and the overlying shales the Almond formation.[5] These were included in the Mesaverde group on the basis of their stratigraphic position below the Lewis shale, whose marine fauna is of late Montanan

[1] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 98-S, 327–344, 1916.
[2] Ward, L. F., U. S. Geol. Surv. 6th Ann. Rept., 549–557, 1885; U. S. Geol. Surv. Bull. 37, 13–115, 1887.
[3] Lesquereux, L., Rept. U. S. Geol. Surv. Terr., vol. 7, 314–329, 343, 344, 1878.
[4] Knowlton, F. H., U. S. Geol. Surv. Bull. 163, 6, 17–77, 1900.
[5] Sears, J. D., U. S. Geol. Surv. Bull. 781, 20, 1926.

age.[1] Here, then, is an opportunity to see what kind of floral analysis is derived from an assemblage whose Montanan age is established by stratigraphic position and adjacent marine faunas. Such an analysis should prove useful in the correlation of other floral assemblages whose age is not so definitely established.

The Ericson-Almond species give the following analysis:

No outside distribution	14
Outside distribution	35 (14 in common with type Lance)
Total number of species	49

Short-ranging species:		Long-ranging species:		Species of uncertain range	3
Montanan	11	Montanan-Lancian-Paleocene	4		
Lancian	4	Montanan-Lancian	12		
Paleocene	0	Lancian-Paleocene	1 (?)		
	15		17 (?)		

This summary shows that out of a total of 35 species with outside distribution, 14 (40 per cent) are also found in the flora of the type Lance. This is in contrast with the higher percentages seen in floras of known Lancian age and is comparable with the figure for the Vermejo flora. The short-ranging species, however, are overwhelmingly of typical Montanan age, as follows:

Montanan age only:

- Ficus regularis
- Ficus rhamnoides
- Ficus squarrosa
- Ficus wardii
- Grewiopsis cleburni
- Pterospermites undulatus
- Pterospermites wardii
- Quercus dentonoides
- Trapa? cuneata
- Viburnum anomalinervum
- Widdringtonia? complanata

Lancian age only:

- Cornophyllum wardii
- Ficus crossii
- Menispermites belli
- Selaginella? falcata

The age relations of the Ericson-Almond formations to other formations discussed are shown in figure 3.

Mesaverde flora, southeastern Wyoming—Knowlton has described a number of species collected from the Mesaverde formation northwest of Laramie, Wyoming.[2] This small assemblage gives the following analysis:

No outside distribution	10
Outside distribution	11 (5 in common with type Lance)
Total number of species	21

Short-ranging species:		Long-ranging species:		Species of uncertain range	1
Pre-Montanan	1	Pre-Montanan-Montanan	2		
Montanan	0	Montanan-Lancian	5		
Lancian	2	Lancian-Paleocene	0		
	3		7		

[1] Stanton, T. W., and Knowlton, F. H., op. cit., 146, 147, 1897. Wilmarth, M. Grace, U. S. Geol. Surv. Bull. 896, 1175, 1938.

[2] Knowlton, F. H., op. cit., 1-5, 1900.

Here is a typical example of the difficulty encountered when the short-ranging species of an assemblage are too few for reliability. The presence in the flora of 3 species of pre-Montanan occurrence is a fair indication that it is somewhat older than any previously discussed. It is to be hoped that larger collections of plants may be obtained from the Mesaverde formation in order to make its floral assemblage of greater value for correlation.

Tullock-Ludlow flora—The contrast between the flora of the type Tullock and Ludlow and the type Lance has previously been pointed out.[1] Out of a total of 33 species in the type Tullock-Ludlow, there are 21 species with outside distribution, of which only 5 are known also from the type Lance, as is shown in table 3. Moreover, these 5 species are all long-ranging species, 3 from Montanan through Paleocene age and 2 from Lancian through Paleocene. Of the total 21 species there are 11 that are restricted elsewhere to Paleocene age, 5 that are known in both Lancian and Paleocene age, and 5 that range from the Paleocene into the Eocene or later. It is concluded from these figures that the type Tullock and Ludlow beds, which are non-dinosaur-bearing, are of Paleocene age.

It has been shown further [2] that other non-dinosaur-bearing beds which elsewhere overlie the true Lance or Hell Creek formations have at many localities yielded plants which are clearly of Paleocene and not Lancian age. These beds are stratigraphically equivalent to the type Tullock-Ludlow beds, which had previously been regarded as the upper member of the Lance formation mainly because of their interfingering relation with the Cannonball beds, whose marine fauna was regarded as Upper Cretaceous. Recently, however, Fox and Ross have obtained a large foraminiferal assemblage from the Cannonball which is correlated with the Paleocene Midway of the Gulf Coast.[3] Had this correlation been known at the time when the Cretaceous-Tertiary boundary dispute was at high pitch, it seems reasonably sure that Knowlton would not have included the plants of the Tullock, Ludlow, and equivalent beds in his "Lance flora." It would have been apparent that the flora of the true *Triceratops*-bearing Lance and Hell Creek beds is quite distinct from that of the overlying non-dinosaur-bearing Tullock, Ludlow, and equivalents. It is now clear that the belief that the plants of the Tullock, Ludlow, and equivalents belonged to the true Lance was largely responsible for Knowlton's conclusion that this "Lance flora" was essentially a "Fort Union" (Paleocene) assemblage.

Fort Union flora—As is shown in table 3, there are only 5 species of the Lance flora which occur also in the widespread Paleocene "Fort Union" beds. Only 1 of these species, *Cercidiphyllum arcticum*, is elsewhere restricted to beds of known Paleocene age; the remaining 4 species are long-ranging forms in both the late Cretaceous and early Tertiary. The detailed differences between the flora of the type Fort Union and equivalent beds and that of the type Lance has already been reported.[4] It may here be added that other floras of Lancian age, analyzed above, are likewise easily distinguishable from the Fort Union flora or other floras of known

[1] Dorf, E., Bull. Geol. Soc. Amer., vol. 51, 223–226, 1940.
[2] Ibid., 226–232.
[3] Fox, S. K., Jr., and Ross, R. J., Jr., Bull. Geol. Soc. Amer., vol. 51, no. 12, pt. 2, 1970, 1940.
[4] Dorf, E., op. cit., 217–223, 1940.

Paleocene age. Pending the much-needed revision of Rocky Mountain Paleocene floras, at present being undertaken by Dr. Roland W. Brown, of the U. S. Geological Survey, it may be observed that of a total of over 250 Paleocene species there are only 30, of which 15 are very doubtful, which are reported as extending from the Paleocene into the Lance or from the Lance into the Paleocene. These are as follows:

?Aralia notata
Araliæphyllum artocarpoides
?Araucarites longifolia
Celastrus? taurinensis
Cercidiphyllum arcticum
Cercidiphyllum ellipticum
Dillenites cleburni
Diospyros brachysepala
?Euonymus xantholithensis
?Ficus coloradensis
?Ficus planicostata
?Fraxinus leii
Ginkgo adiantoides
?Hicoria antiquora
?Laurophyllum coloradensis
Laurus primigenia
Magnolia magnifolia
?Magnolia pulchra
Platanus aceroides
Platanus raynoldsii integrifolia
?Quercus? viburnifolia
Salix angusta
?Sapindus affinis
?Sequoia dakotensis
Sequoia nordenskiöldi
?Taxodium occidentale
Thuja interrupta
Trapa? microphylla
?Viburnum antiquum
?Viburnum whymperi

This list shows an extremely small number of species that are known definitely to bridge the span between Lancian and Paleocene time. They represent only about 6 per cent of the total number of species of either the Lancian or the Paleocene assemblage. It is difficult to explain this great difference between the typically Lancian forests and those of the Paleocene of the same general region, particularly in view of the apparent conformity between the Lancian and Paleocene rocks. I am not prepared to offer an explanation, though I believe it may be sought in one or another, or some combination, of the following suggestions: (1) there may exist an unrecognized hiatus between the Lancian and Paleocene deposits; (2) there have as yet not been a sufficient number of specimens collected from the upper parts of the Lancian formations or the lower parts of the Paleocene to present a true picture of the floral changes; (3) the late Lancian orogeny in the Rocky Mountain region may have been of sufficient intensity to cause rather sudden and widespread environmental changes and concurrent floral changes; (4) the sudden floral change in the early Paleocene may have been a result of a rather rapid invasion of the Rocky Mountain region, possibly from eastern North America by way of the newly opened route around the north end of the early Paleocene Cannonball sea.

Other floras—There are other floras in the Rocky Mountain region and elsewhere which have a few species in common with that of the type Lance formation, as is shown in table 3. These floras are, however, too remotely related to that of the type Lance or other formations of Lancian age to be considered further at the present time.

Index species and dominants of Lancian floras—From the foregoing analyses it is evident that there are a number of species in the flora of the type Lance which are, so far as is known, restricted elsewhere to floras of Lancian age. These are shown, along with those of wider stratigraphic range, in table 4. Theoretically,

TABLE 4—*Stratigraphic ranges of species of the type Lance*

Species of the type Lance	Pliocene, Miocene, and Oligocene: Innumerable	Eocene and Paleocene: Wilcox, Hanna, middle and upper Ravenscrag; Fort Union; Upper Denver–upper Dawson; Upper Raton; Tullock-Ludlow	Paleocene: Fort Union	Upper Cretaceous (type Lancian age): Type Lance	Upper Cretaceous (also Lancian age): Laramie; Colgate-Hell Creek; Medicine Bow; Lower Denver–lower Dawson; Upper Vermejo?–lower Raton?	Upper Cretaceous (Montanan age): Trinidad-lower Vermejo; Fox Hills; Ericson-Almond; Mesaverde; Judith River; Belly River
Araucarites longifolia	...	?	...	—	—	—
Asplenites tenellum	...	...	...	—	—	—
Canna? magnifolia	...	...	...	—	—	—
Cinnamomum? affine	...	...	...	—	—	?
Cornophyllum wardii	...	...	...	—	—	—
Dombeyopsis obtusa	...	...	...	—	—	—
Dryophyllum subfalcatum	...	...	...	—	—	—
Ficus planicostata	...	?	...	—	—	—
Ficus? trinervis	...	...	...	—	—	—
Platanophyllum platanoides	...	...	...	—	—	?
Laurophyllum meeki	...	...	...	—	—	?
Laurophyllum salicifolium	...	...	...	—	—	—
Menispermites belli	...	...	...	—	—	—
Menispermites knightii	...	...	...	—	...	—
Myrtophyllum torreyi	...	...	...	—	—	—
Nymphæites dawsoni	...	...	...	—	—	—
Pistia corrugata	...	...	...	—	—	—
Quercophyllum gardneri	...	...	...	—	—	?
Sabalites montana	...	...	...	—	—	—
Selaginella? falcata	...	...	...	—	...	—
Viburnum montanum	...	...	...	—	—	—
Vitis stantoni	...	...	...	—	—	—
Woodwardia? crenata	...	...	...	—	?	—
Anona? robusta	...	...	...	—	—	
Apeibopsis? discolor	...	...	...	—	—	
Aristolochites brittoni	...	...	...	—	—	
Carpites lancensis	...	...	...	—	—	
Carpites verrucosus	...	...	...	—	—	
Carpites walcotti	...	...	...	—	—	
Cissus? lobato-crenata	...	...	...	—	—	
Dombeyopsis colgatensis	...	...	...	—	—	
Dombeyopsis trivialis	...	...	...	—	—	
Ficus? ceratops	...	...	...	—	—	
Fraxinus leii	...	?	...	—	—	
Grewiopsis saportana	...	...	...	—	—	
Laurophyllum coloradensis	...	...	...	—	—	
Laurophyllum wardiana	...	...	...	—	—	
Magnoliophyllum cordatum	...	...	...	—	—	
Menispermites cockerelli	...	?	...	—	—	
Nelumbo tenuifolia	...	...	...	—	—	
Palæoaster inquirenda	...	...	...	—	—	
Pistacia eriensis	...	...	...	—	—	
Platanophyllum montanum	...	...	...	—	—	
Rhamnus? minutus	...	...	...	—	—	
Sabalites eocenica	...	...	...	—	—	
Saliciphyllum wyomingensis	...	...	...	—	—	
Salix lancensis	...	...	...	—	—	
Sequoia dakotensis	...	?	...	—	—	
Viburnum marginatum	...	...	...	—	—	
Araliæphyllum artocarpoides	...	—	—	—	—	
Celastrus? taurinensis	...	—	—	—	—	
Cercidiphyllum arcticum	...	—	—	—	?	
Cercidiphyllum ellipticum	...	—	?	—	—	—
Dillenites eleburni	...	—	...	—	—	?
Quercus? viburnifolia	...	—	...	—	—	
Trapa? microphylla	...	—	—	—	—	—
Ginkgo adiantoides?	—	—	—	—	—	—

the presence of any one of the restricted Lancian species in an assemblage of unknown age should indicate Lancian age. In actual practice, however, no such assumption can be made with confidence, since an extension of the range of some of these species can reasonably be expected to be made by future discoveries. An association of a number of these restricted species in a flora should indicate Lancian age. Some species are considered more reliable than others because of their abundance and their well-defined characters. Also there are a few species which are absent from the type Lance, for unknown reasons, which are abundant in other floras of Lancian age. The complete association of species which I consider the best indices of Lancian age is as follows:

Anona? robusta
Dombeyopsis trivialis
Ficus? ceratops
Fraxinus leii
Grewiopsis saportana
Laurophyllum wardiana
Magnoliophyllum cordatum
Menispermites cockerelli
Nelumbo tenuifolia
Pistacia eriensis
Platanophyllum montanum
Sabalites eocenica
Viburnum marginatum

In addition to these restricted species there are others which though of wider stratigraphic range are, so far as is known, abundant only in floras of Lancian age. These dominants are as follows:

Cercidiphyllum ellipticum
Dillenites cleburni
Dryophyllum subfalcatum
Ficus planicostata
Ficus? trinervis
Quercus? viburnifolia
Sequoia dakotensis
Vitis stantoni

Both of these lists are obviously to be regarded only as showing the status of these species in the present state of knowledge. As work progresses on the late Cretaceous and early Tertiary floras of the Rocky Mountain region there will undoubtedly be deletions and additions in both lists.

SUMMARY

The present report discusses the flora collected from the Lance formation at its type locality, Niobrara County, Wyoming. The plant remains were obtained from nine localities in the vicinity of Lance Creek; some additional specimens from this area were secured through loan from the U. S. National Museum.

The type Lance formation lies conformably above the Fox Hills sandstone, which carries the typical late Montanan marine fauna of the *Sphenodiscus* zone, and below the typical beds of the Paleocene Fort Union group. Numerous dinosaur remains of the late Cretaceous *Triceratops* zone have long been known from the same parts of the type Lance formation that have now yielded numerous plant remains. Late Cretaceous mammals and fresh-water mollusks are also recorded from the same beds.

The flora of the type Lance formation, as described in the present report, comprises 70 recognizable forms, chiefly of dicotyledons. There are 56 forms referred to species previously known, 5 are described as new species, and 9 are given generic designation but are not specifically determinable. Most of the species are regarded as only distantly related to existing genera. Some of the species are still of very uncertain systematic position; others have been systematically revised or described in detail on the basis of better and more abundant specimens and of comparisons with modern plants. A quantitative analysis of the plant remains indicates that 10 species may be regarded as the dominants of the floral association.

Studies of the structural characters of the dicotyledonous leaves in the Lance flora indicate lowland, humid, warm temperate conditions of growth, approaching subtropical. This conclusion is substantiated by the present distribution of modern correlatives of the Lance species.

For purposes of correlation the Lance formation at its type locality is made the basis of a new provincial time term, "Lancian age." This time unit is regarded, on the basis of the stratigraphic position and palæontology of the type Lance formation, as latest Cretaceous, i.e., post-Montanan and pre-Paleocene.

Analyses of other late Cretaceous floras of the Rocky Mountain region indicate that (1) the Laramie, Medicine Bow, and Colgate–Hell Creek formations are of Lancian age, as is shown also by their stratigraphic position and by other fossil remains; (2) the Arapahoe–lower Denver, lower Dawson, upper Vermejo–lower Raton, and Whitemud–lower Ravenscrag formations and the so-called "Laramie" of southwestern Wyoming are also of Lancian age; (3) the Almond-Ericson, Mesaverde, lower Vermejo, and Fruitland formations are of late Montanan age.

Analyses of Paleocene floras indicate that: (1) the floras of the type Fort Union formation or other undoubted Paleocene beds have less than 10 per cent of their species in common with the type Lance flora or other floras of Lancian age; (2) the floras of the type Tullock and Ludlow beds and equivalents are closely related to the Paleocene Fort Union flora and have little in common with Lancian floras.

The placing of the Cretaceous-Tertiary boundary below the Tullock, Ludlow, and demonstrable equivalents and above the Hell Creek and Lance is consistent with the recent discovery of Paleocene foraminifera in the Cannonball beds of the Dakotas.

SYSTEMATIC PALÆOBOTANY

SYNONYMS AND CHANGES OF NAMES

The disposition of the names which Knowlton[1] tentatively applied to the specimens collected in 1896 in the Lance Creek area is as follows:

Alga (gen. et sp. nov.)—unidentifiable, probably roots.
Aralia sp. = *Platanophyllum montanum* (Brown) Dorf, n. comb.
Carpites 2 sp.—very poor, fragmentary specimens, indeterminable.
Cyperacites sp. = *Cyperacites* sp.
Equisetum sp.? = *Equisetum* sp.
Fern (gen. et sp. nov.) = *Filicites knowltoni* Dorf, n. sp.
Ficus 5 sp. = (1) *Menispermites belli* Berry; (2) *Grewiopsis saportana* Lesquereux; (3) *Ficus? ceratops* Knowlton; (4) very poor specimen, unidentifiable, seems nearest to *Cissites lobatus* Dorf; (5) disregarded because specimen comes from "Fort Union" beds above the type Lance, according to locality records at the U. S. National Museum.
Flabellaria eocenica Lesquereux = *Sabalites eocenica* (Lesquereux) Dorf.
Grewiopsis eocenica (Lesquereux) Knowlton = *Grewiopsis saportana* Lesquereux.
Hicoria sp.—not considered in the present report because specimen comes from "Fort Union" beds above the type Lance, according to locality records at the U. S. National Museum.
Juglans 2 sp.—both specimens disregarded since they are from "Fort Union" beds above the type Lance, according to locality records at the U. S. National Museum.
Lysimachia sp. (new) = *Phyllites trifoliatus* Dorf, n. sp.
Myrica torreyi Lesquereux = *Myrtophyllum torreyi* (Lesquereux) Dorf, n. comb.
Ottelia? sp. (new)—poorly preserved, flattened round objects, not considered identifiable.
Palmocarpon palmarum (Lesquereux) Knowlton—very poorly preserved, unidentifiable.
Phyllites 3 sp.—(1) and (2) poorly preserved, unidentifiable; (3) disregarded since specimen is from "Fort Union" beds above the type Lance, according to locality records at the U. S. National Museum.
Platanus raynoldsii Newberry—disregarded since specimens come from "Fort Union" beds above the type Lance, according to locality records at the U. S. National Museum.
Platanus raynoldsii integrifolia Lesquereux, *Populus subrotunda* Lesquereux, and *Populus amblyrhyncha* Ward—disregarded since specimens come from "Fort Union" beds above the type Lance, according to locality records at the U. S. National Museum.
Qucreus cinereoides Lesquereux of Knowlton = *Saliciphyllum wyomingensis* (Knowlton and Cockerell) Dorf, n. comb.
Quercus viburnifolia Lesquereux = *Quercus? viburnifolia* Lesquereux.
Quercus 3 sp. (new?)—(1) and (2) unidentifiable; (3) disregarded since specimen comes from "Fort Union" beds above the type Lance, according to locality records at the U. S. National Museum.
Sabal rigida Hatcher—palm rays only; may belong to *Sabalites montana* (Knowlton) Dorf.
Salix angusta Al. Braun—disregarded since no specimens referred to this species could be found in the collections at the U. S. National Museum.
Salix 3 sp. (new?)—(1) and (2) = *Dryophyllum subfalcatum* Lesquereux; (3) = *Salix lancensis* Berry.
Salvinia sp. = *Salvinia?* sp.
Sassafras sp. (new) = *Platanophyllum montanum* (Brown) Dorf, n. comb.
Sequoia nordenskiöldi Heer = *Sequoia dakotensis* Brown ?
Taxodium distichum miocenum Heer—disregarded since no specimens referred to this species could be found in the collections at the U. S. National Museum.
Trapa microphylla Lesquereux = *Trapa? microphylla* Lesquereux.

[1] Knowlton, F. H., Proc. Washington Acad. Sci., vol. 11, 207, 1909.

Ulmus sp. = *Carpites ulmiformis* Dorf, n. sp.
Viburnum sp. (new) = small leaves of *Vitis stantoni* (Knowlton) Brown.
Viburnum whymperi Heer = *Viburnum montanum* Knowlton.

Other changes in species concepts, involving either synonymies or changes in generic allocation, are as follows:

Anona coloradensis Knowlton = *Laurophyllum coloradensis* (Knowlton) Dorf, n. comb.
Aristolochia brittoni Knowlton = *Aristolochites brittoni* (Knowlton) Dorf, n. comb.
Asplenium tenellum Knowlton = *Asplenites tenellum* (Knowlton) Dorf, n. comb.
Carpolithus hirsutus Newberry of Brown, and of Dorf = *Carpites lancensis* Dorf, n. sp.
Cornus fosteri Ward = *Aralixphyllum artocarpoides* (Lesquereux) Dorf, n. comb.
Cunninghamites? sp., Knowlton = *Araucarites longifolia* (Lesquereux) Dorf, n. comb.
Dammara sp., Knowlton = *Araucarites longifolia* (Lesquereux) Dorf, n. comb.
Dammara? sp., Dorf = *Araucarites longifolia* (Lesquereux) Dorf, n. comb.
Ficus artocarpoides Lesquereux = *Araliæphyllum artocarpoides* (Lesquereux) Dorf, n. comb.
Ficus cockerelli Knowlton and its included synonyms [1] = *Menispermites cockerelli* (Knowlton) Dorf, n. comb.
Ficus crossii Ward of Knowlton, and of Dorf = *Laurophyllum meeki* Dorf.
Ficus post-trinervis Knowlton = *Ficus? trinervis* Knowlton.
Ficus preartocarpoides Brown (in part) = *Araliæphyllum artocarpoides* (Lesquereux) Dorf, n. comb.
Ficus uncata Lesquereux of Knowlton, and of Dorf = *Anona? robusta* Lesquereux.
Geinitzia formosa Heer of Knowlton = *Araucarites longifolia* (Lesquereux) Dorf, n. comb.
Geinitzia longifolia (Lesquereux) Knowlton = *Araucarites longifolia* (Lesquereux) Dorf, n. comb.
Ginkgo laramiensis Ward = *Ginkgo adiantoides* (Unger) Heer.
Grewiopsis tenuifolia Lesquereux = *Vitis stantoni* (Knowlton) Brown.
Laurus lakesii Knowlton = *Saliciphyllum wyomingensis* (Knowlton and Cockerell) Dorf, n. comb.
Laurus lanceolata Knowlton = *Laurophyllum salicifolium* (Lesquereux) Dorf, n. comb.
Laurus ocoteoides Lesquereux = *Laurophyllum wardiana* (Knowlton) Dorf, n. comb.
Laurus socialis Lesquereux of Knowlton, and of Dorf = *Laurophyllum coloradensis* (Knowlton) Dorf, n. comb.
Laurus wardiana Knowlton = *Laurophyllum wardiana* (Knowlton) Dorf, n. comb.
Liriodendron sp., Brown = *Apeibopsis? discolor* (Lesquereux) Lesquereux.
Myrica torreyi Lesquereux and its included synonyms [2] = *Myrtophyllum torreyi* (Lesquereux) Dorf, n. comb.
Nelumbo dawsoni Hollick = *Nymphæites dawsoni* (Hollick) Dorf, n. comb.
Phyllites colubrinoides Dorf, 1940 (not Dorf, 1938) = *Cercidiphyllum arcticum* (Heer) Brown.
Platanus platanoides (Lesquereux) Knowlton (in part) = *Platanophyllum platanoides* (Lesquereux) Dorf, n. comb.
Platanus sp., Brown = *Platanophyllum platanoides* (Lesquereux) Dorf, n. comb.
Quercus cinereoides Lesquereux of Knowlton = *Saliciphyllum wyomingensis* (Knowlton and Cockerell) Dorf, n. comb.
Quercus gardneri Knowlton = *Quercophyllum gardneri* (Knowlton) Dorf, n. comb.
Quercus rockvalensis Knowlton = *Quercophyllum gardneri* (Knowlton) Dorf, n. comb.
Rhamnus cleburni Lesquereux (in part) and its included synonyms [3] = *Dillenites cleburni* (Lesquereux) Dorf, n. comb.
Rhamnus salicifolius Lesquereux and its included synonyms [4] = *Laurophyllum salicifolium* (Lesquereux) Dorf, n. comb.
Salix wyomingensis Knowlton and Cockerell = *Saliciphyllum wyomingensis* (Knowlton and Cockerell) Dorf, n. comb.
Sassafras montana Brown = *Platanophyllum montanum* (Brown) Dorf, n. comb.
Selaginella laciniata Lesquereux = *Selaginella? falcata* Lesquereux.
Sequoia acuminata Lesquereux = *Araucarites longifolia* (Lesquereux) Dorf, n. comb.

[1] Dorf, E., Carnegie Inst. Wash. Pub. No. 508, pt. I, 55, 1938.
[2] Ibid., 49.
[3] Ibid., 67.
[4] Ibid., 66.

Sequoia longifolia Lesquereux = *Araucarites longifolia* (Lesquereux) Dorf, n. comb.
Trochodendroides sp., Dorf, 1940 = *Cercidiphyllum ellipticum* (Newberry) Brown.
Viburnum anomalinervum Knowlton of Dorf, 1940 (not Knowlton) = *Vitis stantoni* (Knowlton) Brown.
Viburnum platanoides Lesquereux = *Platanophyllum platanoides* (Lesquereux) Dorf, n. comb.
Viburnum richardsoni Knowlton = *Vitis stantoni* (Knowlton) Brown.
Viburnum whymperi Heer (in part) = *Vitis stantoni* (Knowlton) Brown.
Zizyphus ripleyensis Berry of Dorf, 1940 = *Phyllites* sp.

DESCRIPTIONS

Family POLYPODIACEÆ

Genus ASPLENITES Goeppert

plenites tenellum (Knowlton) Dorf, n. comb.

(Plate 4, Figs. 1–3)

Asplenium tenellum Knowlton, U. S. Geol. Surv. Bull. 163, 19, pl. 3, figs. 1, 2, 1900. Brown, U. S. Geol. Surv. Prof. Paper 189, 245, pl. 48, fig. 1, 1939. Dorf, Bull. Geol. Soc. Amer., vol. 51, 222, 1940.

There are 3 specimens in the collections which are similar in all essential characters to the figured and type specimens of this species. In plate 4, figure 3 are shown the delicate pinnules borne alternately on a slender pinna. The details of the venation and margins are shown in the enlarged pinnules, figures 1 and 2.

The general shape, size, and venation of these pinnules are suggestive of *Hymenophyllum confusum* Lesquereux from the Denver flora;[1] this may be distinguished, however, by the decurrent extension of the pinnules along the pinnæ, a character not seen in any of the known specimens of *Asplenites tenellum*.

The original type specimens of *A. tenellum* were obtained from the Montana group (Mesaverde formation) of southeastern Wyoming. It has since been encountered only in the Colgate flora of eastern Montana and in the type Lance of the present report.

Although these pinnules are undeniably similar to those of several living species of *Asplenium*, it seems advisable to refer this species to the less positive *Asplenites*, at least until specimens of fertile parts are discovered.

Occurrence—Localities P3853, P3858.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 2450, 2451, 2452.

Genus WOODWARDIA Smith ?

Woodwardia? crenata Knowlton

(Plate 4, Figs. 5, 6)

Woodwardia crenata Knowlton, U. S. Geol. Surv. Bull. 163, 22, pl. 3, fig. 3, 1900; U. S. Geol. Surv. Prof. Paper 101, 246, 1917.
Woodwardia sp., Knowlton, Bull. Geol. Soc. Amer., vol. 8, 154, 1897.

There are 6 specimens of fern fragments which I cannot distinguish from the type and described specimens of this species. As is shown in the fragments here figured, the pinnules are distinctly crenate and the venation is precisely as in the original type. The absence of finer serrations in the Lance Creek specimens is not considered sufficiently important for specific separation, in view of the variations of this kind noted in pinnules of modern ferns.

I have questioned the reference of this species to the genus *Woodwardia*. There is, to be sure, a resemblance to several living species of this genus, but there is also resemblance to the living *Onoclea*. A definite generic reference can probably not be made until fruiting organs have been found in attachment to pinnules of this form.

[1] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 155, 17, pl. 1, fig. 4, 1930.

Aside from its occurrence in the type Lance flora, this species is known only from the upper Mesaverde group and the Vermejo formation.

Occurrence—Localities P3854, P3858.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 2453, 2454.

Family SALVINIACEÆ?

Genus SALVINIA (Micheli) Schreber ?

Salvinia? sp.

(Plate 4, Fig. 4)

Salvinia sp., Knowlton, Bull. Geol. Soc. Amer., vol. 8, 133, 1897; Proc. Washington Acad. Sci., vol. 11, 207, 1909.

In the collections at the U. S. National Museum there is a single specimen, here figured, which Knowlton regarded as belonging to the genus *Salvinia*. Unfortunately the two incomplete pinnules on the specimen are too poorly preserved to bring out the details of venation and of pitting which are essential for description or identification.

Occurrence—U. S. Geol. Survey Locality 1462.

Collection—U. S. National Museum, No. 40249.

FILICALES, Position Uncertain

Genus FILICITES Brongniart

Filicites knowltoni Dorf, n. sp.

(Plate 4, Figs. 7, 8, 10, 11)

Fern (gen. et sp. nov.), Knowlton, Proc. Washington Acad. Sci., vol. 11, 207, 1909.

There are 11 well-preserved specimens of this species, of which 9 are in the collections of the U. S. National Museum.

Description—Pinnules relatively small, averaging 6–9 mm. long and 3–5 mm. wide, oblong-elliptic, entire-margined, and with fine, numerous, anastomosing veins obliquely diverging from an indistinct midrib; pinnules closely spaced on pinna in alternate arrangement, attached only by central part of base; ultimate disposition of pinnæ unknown; fertile parts not preserved.

I have been unable to find any living or fossil ferns with which these delicate specimens can be adequately compared.

Occurrence—Localities P3856, P3858; U. S. Geol. Survey Locality 1462.

Collection—U. S. National Museum, Cotype Nos. 40250, 40250*a* (counterpart); U. C. Mus. Pal., Cotypes Nos. 2455, 2456.

Family EQUISETACEÆ

Genus EQUISETUM Linné

Equisetum sp.

(Plate 6, Figs. 2, 3)

Equisetum sp.?, Knowlton, Proc. Washington Acad. Sci., vol. 11, 207, 1909.

There are 3 well-preserved specimens and several fragments of ribbed, jointed stems clearly referable to the genus *Equisetum*. There is also an excellent specimen of this form in the Lance collections from this same area in the U. S. National Museum (specimen No. 1007 [1462]). As is usually the case, none of these specimens shows features of diagnostic value for specific identification. In addition to jointed stems, the Lance Creek collections also contain a specimen (fig. 3) which I regard as a pair of typical equisetaceous tubers, and another specimen (fig. 2) which is clearly an impression of a nodal diaphragm.

Although widely recorded in floras of Cretaceous and Tertiary age, the remains of *Equisetum* are too generalized to be safely used for purposes of correlation.

Occurrence—Localities P3853, P3856, P3858, P3859.

Collection—U. C. Mus. Pal., Nos. 2457, 2458.

Family SELAGINELLACEÆ?

Genus SELAGINELLA Spring ?

Selaginella? falcata Lesquereux

(Plate 6, Fig. 1)

Selaginella? falcata Lesquereux, U. S. Geol. and Geog. Surv. Terr., Bull., vol. 1, 365, 1876; U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1874), 297, 1876; Rept. U. S. Geol. Surv. Terr., vol. 7, 46, only pl. 61, figs. 12–15, 1878.

Selaginella laciniata Lesquereux, U. S. Geol. and Geog. Surv. Terr., Bull., vol. 1, 378, 1876; U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1874), 297, 1876; Rept. U. S. Geol. Surv. Terr., vol. 7, 47, pl. 64, figs. 12, 12*a*, 1878. Knowlton, U. S. Geol. Surv. Bull. 163, 24, pl. 3, figs. 5–8, 1900. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

There are 5 specimens from Locality P3853 which were at first regarded as *Selaginella laciniata*. After consulting the collections at the U. S. National Museum, however, I believe that the two species listed above, which were collected from precisely the same locality, represent one and the same species in different states of preservation. The distinguishing features of these two species have been the threadlike laciniæ of *S. laciniata* and the narrow leaves of *S.? falcata*. Both of these features are to be seen on a single stalk in several of the Lance Creek specimens. There are apparently no other comparable specimens reported from Cretaceous or Tertiary floras of North America.

The reference of this species to *Selaginella* is doubtful, as is indicated by the question mark originally inserted by Lesquereux. I have been unable to find any living species with either aerial or submerged leaves of this particular form.

Occurrence—Locality P3853.

Collection—U. C. Mus. Pal., Plesiotype No. 2459.

Family GINKGOACEÆ

Genus GINKGO (Kaempfer) Linné

Ginkgo adiantoides (Unger) Heer ?

Ginkgo adiantoides (Unger) Heer, Fl. Foss. Arct., vol. 5, pt. 3, 21, pl. 2, figs. 7–10, 1878. Ward, U. S. Geol. Surv. 6th Ann. Rept., 549, pl. 31, figs. 5, 6, 1885; U. S. Geol. Surv. Bull. 37, 15, pl. 1, figs. 5, 6, 1887. Lesquereux, Proc. U. S. Nat. Mus., vol. 10, 35, 1887. Knowlton, Bull. Geol. Soc. Amer., vol. 5, 579, 1893; Proc. U. S. Nat. Mus., vol. 17, 215, 1894; Proc. Washington Acad. Sci., vol. 11, 185, 197, 198, 204, 213, 1909; Jour. Geol., vol. 19, 370, 1911. Penhallow, Canada Geol. Surv., Pub. 1013, 57, text fig. 12, 1908. Berry, Trans. Roy. Soc. Canada, vol. 20, sec. 4, 190, 1926; Canada Geol. Surv. Bull. 42, 96, 1926; Canada Nat. Mus. Mem. 63, 18, 1930; Canada Geol. Surv. Mem. 182, 17, 1935. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

Salisburia adiantoides Unger, Syn. Pl. Foss., 211, 1845.

Ginkgo laramiensis Ward, Science, vol. 5, 496, fig. 7, 1885; U. S. Geol. Surv. 6th Ann. Rept., 549, pl. 31, fig. 4, 1885; U. S. Geol. Surv. Bull. 37, 15, pl. 1, fig. 4, 1887. Knowlton, U. S. Geol. Surv. Bull. 163, 31, pl. 4, figs. 7–10, pl. 5, fig. 5, 1900. Brown, U. S. Geol. Surv. Prof. Paper 189, 246, pl. 48, figs. 12–18, pl. 59, figs. 1–3, 1939 (see synonymy).

There is a single specimen from Locality P3857 which clearly is a characteristic fan-shaped leaf of the modern genus *Ginkgo*. The widespread occurrences of Tertiary representatives of this genus are usually referred to the nominal species *Ginkgo adiantoides*, whose leaves are identical with those of the living species *G. biloba* Linné. Several attempts have been made by palæobotanists to distinguish the late Cretaceous *Ginkgo* leaves as a separate species, *G. laramiensis*. As Berry has pointed out,[1] the leaf forms shown in specimens of both the Cretaceous and the Tertiary species fail "to disclose as much variation as can be selected from a single existing tree."

[1] Berry, E. W., Canada Geol. Surv. Mem. 182, 17, 1935.

Shaparenko,[1] who has studied the past records of *Ginkgo* in detail, does not regard *G. laramiensis* as a valid species. Brown, on the other hand, distinguishes between *G. adiantoides* and *G. laramiensis* on the basis of the character of mature average leaf forms.[2] He states: "During Upper Cretaceous time the average form was still cuneate, but the tendency was to be entire, undulate, or only slightly bilobate, as in *G. laramiensis*. From the Eocene onward the average type was reniform and bilobate and is typified by *G. adiantoides*." This is certainly a valid observation, but is impossible to apply, as Brown has pointed out, unless abundant specimens are secured. In the Lance Creek collections, only a single, incomplete specimen is known, so that a positive specific reference cannot be made.

As is indicated in the long list of references above, the well-defined leaves of this form are of common occurrence in the Upper Cretaceous and Tertiary rocks of North America. Whether or not a single species of *Ginkgo* has survived from the Upper Cretaceous to the present day cannot be determined on the basis of leaves alone.

Occurrence—Locality P3857.

Collection—U. C. Mus. Pal., No. 2460.

Family TAXODIACEÆ

Genus SEQUOIA Endlicher

Sequoia dakotensis Brown

(Plate 6, Figs. 4–11)

Sequoia dakotensis Brown, Jour. Washington Acad. Sci., vol. 25, 447, 1935; U. S. Geol. Surv. Prof. Paper 189, 247, pl. 48, figs. 6–10, 1939. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.
?*Sequoia nordenskiöldi* Heer. Knowlton, Proc. Washington Acad. Sci., vol. 11, 207, 1909.

There are 20 specimens of cone impressions and casts in the collections. The excellent preservation of one of these (plate 6, fig. 7) as a mud cast makes it possible to compare it with the casts described by Brown as *Sequoia dakotensis*. The description given by Brown is as follows:

"Cones, 1.5–4 cm. long, 1.2–3 cm. in diameter, with about 30 scales, arranged in two sets of spiral rows, the steep-angled set in 5 rows, and the flat-angled set in 3 rows. The faces of the scales present sections that are long and narrow, roughly diamond-shaped, but occasionally with one or two additional angles. Peduncles of the scales abruptly narrowed to the point of attachment at the axis of the cone. Surface of the scales smooth, or sometimes slightly wrinkled."

The single cast in the Lance Creek collection has 28 scales; an examination of the large number of typical specimens of this species at the U. S. National Museum has shown that this number of scales is within the range of variability of "about 30 scales," as described above. The remaining characters of the cone and of other cone impressions in my collections are precisely as enumerated by Brown.

At the Lance Creek localities which have yielded them, these cones are always associated with foliage which is clearly of the *Sequoia* type (plate 6, figs. 4–6). In view of this invariable association and the absence of other coniferous foliage at these localities, it is reasonably certain that the cones and foliage belong to the same species. This foliage cannot be distinguished from that of such nominal "species" as *S. langsdorfii* (Brongniart) Heer, *S. nordenskiöldi* Heer, or *S. obovata* Knowlton.[3] These "species" have little meaning, either botanically or geologically, because of their lack of distinguishing characteristics. On foliage characters alone they cannot be separated from the living *S. sempervirens* Endlicher. When foliage remains are intimately associated with well-defined cones, however, there can be no natural or valid grounds for referring the foliage and the cones to two distinct "species."

Occurrence—Localities P3651, P3652, P3855, P3857, P3859.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 2461, 2462, 2462*a* (counterpart), 2463, 2464, 2465, 2466, 2467, 2468; Nos. 2469, 2470, 2471, 2472, 2473.

[1] Shaparenko, K., Philippine Jour. Sci., vol. 57, pt. 1, 1–28, 1935.
[2] Brown, R. W., U. S. Geol. Surv. Prof. Paper 189, 247, 1939.
[3] For the numerous references to these widespread forms, consult Knowlton, F. H., U. S. Geol. Surv. Bull. 696, 594, 595, 596, 1919.

Family ARAUCARIACEÆ

Genus ARAUCARITES Presl

Araucarites longifolia (Lesquereux) Dorf, n. comb.

(Plate 4, Figs. 9, 12, 13; Plate 5, Figs. 1–6)

Sequoia longifolia Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1874), 298, 1876; Rept. U. S. Geol. Surv. Terr., vol. 7, 79, pl. 7, figs. 14, 14*a*, pl. 61, figs. 28, 29, 1878. Cockerell, Torreya, vol. 9, 142, 1909. Knowlton, U. S. Geol. Surv. Prof. Paper 130, 115, pl. 3, fig. 3, pl. 4, fig. 2, 1922. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

Sequoia acuminata Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1874), 310, 1876; Rept. U. S. Geol. Surv. Terr., vol. 7, 80, pl. 7, figs. 15–16*a*, 1878. Knowlton, Jour. Geol., vol. 19, 371, 1911; U. S. Geol. Surv. Prof. Paper 130, 114, pl. 2, figs. 7, 8, 1922. Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. I, 45, pl. 2, fig. 1, 1938.

Geinitzia longifolia (Lesquereux) Knowlton, U. S. Geol. Surv. Bull. 163, 28, 1900.

Cunninghamites? sp., Knowlton, U. S. Geol. Surv. Bull. 163, 29, pl. 5, fig. 3, 1900.

Geinitzia formosa Heer. Knowlton, U. S. Geol. Surv. Bull. 163, 28, pl. 5, figs. 1, 2, 1900; U. S. Geol. Surv. Prof. Paper 101, 251, pl. 31, figs. 1–3, 1917.

Dammara sp., Knowlton, U. S. Geol. Surv. Prof. Paper 130, 114, pl. 2, fig. 4, 1922.

Dammara? sp., Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

Several hundred specimens of this long-leaved conifer and associated cone scales were obtained, mainly from Locality P3853. About 150 specimens were retained for study. The recovery of so large a suite of specimens, showing many stages of growth and varieties of preservation, has made it possible to show that the several species cited above are in reality referable to a single species. The specific name *longifolia* has priority over the others.

As was pointed out by Knowlton,[1] the original type specimens of *Sequoia longifolia* were described by Lesquereux from the Mesaverde formation at Point of Rocks, Wyoming. The original description was as follows:

"Branches and branchlets thick; leaves close, open, slightly narrowed to the decurring base, thick; scars deep, ligulate, obtusely pointed, marked by a deep groove in the middle."

The Lance Creek foliage specimens clearly agree with this description and are indistinguishable from the original type and figured specimens. None of these, moreover, differ in any valid, essential detail from the specimens from Black Buttes which were called *Sequoia acuminata*. Lesquereux recognized the close resemblance of these specimens to *S. longifolia* and hesitated to describe the two species as distinct. They apparently differed only in the absence of scars on the branches of *S. acuminata*. From the numerous specimens available in the Lance Creek collections it is evident that leaf scars are often concealed by flattened leaf bases; accordingly, the absence of leaf scars in the Black Buttes specimens is here regarded as fortuitous.

The Mesaverde (?) specimens of *Geinitzia longifolia* and *Cunninghamites*? sp. were included in the species *Sequoia longifolia* by Knowlton [2] on what appear to be justifiable grounds. Nor is there any discernible difference in the Mesaverde and Vermejo specimens which Knowlton referred to *Geinitzia formosa* Heer. Knowlton characterized these specimens in part by the alternation of the normal needles "with smaller intermediate scalelike leaves." The type specimens do not bear out this observation; the apparent smaller leaves are merely the basal parts of longer leaves which are cut off by projection into the matrix or out to the fracture plane along which the rock was split.

The intimate association of a great many individual cone scales with the hundreds of specimens of the foliage of this type, coupled with the absence of other conifer foliage or cone scales at these localities, makes it reasonably certain that these two types of remains belong to the same species of conifer. These cone scales (plate 5, figs. 2–6) are identical with the type specimen and with more complete, unfigured specimens [3] of *Dammara* sp., from the Laramie formation at Marshall, Colorado. As at the Lance Creek localities, these Laramie cone scales were associated at the Marshall locality with foliage referred to *Sequoia longifolia*. A similar occurrence of this type of cone scale and foliage has been noted in a collection from the Hell Creek formation at the

[1] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 130, 115, 1922.

[2] Ibid.

[3] U. S. National Museum collections, No. 36709.

U. S. National Museum (specimens No. 5, Locality 8536). Comparable scales, referred to *Dammara acicularis* Knowlton,[1] from the Judith River formation differ from the Lance and Laramie species chiefly in their consistently shorter apical spines; they undoubtedly belong to the same genus.

I can see no justification for the retention of the generic name *Sequoia* for this species. Neither the foliage nor the cone scales resemble in any way the living species of *Sequoia*. An examination of herbarium specimens of all available species of conifers at the New York Botanical Garden has convinced me that the closest resemblance is to the living Araucariaceæ. The foliage is of the same type seen in *Araucaria excelsa* (Lamb.) R. Br. and *A. cunninghamii* Ait. The needles of these species are radially arranged, are marked by a medial fold or false midrib, and are attached to the branches in the same manner as in the fossil specimens. They differ only in their shorter length and greater width. It is significant, moreover, that the cones of these living species are deciduous, as in the fossil species, and have cone scales which closely resemble those of the fossil specimens in size, shape, and terminal spines.

Occurrence—Localities P3853, P3859.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 2474, 2475, 2476, 2477, 2478, 2479, 2480, 2481, 2482.

Family TYPHACEÆ

Genus TYPHA Linné

Typha sp.

There are 9 specimens of this ubiquitous form. None of these has characters sufficiently well defined to attempt specific determination or description.

Remains of this type, generally referred to *Typha*, are common throughout Cretaceous and Tertiary time. Of no use for correlation purposes because of their lack of diagnostic features, they indicate a wet habitat, with inadequate drainage resulting in shallow standing bodies of water.

Occurrence—Localities P3651, P3853, P3856, P3857, P3858, P3859.

Collection—U. C. Mus. Pal., Nos. 2483, 2484.

Family CYPERACEÆ

Genus CYPERACITES Schimper

Cyperacites sp.

Remains of finely parallel-veined leaves, referable to the form genus *Cyperacites*, are fairly abundant in the collection from Locality P3857. These are the same as other specimens from the Lance Creek area which are in the collections at the U. S. National Museum.[2] These monocotyledonous leaves do not have any characters by which they can be defined or recognized as "species"; they are recorded here only for their ecological connotations.

Occurrence—Locality P3857.

Collection—U. C. Mus. Pal., No. 2485.

Family PALMÆ

Genus SABALITES Saporta

Sabalites eocenica (Lesquereux) Dorf

(Plate 7, Fig. 1)

Sabalites eocenica (Lesquereux) Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. I, 48, pl. 2, fig. 6, pl. 3, fig. 3, 1938.

Flabellaria eocenica Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1872), 391, 1873; U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1873), 380, 1874; U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1876), 502, 1878; Rept. U. S. Geol. Surv. Terr., vol. 7, 111, pl. 13, figs. 1, 2 (not 3), 1878.

Sabal communis Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1874), 311, 1876.

[1] Knowlton, F. H., U. S. Geol. Surv. Bull. 257, 134, pl. 15, figs. 2–5, 1905.

[2] Specimen No. 1008 (1462).

Flabellaria communis Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1875), 385, 1876.
Sabal inquirenda Knowlton, U. S. Geol. Surv. Prof. Paper 101, 288, pl. 56, 1917.
Sabal? rugosa Knowlton, U. S. Geol. Surv. Prof. Paper 101, 288, pl. 58, 1917.
Sabal? coccnica Knowlton, U. S. Geol. Surv. Bull. 696, 557, 1919.

There are 2 impressions from Locality P3853 which have the characters considered diagnostic of this species. Knowlton has previously reported this species (as *Flabellaria eocenica*) from the Lance Creek area.[1] I have seen this specimen in the collections at the U. S. National Museum; it is not numbered, so that the exact locality from which it was collected is not known. In view of the present discovery of this species in the same region, it is reasonably certain that Knowlton was correct in stating that his specimen was collected from the type Lance formation.

In addition to its present occurrence, this species is reported only from floras which I consider the uppermost Cretaceous in the Rocky Mountain region: the Black Buttes, the lower Raton, and the Medicine Bow; it is also present in the Laramie flora, being represented in the collection of undescribed and unlabeled Laramie specimens at the U. S. National Museum (specimens Nos. 570*a*, 1327).

Occurrence—Locality P3853.

Collection—U. C. Mus. Pal., Pleisotype No. 2487.

Sabalites montana (Knowlton) Dorf

(Plate 6, Fig. 12)

Sabalites montana (Knowlton) Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. 1, 47, pl. 3, fig. 2, 1938; Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.
Sabal montana Knowlton, U. S. Geol. Surv. Prof. Paper 101, 253, pl. 32, fig. 3, 1917; U. S. Geol. Surv. Prof. Paper 130, 119, pl. 3, fig. 4, 1922.
Sabalites grayanus (Lesquereux) Lesquereux (in part), Rept. U. S. Geol. Surv. Terr., vol. 7, 112, pl. 12, fig. 1 (not pl. 12, fig. 2), 1878. Knowlton, U. S. Geol. Surv. Prof. Paper 155, 36, pl. 9, fig. 5, 1930.
?*Sabal rigida* Hatcher, Ann. Carnegie Mus., vol. 1, 263, text fig. 1, 1901.

In addition to a large number of impressions of the outer rays of palm leaves, the Lance Creek collections contain 2 impressions of the basal parts of leaves, of which the better is figured. In size, approximate number of rays, and length and character of acumen, these impressions are referable to the species *Sabalites montana*.

In 1900 Hatcher collected an impression of a part of a palm leaf from the Lance Creek area. This was described and figured as a new species, *Sabal rigida*. In the absence of the diagnostic basal part of this leaf, it is doubtful whether the recognition of this specimen as a distinct species will serve any useful purpose. I have questionably united it with the present species, whose outer rays are of the same general character and size.

As known at present, this species occurs in the upper Mesaverde group and the Vermejo, Laramie,[2] Medicine Bow, lower Denver, and type Lance formations.

Occurrence—Locality P3853.

Collection—U. C. Mus. Pal., Plesiotype No. 2486.

Family ARACEÆ

Genus PISTIA Linné

Pistia corrugata Lesquereux

(Plate 7, Figs. 3, 4, 6)

Pistia corrugata Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1874), 299, 1876; Rept. U. S. Geol. Surv. Terr., vol. 7, 103, pl. 61, figs. 1, 3, 4, 6, 7, 9–11, 1878. Knowlton, U. S. Geol. Surv. Bull. 163, 31, 1900; U. S. Geol. Surv. Prof. Paper 98, 334, pl. 85, fig. 4, 1916. Berry, Canada Geol. Surv. Mem. 182, 23, 1935. Brown, U. S. Geol. Surv. Prof. Paper 189, 248, pl. 49, figs. 7–9, pl. 56, fig. 6*a*, 1939. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.
Ottelia americana Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1874), 300, 1876; Rept. U. S. Geol. Surv. Terr., vol. 7, 98, pl. 61, fig. 8, 1878. Knowlton, U. S. Geol. Surv. Bull. 163, 32, 1900.
Lemna scutata Dawson. Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 7, 102, pl. 61, fig. 5 only, 1878.

[1] Knowlton, F. H., Proc. Washington Acad. Sci., vol. 11, 207, 1909.

[2] In addition to the figured Laramie specimen, there is a better, undescribed specimen (No. 569*a*) in the Laramie collection at the U. S. National Museum.

There are 27 specimens clearly referable to this well-defined species, from two localities in the Lance Creek area. Most of the specimens are well preserved, although the venation seems always to be only faintly impressed, as a result of the thick texture of the leaves.

Pistia corrugata was described by Lesquereux from abundant remains in the upper Mesaverde group at Point of Rocks, Wyoming. The original description is as follows:

"Leaves broadly obovate, incrassated from the middle toward the base, bordered upward by a wavy margin, gradually narrowed into a short pedicel with bundles of radicles at its base; veins going out from the pedicel in two or three compact fascicles, dividing in passing up from the base of the leaves, and forming, by cross-branchlets, large irregular polygonal meshes."

The abundant specimens in the Lance Creek collections do not differ in any respect from the above description. Comparisons with the type specimens at the U. S. National Museum have shown that the average size of the Lance Creek leaves is somewhat greater than that of the type specimens figured by Lesquereux. Berry has made the same observation on specimens from the Whitemud formation of Saskatchewan. There are, however, several unfigured specimens from the Mesaverde formation in the collections at the U. S. National Museum which closely approach in size the Lance and Whitemud specimens. On the basis of other variations observed in a large number of specimens from the Fox Hills and Colgate, Brown has synonymized the specimen of *Ottelia americana* Lesquereux and one specimen of *Lemna scutata* Dawson with *Pistia corrugata*.

As known at present, the leaves of *P. corrugata*, which are usually well defined and fairly common, are valuable index forms for the Montana and post-Montana Cretaceous. They are now known from the Mesaverde, Judith River, Kirtland, Belly River, Whitemud, Fox Hills, Colgate, and true Lance formations. No comparable leaves have ever been reported from the extensive "Fort Union" flora of the Rocky Mountain region. The Wilcox species, *Pistia wilcoxensis*, is regarded by Berry as "clearly distinct from previously described fossil forms of *Pistia*." [1]

The reference of these fossil leaves to the genus *Pistia* has been amply substantiated by comparison with leaves of the single living species. They are, indeed, difficult to separate from the leaves of the modern "water lettuce," *Pistia stratiotes* Linné,[2] which is widespread in southeastern United States, Mexico, and Central and South America, and is known also in Asia and Africa.

Occurrence—Localities P3853, P3858.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 2488, 2489, 2490; No. 2491.

Family CANNACEÆ

Genus CANNA Linné ?

Canna? magnifolia Knowlton

(Plate 8, Fig. 1)

Canna? magnifolia Knowlton, U. S. Geol. Surv. Prof. Paper 101, 254, pl. 36, fig. 3, 1917. Berry, U. S. Geol. Surv. Prof. Paper 185-F, 129, 1934. Dorf, Bull. Geol. Soc. Amer., vol. 51, 222, 225, 1940.

The specimen here figured is the better of 2 incomplete leaves of this type in the Lance Creek collections. Except for the somewhat larger angle of divergence of the secondary venation, these leaves cannot be distinguished from the figured and type specimen of *Canna? magnifolia* from the Vermejo formation of Colorado. The Medicine Bow specimen referred to *Canna* cf. *C.? magnifolia* differs only in the absence of the alternation of thick and thin veins.[3] I have not been able to compare these specimens with the reported example of this species which Berry described from the lower Lance (Hell Creek) formation of South Dakota.[4]

The uncertainty regarding the taxonomic affinities of this species has been discussed in my cited report on the Medicine Bow flora.

Occurrence—Localities P3652, P3853.

Collection—U. C. Mus. Pal., Plesiotype No. 2492.

[1] Berry, E. W., U. S. Geol. Surv. Prof. Paper 91, 175, pl. 113, fig. 4, 1916.
[2] New York Botanical Garden, sheets Nos. 18, 2687.
[3] Dorf, E., Carnegie Inst. Wash. Pub. No. 508, pt. I, 49, pl. 2, fig. 5, 1938.
[4] Property of Mr. Henry Lee, of Rapid City, South Dakota.

Family SALICACEÆ

Genus SALIX Linné

Salix lancensis Berry

(Plate 7, Figs. 2, 5, 7, 8; Plate 8, Fig. 3)

Salix lancensis Berry, U. S. Geol. Surv. Prof. Paper 185-F, 130, pl. 25, fig. 8, 1934.
Salix sp., Knowlton, Proc. Washington Acad. Sci., vol. 11, 207, 1909.

There are nearly a hundred specimens, from six localities, which agree closely with the specimens which Berry described and figured from the lower Lance (Hell Creek) formation of Harding County, South Dakota. The Lance Creek specimens apparently differ only in the somewhat more widely spaced marginal teeth. Since the marginal characters of the Harding County specimens are poorly preserved, it may be that more adequate specimens would reveal the same kind of teeth as are seen in those from the Lance Creek area.

There are apparently no other later Cretaceous or early Tertiary species of *Salix* with which these specimens can be compared. There is a possibility that they may be slender forms of *Fraxinus leii* Berry, from which they appear to differ mainly in their very lanceolate shape and their more numerous secondaries and marginal teeth.

The generic reference to *Salix* seems reasonably justifiable.

Occurrence—Localities P3652, P3853, P3854, P3857, P3859; U. S. Geol. Survey Locality 1469.

Collection—U. S. National Museum, Plesiotypes Nos. 40251, 40252; U. C. Mus. Pal., Plesiotypes Nos. 2493, 2494, 2495.

Genus SALICIPHYLLUM Fontaine

Saliciphyllum wyomingensis (Knowlton and Cockerell) Dorf, n. comb.

(Plate 8, Fig. 5)

Salix wyomingensis Knowlton and Cockerell, U. S. Geol. Surv. Bull. 696, 572, 1919. Knowlton, U. S. Geol. Surv. Prof. Paper 130, 125, pl. 4, figs. 3, 4, 8, 1922.
Salix integra Goeppert, Ztschr. Deut. geol. Gesellsch., vol. 4, 493, 1852. Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1873), 397, 1874; Rept. U. S. Geol. Surv. Terr., vol. 7, 167, pl. 22, figs. 1, 2, 1878.
?*Quercus cinereoides* Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 7, 152, pl. 21, fig. 6, 1878. Knowlton, Proc. Washington Acad. Sci., vol. 11, 207, 1909.
Laurus lakesii Knowlton, U. S. Geol. Surv. Prof. Paper 130, 144, pl. 22, fig. 6, 1922.

There are 3 specimens which are sufficiently complete to indicate their identity with the type and figured specimens of *Salix wyomingensis* from the Black Buttes and Laramie floras. I have also seen the specimen from the Lance formation which Knowlton referred to *Quercus cinereoides* and find it indistinguishable. The original type specimen of *Q. cinereoides* ("Locality unknown") is not to be found in the collection at the U. S. National Museum, hence I have questioned its reference to the new combination. I can see no justifiable basis of distinction for the Laramie specimen described by Knowlton as *Laurus lakesii*, which was collected from the same locality as several specimens of *Salix wyomingensis*.

This somewhat generalized leaf form may be distinguished from other species of similar shape by the number and the high angle of its secondaries, which loop abruptly upward near the margins, by its indistinct tertiary venation, and by its entire margins. It resembles, except for its tertiary venation, the specimens from Evanston, Wyoming, which Lesquereux referred to *Laurus primigenia* Unger.[1]

A definite reference of this species to the existing genus *Salix* seems unwarranted. Its characters seem equally lauraceous.[2] Pending more definite comparisons, it is advisable to refer it to the form genus *Saliciphyllum*, indicating only a similarity to the leaves of *Salix*.

Occurrence—Locality P3857.

Collection—U. C. Mus. Pal., Plesiotype No. 2496.

[1] Lesquereux, L., Rept. U. S. Geol. Surv. Terr., vol. 7, 214, pl. 36, figs. 5, 6, 8, 1878.
[2] Cf. *Litsea glaucescens* H. B. and K., New York Botanical Garden, Nos. 7352, 1489.

Family FAGACEÆ

Genus DRYOPHYLLUM Debey

Dryophyllum subfalcatum Lesquereux

(Plate 8, Figs. 2, 4, 6, 7)

Dryophyllum (Quercus) subfalcatum Lesquereux, U. S. Geol. and Geog. Surv. Terr., Bull., vol. 1, 379, 1876; U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1874), 301, 1876; Rept. U. S. Geol. Surv. Terr., vol. 7, 163, pl. 63, fig. 10, 1878. Knowlton, U. S. Geol. Surv. Bull. 163, 41, 1900; Proc. Washington Acad. Sci., vol. 11, 211, 1909. Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. I, 51, pl. 5, figs. 1, 2, 6, 1938. Brown, U. S. Geol. Surv. Prof. Paper 189, 248, pl. 50, figs. 1–8, pl. 51, figs. 1–7, 8*b*, pl. 52, figs. 1–3, pl. 54, fig. 1, 1939. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

Dryophyllum aquamarum Ward, U. S. Geol. Surv. 6th Ann. Rept., 551, pl. 37, figs. 3–5, 1885; U. S. Geol. Surv. Bull. 37, 26, pl. 10, figs. 2–4, 1887. Knowlton, U. S. Geol. Surv. Prof. Paper 101, 299, pl. 70, fig. 2, 1917.

Dryophyllum bruneri Ward, U. S. Geol. Surv. 6th Ann. Rept., 551, pl. 36, figs. 6–9, 1885; U. S. Geol. Surv. Bull. 37, 27, pl. 10, figs. 5–8, 1887. Knowlton, U. S. Geol. Surv. Prof. Paper 101, 259, pl. 53, fig. 5, 1917. Hollick, U. S. Geol. Surv. Prof. Paper 159, 70, pl. 38, fig. 2, 1930.

Dryophyllum falcatum Ward, U. S. Geol. Surv. 6th Ann. Rept., 551, pl. 37, fig. 10, 1885; U. S. Geol. Surv. Bull. 37, 27, pl. 11, fig. 1, 1887. Knowlton, U. S. Geol. Surv. Bull. 163, 42, pl. 8, fig. 1, 1900.

Quercus gracilis Newberry, Proc. U. S. Nat. Mus., vol. 5, 504, 1883; U. S. Geol. Surv. Mon. 35, 75, pl. 67, fig. 4, 1898.

Quercus doljensis Pilar. Ward, U. S. Geol. Surv. 6th Ann. Rept., 551, pl. 36, figs. 9, 10, 1885; U. S. Geol. Surv. Bull. 37, 25, pl. 9, figs. 4, 5, 1887.

Quercus whitmani Knowlton, U. S. Geol. Surv. Prof. Paper 155, 52, pl. 17, fig. 5, 1930.

Quercus turbulenta Hollick, U. S. Geol. Surv. Prof. Paper 159, 70, pl. 38, fig. 3, 1930.

Rhus pseudo-meriani Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 7, 293, pl. 58, fig. 11, 1878.

Fraxinus? princetoniana Knowlton, U. S. Geol. Surv. Prof. Paper 130, 161, pl. 22, fig. 7, 1922.

Salix sp., Knowlton (2 spp.), Proc. Washington Acad. Sci., vol. 11, 207, 1909.

As in the Medicine Bow flora, the leaves of this distinctive type are among the dominants of the Lance flora in the Lance Creek area. They are also reported by Brown as abundant in the Colgate and true Lance (Hell Creek formation) of eastern Montana. The Lance Creek specimens, of which 2 are here figured, show the same kind and degree of variation as is apparent in the leaves of this form in the Medicine Bow, the Hell Creek, and the Black Buttes floras.

The systematic status and the stratigraphic significance of this species have been fully discussed in my report, cited above, on the Medicine Bow flora.

Occurrence—Localities P3651, P3854, P3855, P3857, P3858, P3859.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 2497, 2498, 2499, 2500.

Genus QUERCOPHYLLUM Fontaine

Quercophyllum gardneri (Knowlton) Dorf, n. comb.

(Plate 9, Fig. 3)

Quercus gardneri Knowlton, U. S. Geol. Surv. Prof. Paper 101, 259, pl. 38, fig. 3, 1917. Dorf, Bull. Geol. Soc. Amer., vol. 51, 222, 1940.

Quercus rockvalensis Knowlton, U. S. Geol. Surv. Prof. Paper 101, 259, pl. 38, fig. 4, 1917.

There are 4 fairly complete specimens, from two localities, which I cannot distinguish from the type and figured Vermejo specimens which Knowlton referred to the two species above. I can see no valid grounds for their separation; the slight differences in a few tertiary veins between the two Vermejo specimens, and between these and the Lance Creek example figured, can hardly be regarded as of specific importance. No other recorded leaves from the late Cretaceous or early Tertiary have comparable features.

These leaves bear an undeniable resemblance to the leaves of several existing oaks, such as *Quercus undulata* Torrey, as is pointed out by Knowlton, and more especially *Q. sinuata* Walter and *Q. margaretta* Ashe of southeastern United States. These are generally more prominently lobed, however, and have stronger veins. In view of the absence of positive evidence of relationship to *Quercus*, it is thought best to refer the fossil species to the less definite form genus *Quercophyllum*.

Occurrence—Localities P3853, P3858.

Collection—U. C. Mus. Pal., Plesiotype No. 2501.

Family MORACEÆ

Genus FICUS (Tournefort) Linné

Ficus planicostata Lesquereux

Ficus planicostata Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1872), 393, 1873; Rept. U. S. Geol. Surv. Terr., vol. 7, 201, pl. 31, figs. 1–8, 10–12, 1878. Knowlton, U. S. Geol. Surv. Bull. 163, 52, pl. 10, fig. 4, pl. 12, figs. 2, 3 (not 4), 1900; Proc. Wash. Acad. Sci., vol. 11, 211, 1909. Cockerell, Univ. Colorado Studies, vol. 7, 151, 1910. Knowlton, U. S. Geol. Surv. Prof. Paper 130, 131, 1922; U. S. Geol. Surv. Prof. Paper 134, 82, pl. 9, fig. 2, 1924. Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. 1, 53, pl. 5, figs. 3–5, 7, 1938; Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.
Ficus planicostata goldiana Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1873), 399, 1874; Rept. U. S. Geol. Surv. Terr., vol. 7, 202, pl. 33, figs. 1–3, 1878. Knowlton, U. S. Geol. Surv. Prof. Paper 155, 70, pl. 28, fig. 5, 1930.
Ficus planicostata clintoni (Lesquereux) Knowlton, U. S. Geol. Surv. Bull. 152, 103, 1898; U. S. Geol. Surv. Prof. Paper 101, 303, pl. 76, fig. 3, 1917.
Ficus clintoni Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1872), 393, 1873.
Ficus planicostata magnifolia Knowlton, U. S. Geol. Surv. Prof. Paper 130, 133, pl. 10, fig. 3, 1922.
Ficus leei Knowlton (in part), U. S. Geol. Surv. Prof. Paper 101, 261, pl. 39, figs. 2–5 only, 1917; U. S. Geol. Surv. Prof. Paper 98, 338, pl. 90, fig. 2, 1916.
Ficus pseudopopulus Lesquereux (in part). Knowlton, U. S. Geol. Surv. Prof. Paper 101, 304, pl. 72, figs. 3, 4 only, 1917; U. S. Geol. Surv. Prof. Paper 134, 83, pl. 7, fig. 4, pl. 9, fig. 3, 1924; U. S. Geol. Surv. Prof. Paper 155, 66, only pl. 25, figs. 3–5, 1930.
Ficus neoplanicostata Knowlton (in part), U. S. Geol. Surv. Prof. Paper 101, 303, pl. 73, fig. 4, pl. 74, figs. 2, 3, pl. 76, fig. 4, 1917; U. S. Geol. Surv. Prof. Paper 134, 82, pl. 9, fig. 4, 1924; U. S. Geol. Surv. Prof. Paper 155, 69, only pl. 28, figs. 3–7, 1930.
Ficus prælatifolia Knowlton, U. S. Geol. Surv. Prof. Paper 98, 338, pl. 87, fig. 4, 1916.
Pterospermites neomexicanus Knowlton, U. S. Geol. Surv. Prof. Paper 98, 341, pl. 90, fig. 6, 1916.
Ficus impressa Knowlton, U. S. Geol. Surv. Prof. Paper 130, 134, pl. 7, figs. 1–3, pl. 16, fig. 3, 1922.

There are only 5 specimens in the collections which are referable to this well-defined leaf type. This is in marked contrast with its abundance in the Black Buttes, Laramie, and Medicine Bow floras.

A detailed discussion of this species has already been given in my report on the Medicine Bow flora, cited above. On the basis of present knowledge, it is apparent that the Lance Creek area was near the northern limit of the range of this species, since it is not known to occur in the Hell Creek flora of similar age in Montana and the Dakotas, or in the equivalent Whitemud flora of Saskatchewan.

Occurrence—Locality P3853.

Collection—U. C. Mus. Pal., No. 2502.

Family PLATANACEÆ

Genus PLATANOPHYLLUM Fontaine

Platanophyllum montanum (Brown) Dorf, n. comb.

(Plate 9, Figs. 1, 4)

Sassafras montana Brown, U. S. Geol. Surv. Prof. Paper 189, 250, pl. 52, fig. 4, pl. 55, fig. 4*b*, 1939. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.
Sassafras sp., Knowlton, Proc. Washington Acad. Sci., vol. 11, 207, 1909.
Aralia sp., Knowlton, Proc. Washington Acad. Sci., vol. 11, 207, 1909.

This well-defined leaf form is the dominant among the specimens collected at Locality P3854. More than 75 specimens were obtained for study. None of these is preserved in its entirety, owing to the conchoidal and fractured nature of the matrix. A sufficient number of fairly complete specimens were secured, however, to show the essential details of shape, size, margin, and venation.

Sassafras montana was described by Brown for specimens from the Hell Creek formation of Montana, as follows:

"Leaves 8 centimeters or more wide, three-lobed, the lobes relatively short, blunt-rounded; sinuses narrow, rounded; base cuneate; petiole 5 centimeters long. The lateral primary veins depart from the midrib 0.5 centimeter above the top of the petiole, and after running a fairly straight course pass into the two lateral lobes. The secondary venation is camptodrome."

Examination of Brown's type specimens at the U. S. National Museum has shown that the leaves are actually remotely dentate, though the coarse sandy matrix makes this feature inconspicuous. There is no doubt in my mind, therefore, that the Lance Creek forms are referable to the species described by Brown.

Knowlton had already encountered this type of leaf in his collections from the Lance Creek area, which I have consulted at the U. S. National Museum. These were tentatively referred by him to *Sassafras* sp. and *Aralia* sp. in his published lists, and to *Aralia* n. sp. (specimen No. 1017) in the collections. All these specimens are essentially similar to those from my collection and from Montana.

As was pointed out by Brown, there is a general resemblance between this species and *Araliopsoides cretacea* (Newberry) Berry (= *Sassafras cretaceum* Newberry) from the Dakota, Raritan, and Magothy floras.[1] There is also a resemblance to *Aralia veatchii* Knowlton from the Frontier formation.[2] In both these species, however, there are differences from *Platanophyllum montanum* in shape, venation, and marginal characters.

After consulting all available herbarium specimens of the living species of *Sassafras* at the New York Botanical Garden, I am convinced that the Lance specimens of this species are not referable to the genus *Sassafras*. In *Sassafras* leaves the 3 basal primaries are always suprabasilar, the lobes are entire and rounded, and the venation is lauraceous in character. In the modern Platanaceæ, on the other hand, the leaves are more like the fossils here concerned in shape, venation, and marginal characters.

Occurrence—Localities P3854, P3855, P3857, P3859.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 2503, 2504, 2505.

Platanophyllum platanoides (Lesquereux) Dorf, n. comb.

Viburnum platanoides Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1874), 314, 1876; Rept. U. S. Geol. Surv. Terr., vol. 7, 224, pl. 38, figs. 8, 9, 1878. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

Platanus platanoides (Lesquereux) Knowlton (in part), U. S. Geol. Surv. Bull. 152, 171, 1898.

Platanus sp., Brown, U. S. Geol. Surv. Prof. Paper 189, 249, pl. 59, fig. 4 only, 1939.

There are 4 well-preserved, though not complete, specimens from Locality P3652 which are referable to this species. Unfortunately the specimens are so curled in the matrix that they cannot be adequately photographed and figured.

Lesquereux distinguished this species from *Viburnum marginatum* Lesquereux by "the less numerous, more open, lateral veins, whose branches are more curved in passing up to the borders, and especially by the enlarged truncate or subtruncate base of the leaves." It may be added that the coarse tertiaries, the large, obtuse teeth, and the presence of teeth along the basal edge of the leaves are also diagnostic characters.

Outside of its type locality at Black Buttes, Wyoming, this species has been described and figured from the Raton,[3] the Denver,[4] and the Laramie floras.[5] The Raton and Laramie specimens do not have the diagnostic characters of the species and have been referred to *Viburnum marginatum* Lesquereux.[6] The Denver specimen is a very inadequate one which does not, moreover, have the truncate, enlarged basal characters of *Platanophyllum platanoides*.

One of the Fox Hills specimens which Brown referred to *Platanus* sp., which I have seen, is believed to belong to this same species.

The platanoid character of these leaves is apparent. Following the trend of modern nomenclators, it seems advisable, in the absence of definite proof, to refer the species to the less positive genus *Platanophyllum*.

Occurrence—Locality P3652.

Collection—U. C. Mus. Pal., No. 2506.

[1] Berry, E. W., Maryland Geol. Surv., Upper Cretaceous, 879, pl. 74, fig. 3, pl. 84, figs. 1, 2, pl. 85, figs. 1–5, pl. 88, figs. 1–3, 1916. Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 6, 80, pl. 11, figs. 1, 2, pl. 12, fig. 2, 1874.

[2] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 108, 92, pl. 36, fig. 4, pl. 37, fig. 4, pl. 38, fig. 1, pl. 39, 1917.

[3] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 101, 323, pl. 95, fig. 4, 1917.

[4] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 155, 82, pl. 36, fig. 5, 1930.

[5] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 130, 146, pl. 13, fig. 1, 1922.

[6] Dorf, E., Carnegie Inst. Wash. Pub. No. 508, pt. I, 73, 1938.

Family ARISTOLOCHIACEÆ

Genus ARISTOLOCHITES Heer

Aristolochites brittoni (Knowlton) Dorf, n. comb.

(Plate 10, Fig. 1)

Aristolochia brittoni Knowlton, U. S. Geol. Surv. Bull. 696, 96, 1919; U. S. Geol. Surv. Prof. Paper 130, 140, pl. 23, figs. 3-5, 1922. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

There are 2 fairly complete specimens in the collections which are indistinguishable in essential details from the figured and type specimens of this species, known previously only from the Laramie formation.

After consulting several hundred genera of living forms, one has little doubt, as Knowlton has already stated, as to the close similarity between these fossil leaves and those of several existing species of *Aristolochia*. Knowlton has pointed out the resemblance to *A. clematis* Linné and *A. hirta* Linné of the Old World and to the American *A. tomentosa* Sims. I have noted also an agreement in essential details with the leaves of *A. gigantea* M. and Z., at the New York Botanical Garden.[1] In the absence of positive proof of generic identity, however, it seems advisable to refer this species to *Aristolochites*, implying family relationship to the modern Aristolochiaceæ.

Occurrence—Locality P3854.

Collection—U. C. Mus. Pal., Plesiotype No. 2507.

Family LAURACEÆ

Genus LAUROPHYLLUM Goeppert

Laurophyllum coloradensis (Knowlton) Dorf, n. comb.

(Plate 9, Fig. 2)

Anona coloradensis Knowlton, U. S. Geol. Surv. Bull. 696, 78, 1919; U. S. Geol. Surv. Prof. Paper 130, 143, pl. 18, fig. 4, 1922.

Laurus socialis Lesquereux. Knowlton, U. S. Geol. Surv. Prof. Paper 155, 85, pl. 38, fig. 4, 1930. Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. I, 61, pl. 7, fig. 4, 1938; Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

There is a single nearly complete specimen and several fragmentary impressions which are indistinguishable from the type and figured specimens listed above. In the discussion of this leaf form in the Medicine Bow flora, I stated that the incomplete specimens were "referred with doubt" to *Laurus socialis*. It was noted that in the type specimens of that species "the shape is more lanceolate and the secondaries are more numerous, more obtuse, and less prominently looped near the borders." With the more complete material now at hand in the Lance collections, it is certain that these well-defined leaves are not referable to *Laurus socialis*. The type specimen of *Anona coloradensis* from the Laramie formation is, on the other hand, more clearly defined than its reproduction implies, and is not distinguishable from the Dawson and Medicine Bow specimens which were alleged to be *Laurus socialis*. The specimen previously identified as *Juglans leconteana* Lesquereux[2] comes from the same locality as the specimen of *Laurophyllum coloradensis* here figured and is not now regarded as sufficiently distinct to warrant separation from the latter species.

In his description of *Anona coloradensis*, Knowlton noted a resemblance to the living *Anona palmeri* Safford of Mexico, but observed that there were usually fewer secondaries in the fossil specimens. After consulting the leaves of all available species of *Anona* at the New York Botanical Garden, I am convinced that this comparison is rather remote. As was pointed out in my Medicine Bow report,[3] these fossil specimens resemble more closely such lauraceous genera as *Persea* and *Laurus*. It has therefore seemed more advisable to refer these forms to the genus *Laurophyllum*, indicating a similarity to the leaves of the Lauraceæ.

Occurrence—Localities P3854, P3855, P3858.

Collection—U. C. Mus. Pal., Plesiotype No. 2508.

[1] Sheet No. 19982—Vicinity of Machado Portello, Bahia, Brazil.

[2] Dorf, E., Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

[3] Dorf, E., Carnegie Inst. Wash. Pub. No. 508, pt. I, 61, 1938.

Laurophyllum meeki Dorf

Laurophyllum meeki Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. I, 60, pl. 7, fig. 5, 1938.
Diospyros? ficoidea Lesquereux (in part), Rept. U. S. Geol. Surv. Terr., vol. 7, 231, pl. 40, fig. 6 only, 1878.
Daphnogene elegans Watelet. Ward, U. S. Geol. Surv. 6th Ann. Rept., 553, pl. 47, fig. 4, 1885; U. S. Geol. Surv. Bull. 37, 51, pl. 35, fig. 1, 1887.
Ficus crossii Ward. Knowlton, U. S. Geol. Surv. Prof. Paper 130, 139, pl. 11, fig. 2, 1922. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

There are 4 well-preserved specimens which were misidentified as *Ficus crossii* because of their similarity to the Laramie specimen which Knowlton had referred to that species. I had previously regarded the Laramie specimen as more probably referable to *Rhamnus goldianus* Lesquereux[1] and certainly not to *Ficus crossii.* On the basis of further studies with the type specimens at the U. S. National Museum, however, it has become evident that the Laramie specimen, as well as those of the type Lance, cannot be distinguished from the type specimens of *Laurophyllum meeki* or its synonymous forms. The leaves of *Rhamnus goldianus* were found to be uniformly of thinner texture, with more closely spaced secondaries and with more numerous, parallel tertiaries.

As here interpreted, *Laurophyllum meeki* is known from the Black Buttes, Medicine Bow, Laramie, and type Lance floras. Its resemblance to existing lauraceous leaves has already been pointed out in my original discussion of the species.

Occurrence—Locality P3853.

Collection—U. C. Mus. Pal., No. 2509.

Laurophyllum salicifolium (Lesquereux) Dorf, n. comb.

(Plate 9, Fig. 5)

Rhamnus salicifolius Lesquereux, Amer. Jour. Sci., 2d ser., vol. 45, 206, 1868; U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1869), 196, 1873 (reprint); Rept. U. S. Geol. Surv. Terr., vol. 7, 282, pl. 53, figs. 9, 10, 1878. Knowlton, U. S. Geol. Surv. Prof. Paper 101, 271, 1917; U. S. Geol. Surv. Prof. Paper 130, 154, pl. 15, fig. 4, pl. 19, fig. 2*b*, 1922. Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. I, 66, pl. 12, figs. 4, 5, pl. 13, fig. 4, 1938; Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.
Rhamnus salicifolius Lesquereux?. Knowlton, U. S. Geol. Surv. Bull. 163, 70, 1900; U. S. Geol. Surv. Prof. Paper 155, 107, pl. 46, fig. 12, 1930.
Rhamnus belmontensis Knowlton and Cockerell, U. S. Geol. Surv. Bull. 696, 544, 1919. Knowlton, U. S. Geol. Surv. Prof. Paper 130, 155, 1922.
Rhamnus elegans Newberry, Ann. New York Lyc. Nat. Hist., vol. 9, 49, 1868; U. S. Geol. Surv. Mon. 35, 117, pl. 50, fig. 2, 1898.
Juglans laramiensis Knowlton, U. S. Geol. Surv. Prof. Paper 130, 120, pl. 20, fig. 12, 1922.
Ficus? smithsoniana (Lesquereux) Lesquereux ?. Knowlton, U. S. Geol. Surv. Prof. Paper 130, 130, pl. 21, fig. 4, 1922.
Laurus lanceolata Knowlton, U. S. Geol. Surv. Bull. 696, 346, 1919; U. S. Geol. Surv. Prof. Paper 130, 143, pl. 21, fig. 7, 1922. Brown, U. S. Geol. Surv. Prof. Paper 189, 250, pl. 53, fig. 6, 1939.

This well-defined leaf form is rare in the Lance Creek collections, being represented by only 5 specimens from three localities. A full description and discussion of this species has been given in my report on the Medicine Bow flora. The inclusion of the specimens of *Laurus lanceolata* in this species is here made on the basis of further consultation of the collections at the U. S. National Museum. These collections were found to contain also the following unidentified specimens which I believe belong to this species: 1 nearly perfect specimen in the Laramie collection (No. 130), and 3 specimens in the Vermejo collection (Nos. 34502, 51154, 254). The species was reported and figured previously from both these formations.

As I have previously pointed out, these fossil leaves are distinctly not rhamnaceous, but are difficult to distinguish from several living species of *Persea* and *Nectandra* of the Lauraceæ. The resemblance to this family is accordingly indicated by referring the species to the genus *Laurophyllum.*

Occurrence—Localities P3854, P3857, P3859.

Collection—U. C. Mus. Pal., Plesiotype No. 2510.

[1] Dorf, E., Carnegie Inst. Wash. Pub. No. 508, pt. I, 56, 1938.

Laurophyllum wardiana (Knowlton) Dorf, n. comb.

(Plate 9, Fig. 6)

Laurus wardiana Knowlton, U. S. Geol. Surv. Bull. 152, 129, 1898. Berry, U. S. Geol. Surv. Prof. Paper 91, 13, 1916. Knowlton, U. S. Geol. Surv. Prof. Paper 130, 144, pl. 16, fig. 1, 1922. Berry, U. S. Geol. Surv. Prof. Paper 185-F, 132, pl. 26, fig. 3, 1934. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

Laurus ocoteoides Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 7, 215, pl. 36, fig. 10, 1878; U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1876), 510, 1878. [Homonym *Laurus ocoteæoides* Massalongo, Syn. Fl. Foss. Senogalliensis, 57, pl. 24, fig. 3, pl. 40, fig. 1, 1858.]

The nearly complete specimen figured here is the best of 3 specimens of this leaf form in the collections. These are clearly indistinguishable from the type and figured specimens of the Laramie species originally referred by Lesquereux to *Laurus ocoteoides*, a name preoccupied by Massalongo. The original description of this species was as follows:

"Leaf long, coriaceous, narrowly lanceolate, gradually tapering from below the middle upward to an obtuse acumen, cuneate to the petiole; lateral veins thin, open, subequidistant, close, slightly curved."

Although the essential characters of the leaf of this species are well defined, the species is apparently not a common form in the late Cretaceous of the Rocky Mountain region. It is at present known only from a few specimens from each of the following formations: Laramie, Hell Creek, Medicine Bow (?), lower Dawson (?),[1] and the type Lance. There is a similarity in leaf form to the Laramie specimens referred to *Ficus navicularis* Cockerell.[2] Both the figured and the type specimens of this species indicate, however, striking differences in the areolated tertiary venation.

There seems little justification for the positive reference of this species to the modern genus *Laurus*. As Berry has pointed out, these leaves "cannot be certainly distinguished from the leaves of a number of existing genera such as *Nectandra*, *Oreodaphne*, and *Mespilodaphne*."

Occurrence—Locality P3859.

Collection—U. C. Mus. Pal., Plesiotype No. 2511.

Family CERCIDIPHYLLACEÆ

Genus CERCIDIPHYLLUM Siebold and Zuccarini

Cercidiphyllum arcticum (Heer) Brown

(Plate 10, Fig. 5)

Cercidiphyllum arcticum (Heer) Brown, Jour. Paleontol., vol. 13, 492, pl. 53, pl. 54, figs. 1–7, 12, 13, 17, pl. 56, figs. 1–6a, 10, 11, 1939 (see complete synonymy).

Phyllites colubrinoides Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940 (not Dorf, 1938).

There is a single complete specimen from Locality P3854 which I had previously regarded as a variant of the normal leaf form of *Phyllites colubrinoides*. Since the excellent synthesis of the late Cretaceous and Tertiary species of *Cercidiphyllum* by Brown, it has become evident that the specimen is more properly considered within the rather wide range of variability of *C. arcticum*. It cannot be separated on any rational basis, for example, from the specimens figured by Brown on his plate 53, figure 6, nor from those figured by Berry from the Ravenscrag formation[3] of Saskatchewan.

Leaves of this species are exceedingly rare in the late Cretaceous sediments of the Rocky Mountain region. They are very abundant, on the other hand, in deposits of known Paleocene age, such as the "Fort Union," Hanna, Paskapoo, and Ravenscrag.

Both Berry and Brown have pointed out the similarity of the leaves of this species to those of *Cercidiphyllum japonicum* S. & Z. of eastern Asia.

Occurrence—Locality P3854.

Collection—U. C. Mus. Pal., Plesiotype No. 2515.

[1] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 130, 24, 1922.
[2] Ibid., 137, pl. 6, figs. 4, 5, pl. 11, figs. 3–5.
[3] Berry, E. W., Canada Geol. Surv. Mem. 182, 34, pl. 6, figs. 3, 5, 1935 (*Trochodendroides cuneata*).

Cercidiphyllum ellipticum (Newberry) Brown

(Plate 10, Figs. 2–4)

Cercidiphyllum ellipticum (Newberry) Brown, Jour. Paleontol., vol. 13, no. 5, 491, pl. 52, figs. 1–17, pl. 54, figs. 8, 9–11, 14–16, 1939 (see synonymy).

Populus elliptica Newberry, Ann. New York Lyc. Nat. Hist., vol. 9, 16, 1868; U. S. Geol. Surv. Mon. 35, 43, pl. 3, figs. 1, 2, 1898.

Trochodendroides nebrascensis (Newberry) Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. I, 61, pl. 11, figs. 1, 4, 6, 7, 1938 (see synonymy); Bull. Geol. Soc. Amer., vol. 51, 218, 220, 222, 225, 1940.

Trochodendroides sp., Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 220, 225, 1940.

The somewhat variable leaves of this species are not so abundant in the type Lance flora as they are in the Medicine Bow and Denver. Only 9 specimens from three localities have been found. The figured specimen, though not complete, shows the typical ovate-elliptic shape, rounded base, and toothed margin which serve to distinguish this species from others. The venation, which is known to be variable, is of precisely the character seen in several of the numerous Medicine Bow specimens of this species in the Princeton and University of California collections.[1] Numerous specimens from the Hell Creek formation in the collections of Princeton University (Corbin collection) are also of precisely the same character.

Brown's recent studies of this and related species have shown that leaves of the form referred to *Cercidiphyllum ellipticum* are widely distributed, and usually abundant, in the Upper Cretaceous of the Northern Hemisphere. It is apparently also known, though of rare occurrence, in the early Paleocene of North America.

The generic status of this species has been satisfactorily clarified by Brown's discovery of the characteristic fruits and seeds of *Cercidiphyllum* in association with the leaves, which had already previously been regarded as of the *Cercidiphyllum* form. Brown has found the leaves, fruits, and seeds in association at no less than thirty localities in the Upper Cretaceous and Tertiary deposits of the United States. In the Lance Creek collections there are associated fruits, hitherto called *Leguminosites arachioides minor*, but none of the small winged seeds have been detected.

Occurrence—Localities P3652, P3858, P3859.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 2512, 2513, 2514.

Family NYMPHÆACEÆ

Genus NELUMBO Adanson

Nelumbo tenuifolia (Lesquereux) Knowlton

(Plate 10, Fig. 10)

Nelumbo tenuifolia (Lesquereux) Knowlton, U. S. Geol. Surv. Prof. Paper 130, 141, pl. 26, fig. 7, 1922; U. S. Geol. Surv. Prof. Paper 155, 92, pl. 41, fig. 2, 1930. Berry, Canada Geol. Surv. Mem. 182, 37, pl. 7, figs. 2, 3, 1935.

Nelumbium tenuifolium Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1873), 402, 1874; Rept. U. S. Geol. Surv. Terr., vol. 7, 253, pl. 46, fig. 3, 1878.

Nelumbium lakesianum Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1873), 403, 1874.

Nelumbium lakesii Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 7, 252, pl. 46, figs. 1, 2, 1878.

Nelumbo lakesiana (Lesquereux) Knowlton, U. S. Geol. Surv. Prof. Paper 101, 308, 1917; U. S. Geol. Surv. Prof. Paper 155, 91, pl. 41, fig. 1, pl. 42, fig. 2, 1930.

In the collection borrowed from the U. S. National Museum there is a single fairly complete specimen which agrees in all essential details with the characters of the type specimens of *Nelumbo tenuifolia*. Berry has recently properly united *N. lakesiana* with the former species on the basis of similarity of significant features.

As at present interpreted, this species is fairly widely distributed in the late Cretaceous sediments of the Rocky Mountain region and may possibly continue into the early Paleocene. It has been reported on adequate material from the Laramie, Denver, and Raton formations of Colorado, the Lance of Wyoming, and the Whitemud and middle Ravenscrag (?) of Saskatchewan. It is

[1] Dorf, E., Carnegie Inst. Wash. Pub. No. 508, pt. I, pl. 11, fig. 6, 1938.

not known to occur in "Fort Union" sediments or other formations of undisputed Paleocene or later age.

The reference of this species to the existing genus *Nelumbo* seems rather certain; no other modern leaves have come to my attention which have the combination of features observed in the fossil forms.

Occurrence—U. S. Geol. Survey Locality 1485.

Collection—U. S. National Museum, No. 40253.

Genus NYMPHÆITES Sternberg

Nymphæites browni Dorf, n. sp.

(Plate 10, Fig. 9)

The figured specimen, and one other from the collections of the U. S. National Museum, are the only ones of this kind encountered.

Description—Leaf cordate-orbicular, about 3.5–4 cm. in diameter, with entire margin and deeply cordate base; veins radiating from base, about 14 in number, irregularly forking acutely toward the margin, usually twice or three times; tertiary venation not preserved; texture apparently fairly thick.

This species, which differs mainly in its well-defined cordate base from the other species of Nymphæaceæ in the Lance flora, is comparable in some of its characters to *Castalia? duttoniana* Knowlton [1] from the Mesaverde formation of southeastern Wyoming. The deeply cordate base, however, clearly distinguishes it from that species as well as other fossil species. Its modern relationship is clearly with the Nymphæaceæ.

The species is named for Dr. Roland W. Brown, of the U. S. Geological Survey.

Occurrence—U. S. Geol. Survey Locality 1462.

Collection—U. S. National Museum, Cotypes Nos. 40254, 40255.

Nymphæites dawsoni (Hollick) Dorf, n. comb.

(Plate 10, Figs. 6–8)

Nelumbo dawsoni Hollick, Bull. Torrey Bot. Club, vol. 21, 309, 1894. Berry, Canada Geol. Surv. Mem. 182, 36, pl. 7, fig. 1, 1935. Brown, U. S. Geol. Surv. Prof. Paper 189, 250, pl. 48, fig. 11, 1939. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

Brasenia antiqua Newberry. Dawson, Trans. Roy. Soc. Canada, vol. 3, sec. 4, 15, text fig., 1886.

Lemna scutata Dawson. Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 7, 102, pl. 61, fig. 2 only, 1878.

Nelumbo laramiensis Hollick, Bull. Torrey Bot. Club, vol. 21, 307, text fig., 1894.

Nelumbo intermedia Knowlton, U. S. Geol. Surv. Bull. 163, 53, pl. 13, figs. 3–5, 1900.

The 3 specimens figured are the best of 6 impressions of this leaf form in the collections. These cannot be distinguished on any valid, natural basis from the figured or type specimens of the several species listed above.

In their discussions of *Nelumbo dawsoni*, both Berry and Brown united all the above species into one, on the basis of valid resemblances in essential details. No other leaves of comparable size and characteristics have been reported from the Mesozoic or Cenozoic of North America. The species is at present known in the upper Mesaverde, Belly River, Vermejo, Whitemud, Colgate, and type Lance floras. It is not reported from any deposits of known Paleocene or later age.

As was intimated by Berry, the generic reference of this species to *Nelumbo* is doubtful. I have not seen any leaves of modern species of *Nelumbo* which are comparable with the fossil specimens either in size or in average number of secondary veins. The leaves of the living *Brasenia*, on the other hand, are more nearly similar; see, for example, *Brasenia peltata* Pursh. In view of the general resemblance of the fossil species to several genera of the Nymphæaceæ, it seems advisable to refer it to the genus *Nymphæites*, implying family relationship only.

Occurrence—Locality P3853.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 2516, 2517, 2518.

[1] Knowlton, F. H., U. S. Geol. Surv. Bull. 163, 55, pl. 13, fig. 7, 1900.

Family MENISPERMACEÆ

Genus MENISPERMITES Lesquereux

Menispermites belli Berry

(Plate 11, Fig. 4)

Menispermites belli Berry, Canada Geol. Surv. Mem. 182, 36, 1935. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

Ficus asarifolia Ettingshausen. Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 7, 207, 1878. Knowlton, U. S. Geol. Surv. Bull. 163, 49, pl. 11, fig. 4, pl. 13, fig. 2, 1900.

Ficus asarifolia minor Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 7, 208, pl. 61, figs. 18–21, 1878. Newberry, U. S. Geol. Surv. Mon. 35, 85, pl. 67, figs. 5, 6, 1898.

Ficus sp., Knowlton, Proc. Washington Acad. Sci., vol. 11, 207, 1909.

This well-defined leaf form is represented in the collections by 4 well-preserved specimens, of which the figured specimen is the most nearly complete. There are also 2 good specimens of it in the collections from the Lance Creek area in the U. S. National Museum.[1]

The original figured specimens of *Ficus asarifolia minor* Lesquereux were obtained from the upper Mesaverde group at Point of Rocks, Wyoming. Additional specimens were subsequently obtained from the same locality by Knowlton, who referred the specimens with much hesitation to *Ficus asarifolia* Ettingshausen. Knowlton also recorded the presence of a specimen of this species from the Black Buttes collection at the U. S. National Museum. I have consulted both the Mesaverde and Black Buttes specimens at the National Museum and find no essential differences between them and the Lance Creek specimens. Berry has recently obtained identical leaves from the Whitemud formation of Saskatchewan, and has synonymized all previously recorded specimens in the species *Menispermites belli* Berry.

As pointed out by both Knowlton and Berry, there is an unmistakable resemblance of these leaves to the modern family Menispermaceæ.

Occurrence—Locality P3853.

Collection—U. C. Mus. Pal., Plesiotype No. 2519.

Menispermites cockerelli (Knowlton) Dorf, n. comb.

(Plate 11, Fig. 2)

Ficus cockerelli Knowlton, U. S. Geol. Surv. Bull. 696, 273, 1919; U. S. Geol. Surv. Prof. Paper 130, 132, pl. 12, fig. 2, pl. 23, figs. 1, 2, 1922. Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. I, 55, pl. 7, fig. 2, 1938; Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

Ficus latifolia (Lesquereux) Knowlton, U. S. Geol. Surv. Bull. 152, 102, 1898; U. S. Geol. Surv. Prof. Paper 101, 304, 1917. [Homonym, Kunth, Ind. Sem. Hort. Berol., 1846.]

Ficus planicostata latifolia Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1872), 393, 1873; Rept. U. S. Geol. Surv. Terr., vol. 7, 202, pl. 31, fig. 9, 1878.

This species is represented in the collections by 2 fairly complete leaf impressions and several fragments. The 2 better specimens are slightly larger than the original type specimen from Black Buttes, Wyoming, though differing in no other way. They are essentially similar in observable details to the larger leaves figured by Knowlton from the Laramie flora.

In the Rocky Mountain region, this species is now known reliably from abundant specimens in the Laramie, Medicine Bow, and Black Buttes floras, from fewer specimens in the Lance flora, and doubtfully from a single fragment in the Raton flora.

As was pointed out in the discussion of *Ficus cockerelli* in my cited report on the Medicine Bow flora, the relationships of these leaves to modern genera or species are uncertain; they seem to resemble the Menispermaceæ more closely than any other family examined.

Occurrence—Locality P3853.

Collection—U. C. Mus. Pal., Plesiotype No. 2520.

Menispermites knightii Knowlton

(Plate 10, Fig. 11)

Menispermites knightii Knowlton, U. S. Geol. Surv. Bull. 163, 61, pl. 15, fig. 2, 1900. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

[1] Specimens No. 1002 (1462).

The collections contain 6 impressions of cordate-orbicular leaves which differ only in an additional pair of secondaries along the midrib from the type and figured specimen of *Menispermites knightii*. The original description was as follows:

"Leaf evidently thick in texture, broadly cordate, with rounded base and very deep sinuses, rounded, truncate at apex; margin undulate lobed, the lobes very short, obtuse, and entire or erose; nervation palmate, with about seven primary nerves of equal strength which apparently pass to the rounded lobes or are once or twice forked, the branches passing to the lobes; finer nervation not preserved."

The observable characters of this leaf form resemble those of several menispermaceous genera, particularly *Cocculus*. On the other hand, the thick texture is suggestive of an aquatic leaf. Among aquatic genera there is a marked resemblance to several of the Nymphæaceæ, particularly *Castalia* (*Nymphæa*). These differ, however, in minor respects, mainly in their more numerous secondaries and in their deeply cordate bases. In the absence of better comparison with modern leaves, it seems advisable to retain the more general name applied by Knowlton.

This species is at present known only from the Lance formation and the Mesaverde formation of southeastern Wyoming.

Occurrence—Locality P3858.

Collection—U. C. Mus. Pal., Plesiotype No. 2521.

Family MAGNOLIACEÆ

Genus MAGNOLIOPHYLLUM Conwentz

Magnoliophyllum cordatum Dorf

Magnoliophyllum cordatum Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. 1, 64, pl. 9, fig. 5, pl. 10, fig. 1, 1938; Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

This species is not abundant in the collections. Only 4 specimens of incomplete, though well-preserved, leaves were encountered. The general shape, the cordate base, and the prominent secondaries with pronounced marginal loops are sufficiently well shown, however, to permit the determination without hesitation.

I have not as yet encountered specimens or figures of previously reported leaves of this form in the Cretaceous or early Tertiary floras, aside from those of the Medicine Bow flora. The resemblance of these forms to the leaves of the Magnoliaceæ has already been discussed in the original description of this species.

Occurrence—Localities P3855, P3857.

Collection—U. C. Mus. Pal., No. 2522.

Family ANACARDIACEÆ

Genus PISTACIA Linné

Pistacia eriensis Knowlton

(Plate 11, Figs. 1, 3)

Pistacia eriensis Knowlton, U. S. Geol. Surv. Prof. Paper 130, 150, pl. 28, figs. 1–4, 1922. Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. 1, 65, pl. 19, fig. 7, 1938; Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.
Pistacia hollicki Knowlton, U. S. Geol. Surv. Prof. Paper 130, 151, pl. 28, figs. 5, 6, 1922.

There are 3 specimens, from two localities, which cannot be distinguished from any of the various type and figured specimens of this species from the Medicine Bow and Laramie formations.

Both the fossil and modern relationships of this species have already been adequately discussed in the reports cited above.

Occurrence—Localities P3651, P3859.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 2523, 2524.

Family VITACEÆ

Genus VITIS (Tournefort) Linné

Vitis stantoni (Knowlton) Brown

(Plate 11, Figs. 5, 6; Plate 12, Figs. 1–6)

Vitis stantoni (Knowlton) Brown, U. S. Geol. Surv. Prof. Paper 189, 252, pl. 56, figs. 1–5, 6*b*, pl. 57, figs. 1–6, 7*a*, pl. 58, figs. 1–4, pl. 59, fig. 6, 1939. Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. I, 69, pl. 17, fig. 1, 1938; Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.
Castalia stantoni Knowlton, U. S. Geol. Surv. Bull. 258, 147, pl. 19, fig. 4, 1905.
Viburnum vulpinum Knowlton, U. S. Geol. Surv. Prof. Paper 98, 92, pl. 18, fig. 1, 1916.
Vitis dakotana Berry, U. S. Geol. Surv. Prof. Paper 185-F, 130, pl. 26, figs. 4–6, pl. 27, 1934; Canada Geol. Surv. Mem. 182, 47, pl. 12, figs. 1, 2, 1935.
Viburnum whymperi Heer. Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 7, 225, pl. 61, fig. 23 only, 1878.
Viburnum richardsoni Knowlton, U. S. Geol. Surv. Prof. Paper 155, 126, pl. 52, fig. 8, pl. 53, figs. 1, 3–5, pl. 54, figs. 2, 3, 1930.
Viburnum sp., Knowlton, Proc. Washington Acad. Sci., vol. 11, 207, 1909.
Viburnum anomalinervum Knowlton. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.
Grewiopsis tenuifolia Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 7, 258, pl. 40, fig. 14, 1878.

Well-preserved specimens clearly referable to this species were collected from four localities in the Lance Creek area. A suite of 34 specimens was obtained from Locality P3857, where the leaves of this species are among the dominant forms.

This species has been so adequately described and discussed by Brown and Berry that no additional comment is here necessary. It is apparent that these clearly defined leaves of restricted stratigraphic range are useful as indices of late Cretaceous age. The species is now known in the Judith River, Vermejo, Fox Hills, Whitemud, Colgate, lower Denver, lower Dawson, and lower Medicine Bow floras, in addition to its abundance in the true Lance of both eastern Montana (Hell Creek formation) and the Lance Creek area. It has never been reported in the extensive Fort Union flora of the Rocky Mountain region, nor from other deposits of post-Lance age elsewhere.

Occurrence—Localities P3855, P3857, P3858, P3652.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 2525, 2526, 2527, 2528, 2528*a* (counterpart), 2529, 2530, 2531; Nos. 2532, 2533.

Family TILIACEÆ

Genus GREWIOPSIS Saporta

Grewiopsis saportana Lesquereux

Grewiopsis saportana Lesquereux, Rept. U. S. Geol. and Geog. Surv. Terr., vol. 7, 257, pl. 50, figs. 10–12, 1878. Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. I, 70, pl. 13, figs. 1, 5, 6, 1938. Brown, U. S. Geol. Surv. Prof. Paper 189, 251, pl. 55, figs. 1–3, 4*a*, 1939. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.
Aleurites eocenica Lesquereux, U. S. Geol. Surv. Terr., Ann. Rept. (1872), 397, 1873.
Grewiopsis ficifolia Ward, U. S. Geol. Surv. 6th Ann. Rept., 556, pl. 46, figs. 1, 2, 1885; U. S. Geol. Surv. Bull. 37, 92, pl. 41, figs. 1, 2, 1887.
Grewiopsis eocenica (Lesquereux) Knowlton, U. S. Geol. Surv. Bull. 152, 114, 1898; Proc. Washington Acad. Sci., vol. 11, 207, 1909.
Ficus sp., Knowlton, Proc. Washington Acad. Sci., vol. 11, 207, 1909.

In contrast with its abundance in the Medicine Bow formation, there are only 9 specimens from four localities in the Lance Creek area which are referable to this species. Its occurrence in the type Lance formation was previously reported by Knowlton,[1] whose specimen I have seen at the U. S. National Museum.[2]

The modern relationships of this species are still in doubt.

Occurrence—Localities P3854, P3855, P3857, P3859.

Collection—U. S. National Museum, No. 40256.

[1] Knowlton, F. H., Proc. Washington Acad. Sci., vol. 11, 207, 1909.
[2] Specimen No. 40256.

Family DILLENIACEÆ

Genus DILLENITES Berry

Dillenites cleburni (Lesquereux) Dorf, n. comb.

(Plate 13, Fig. 1)

Rhamnus cleburni Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1872), 381, 400, 1873; Rept. U. S. Geol. Surv. Terr., vol. 7, 280, pl. 53, figs. 1–3, 1878. Berry, U. S. Geol. Surv. Prof. Paper 91, 283, 1916. Knowlton, U. S. Geol. Surv. Prof. Paper 101, 332, pl. 113, fig. 3, 1917; U. S. Geol. Surv. Prof. Paper 155, 104, only pl. 46, figs. 10, 11, 1930. Berry, Canada Geol. Surv. Mem. 182, 45, 1935. Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. 1, 67, pl. 14, figs. 5, 6, 1938; Bull. Geol. Soc. Amer., vol. 51, 222, 1940.

Rhamnus rectinervis Heer (in part). Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1871), 295, 298, 1872; U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1872), 382, 397, 402, 1873; U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1873), 405, 1874; Rept. U. S. Geol. Surv. Terr., vol. 7, 278, pl. 52, fig. 15 only, 1878.

Rhamnus brittoni Knowlton, U. S. Geol. Surv. Prof. Paper 130, 156, pl. 15, fig. 6, pl. 24, fig. 8, 1922.

Rhamnus marshallensis Knowlton, U. S. Geol. Surv. Prof. Paper 130, 155, pl. 15, fig. 3, 1922. Dorf, Bull. Geol. Soc. Amer., vol. 51, 222, 1940.

There are several fairly complete specimens from Locality P3652 which are essentially similar to the average leaves of this species, such as the original type specimens figured by Lesquereux. In addition, there are several smaller leaves, one of which is here figured, which were identified as *Rhamnus marshallensis* in my earlier report on the type Lance flora. After a thorough examination of the type collections at the U. S. National Museum, I believe that there can be no valid basis for separating this species from *R. cleburni*. These smaller leaves differ from the type specimens of *R. cleburni* only in the number of secondaries; they are precisely the same in their shape, in their parallel, closely spaced secondaries, and in their very characteristic tertiary venation. The Laramie specimen which Knowlton named *R. marshallensis* is here regarded as an incomplete specimen of the same form.

The collections at the U. S. National Museum contain several undescribed specimens which appear to belong to this species. In the Laramie collection, for example, there is a single specimen (No. 4367, with *Cissus lobato-crenata*) which is similar; in the Vermejo collection there are 7 specimens (see especially Nos. 51216, 51219) which have the typical characters of *R. cleburni;* and in the Denver collection there are 2 smaller leaves (No. 37828) which are similar in form and size to the Lance Creek specimen here figured. It is evident that this species is well represented in the late Cretaceous deposits of the Rocky Mountain region and is not yet authentically reported from beds of undisputed Paleocene age.

After a continued search for comparable leaf forms among living species, I am convinced of the close resemblance of these fossil leaves to the Dilleniaceæ. The similarity to *Doliocarpus dentatus* (Aubl.) Standley and *Davilla multiflora* St. Hil. has already been pointed out.[1] Continued reference to *Rhamnus* would only be misleading and is wholly unsupported by comparison with modern leaves. It has therefore seemed advisable to refer this species to the genus *Dillenites.*

Occurrence—Localities P3651, P3652.

Collection—U. C. Mus. Pal., Plesiotype Nos. 2534, 2534*a* (counterpart).

Family MYRTACEÆ

Genus MYRTOPHYLLUM Heer

Myrtophyllum torreyi (Lesquereux) Dorf, n. comb.

Myrica torreyi Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1872), 392, 1873; Rept. U. S. Geol. Surv. Terr., vol. 7, 129, pl. 16, figs. 3–10, 1878. Ward, U. S. Geol. Surv. 6th Ann. Rept., 551, pl. 40, fig. 4, 1885; U. S. Geol. Surv. Bull. 37, 32, pl. 14, fig. 5, 1887. Knowlton, U. S. Geol. Surv. Bull. 163, 34, pl. 6, figs. 1–3, 1900; U. S. Geol. Surv. Prof. Paper 98, 90, 336, pl. 17, fig. 7, pl. 86, fig. 1, 1916; U. S. Geol. Surv. Prof. Paper 101, 256, pl. 37, figs. 2–4, 1917; U. S. Geol. Surv. Prof. Paper 130, 123, 1922. Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. I, 49, pl. 4, figs. 1, 2, 3, 1938; Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

[1] Dorf, E., Carnegie Inst. Wash. Pub. No. 508, pt. I, 68, 1938.

Myrica torreyi minor Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1873), 397, 1874.
Myrica coriacea Knowlton, U. S. Geol. Surv. Prof. Paper 101, 256, pl. 37, fig. 5, 1917.
Myrica dubia Knowlton, U. S. Geol. Surv. Prof. Paper 130, 123, pl. 5, fig. 3, 1922.
Myrica oblongifolia Knowlton, U. S. Geol. Surv. Prof. Paper 130, 124, pl. 21, fig. 1, 1922.
Myrica sp., Knowlton, U. S. Geol. Surv. Prof. Paper 155, 44, pl. 11, fig. 7, 1930.

Remains of this characteristic leaf, which are abundant in several other floras of similar age, are conspicuously rare in the Lance Creek collections. Only 3 fragmentary specimens have been obtained; one of these from this region is in the collections of the U. S. National Museum (specimen No. 40257). This was probably the specimen on which Knowlton had previously reported the occurrence of this species in the Lance Creek area.[1]

A full description and a discussion of the possible relationships of *Myrica torreyi* has previously been given in my report on the Medicine Bow flora, cited above. A persistent search among living species for leaves like those of this well-defined form has failed to disclose further comparisons. The continued retention of the generic name *Myrica*, with its definite implication of relationship to this modern genus, is therefore not considered warranted. The change to the name *Myrtophyllum* is believed to be substantiated by comparison with leaves of the living Myrtaceæ.

Occurrence—Locality P3853; U. S. Geol. Survey Locality 1464.

Collection—U. S. National Museum, No. 40257.

Family ARALIACEÆ

Genus ARALIÆPHYLLUM Fontaine

Araliæphyllum artocarpoides (Lesquereux) Dorf, n. comb.

(Plate 13, Fig. 4)

Ficus artocarpoides Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 8, 227, pl. 47, figs. 1–5, 1883. Knowlton, Proc. Washington Acad. Sci., vol. 11, 185, 1909. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.
Ficus preartocarpoides Brown (in part), U. S. Geol. Surv. Prof. Paper 189, 249, pl. 53, figs. 4, 5 only, 1939.
Cornus fosteri Ward, U. S. Geol. Surv. 6th Ann. Rept., 553, pl. 47, fig. 8, 1885; U. S. Geol. Surv. Bull. 37, 54, pl. 25, fig. 5, 1887.

The specimen here figured and its counterpart were the only ones of this form encountered. A comparison with the type and figured specimens of *Ficus artocarpoides* and *Cornus fosteri* indicates a striking similarity in all details. The specimens of *Ficus preartocarpoides* recorded by Brown from the Hell Creek flora of Montana are equally comparable, except that some of his larger specimens have distinct lobelike teeth, usually above the middle on one side of the leaf. This occasional occurrence of short lobelike teeth on otherwise entire-margined leaves is often met with in members of the Araliaceæ, especially in *Anomopanax cumingianus* (Presl) Merrill (New York Botanical Garden, sheet No. 1108). I have not seen this type of marginal variation in any species of *Ficus* or *Cornus*, so have accordingly changed the generic name of this leaf type to *Araliæphyllum*, implying a family relationship to the existing Araliaceæ.

As here interpreted, this species is at present known from the type Lance, the Hell Creek, and the Fort Union floras. Brown has recently suggested additions to the synonymy of this species,[2] including specimens from the Paskapoo and Ravenscrag formations of Canada. The Lance Creek specimens are unfortunately not sufficiently complete in the apical region to verify Brown's suggestions. The specimens from the Wilcox and Raton formations which have been referred to this species [3] seem to me to have a different type of venation, lacking branches on the lower sides of the secondaries.

Occurrence—Locality P3651.

Collection—U. C. Mus. Pal., Plesiotype No. 2535.

[1] Knowlton, F. H., Proc. Washington Acad. Sci., vol. 11, 207, 1909.
[2] Brown, R. W., U. S. Geol. Surv. Prof. Paper 189, 249, 1939.
[3] Hollick, A., Geol. Surv. Louisiana, Spec. Rept. 5, 281, pl. 47, figs. 1–5, 1899. Berry, U. S. Geol. Surv. Prof. Paper 91, 200, pl. 34, fig. 2, 1916. Knowlton, U. S. Geol. Surv. Prof. Paper 101, 300, pl. 71, fig. 3, 1917.

Family CORNACEÆ

Genus CORNOPHYLLUM Newberry

Cornophyllum wardii Dorf

Cornophyllum wardii Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. I, 71, pl. 16, fig. 3, 1938; Bull. Geol. Soc. Amer., vol. 51, 222, 1940.

Cornus studeri Heer ?. Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 7, 244, pl. 42, figs. 4, 5, 1878. Ward, U. S. Geol. Surv. 6th Ann. Rept., 553, pl. 48, fig. 1, 1885; U. S. Geol. Surv. Bull. 37, 55, pl. 26, fig. 1, 1887. Knowlton, U. S. Geol. Surv. Bull. 163, 68, pl. 15, fig. 3, 1900; U. S. Geol. Surv. Prof. Paper 101, 342, pl. 109, fig. 2, 1917.

Rhamnus cleburni Lesquereux (in part). Knowlton, U. S. Geol. Surv. Prof. Paper 155, 104, only pl. 40, fig. 6, 1930.

There are about a dozen nearly complete specimens of this well-defined species and an equal number of identifiable fragments. The majority of these are from Locality P3651, where this type of leaf is one of the two dominants. The best specimens are unfortunately curled and twisted, making them difficult or impossible to photograph for reproduction.

In addition to its occurrence in the type Lance formation, this species is now reliably known from the Ericson-Almond (Mesaverde), Medicine Bow, Raton, and Denver formations.

As was pointed out in my original discussion of this species, its modern affinities are somewhat in doubt, though the resemblance to the leaves of the living *Cornus* is undeniable.

Occurrence—Localities P3651, P3853.

Collection—U. C. Mus. Pal., No. 2536.

Family OLEACEÆ

Genus FRAXINUS Linné

Fraxinus leii Berry

(Plate 13, Figs. 2, 3, 7)

Fraxinus leii Berry, U. S. Geol. Surv. Prof. Paper 185-F, 132, pl. 25, figs. 1–5, 1934; ? Canada Geol. Surv. Mem. 182, 55, pl. 15, fig. 4, 1935. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

This species is one of the ten dominants in the Lance Creek collections, in which it is represented by 53 leaf impressions. Many of these are essentially complete leaves in an excellent state of preservation. The leaves here figured are virtually identical in all their characters with the type specimens figured by Berry.

In the course of study of these leaves it became apparent that they are likely to be confused with those of *Dryophyllum subfalcatum* Lesquereux,[1] which they undeniably resemble in a general way. Brown has considered these two species synonymous.[2] In my opinion, the leaves of *Fraxinus leii* may be distinguished by the following characters: (1) shape distinctly narrower, approaching linear rather than lanceolate; (2) teeth more regularly disposed, never absent or poorly developed, and distinctly spinous; (3) both secondary and tertiary veins thin; (4) secondary veins at more regular intervals. Among the numerous excellent specimens of *Dryophyllum subfalcatum* in the Colgate sandstone and Hell Creek collections at the U. S. National Museum, none was seen which had the combination of these definitive characters of *Fraxinus leïi*.

In addition to its occurrence in the Lance formation, this species is reported and figured by Berry from the Ravenscrag formation of Saskatchewan. This specimen does not seem to me to have the diagnostic characters of the original types, particularly in its shape and the character of its marginal teeth.

The generic reference of this species to *Fraxinus* was made by Berry on the basis of resemblance of the original Lance leaves to those of *F. tamariscifolia* Vahl of the Old World.

Occurrence—Localities P3651, P3853, P3854, P3857, P3858.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 2537, 2538, 2539; Nos. 2540, 2541.

[1] Lesquereux, L., Rept. U. S. Geol. Surv. Terr., vol. 7, 163, pl. 63, fig. 10, 1878. Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. I, 51, pl. 5, figs. 1, 2, 6, 1938. Brown, U. S. Geol. Surv. Prof. Paper 189, 248, pl. 50, figs. 1–8, pl. 51, figs. 1–7, 8*b*, pl. 52, figs. 1–3, pl. 54, fig. 1, 1939.

[2] Brown, R. W., op. cit., 248, 1939.

Family BIGNONIACEÆ

Genus DOMBEYOPSIS Unger

Dombeyopsis colgatensis Brown

(Plate 14, Figs. 1, 4)

Dombeyopsis colgatensis Brown, U. S. Geol. Surv. Prof. Paper 189, 252, pl. 60, figs. 1–4, 1939. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

There are 5 well-preserved specimens, 2 of which are figured, which agree in all essential details of shape, venation, and marginal characters with the type specimens of this species from the Colgate flora. The slightly larger size of the Lance Creek specimens is not considered of taxonomic importance.

Except for the attenuate and acuminate character of their bases and tips, the leaves of *Dombeyopsis colgatensis* are comparable to those of *D. obtusa*.[1] In all the latter, however, the bases are obtuse or only slightly attenuate and the leaf tips are invariably bluntly obtuse or slightly emarginate. The venation of these two species is remarkably similar. No other close resemblances to described species have been observed.

As was pointed out by Brown, the reference of this leaf form to *Dombeyopsis*, implying relationship to the living *Dombeya*, is not wholly satisfactory. I have not been able to find any modern leaves with comparable characters.

Occurrence—Locality P3854.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 2542, 2543.

Dombeyopsis obtusa Lesquereux

(Plate 14, Fig. 2)

Dombeyopsis obtusa Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1872), 375, 1873; Rept. U. S. Geol. Surv. Terr., vol. 7, 255, pl. 47, figs. 4, 5, 1878. Knowlton, U. S. Geol. Surv. Prof. Paper 130, 162, pl. 13, fig. 4, pl. 20, fig. 11, pl. 27, figs. 1–4, 1922; U. S. Geol. Surv. Prof. Paper 155, 124, 1930. Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. I, 72, pl. 15, figs. 1, 2, 1938; Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

Phyllites populoides Knowlton, U. S. Geol. Surv. Prof. Paper 101, 280, pl. 50, figs. 1, 2, 1917.

Populus? neomexicana Knowlton, U. S. Geol. Surv. Prof. Paper 101, 258, pl. 53, fig. 3, 1917.

Phyllites trinervis Knowlton, U. S. Geol. Surv. Prof. Paper 130, 166, pl. 24, fig. 12, 1922.

The collections contain 4 nearly complete specimens which are referable to this species. I suspect that if a large suite of specimens of this species and of *Dombeyopsis colgatensis* were ever obtained, there might appear to be gradational variations between these two species. The consistent features of *D. obtusa* seem to be the obtuse character of both the bases and the tips of its leaves.

The occurrence of this species in the true Lance formation further enhances its value as an important index species of the Upper Cretaceous sediments of the Rocky Mountain region. It is known elsewhere from the Laramie, Trinidad, Vermejo, lower Denver, Dawson, and Medicine Bow formations, and has not been found in beds of known Paleocene or later age.

The uncertain systematic status of this species has been discussed in my previous report, cited above.

Occurrence—Localities P3854, P3859.

Collection—U. C. Mus. Pal., Plesiotype No. 2544.

Dombeyopsis trivialis Lesquereux

(Plate 13, Figs. 5, 6, 8)

Dombeyopsis trivialis Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1872), 380, 1873; Rept. U. S. Geol. Surv. Terr., vol. 7, 255, pl. 47, fig. 3, 1878. Knowlton, U. S. Geol. Surv. Prof. Paper 130, 163, pl. 13, fig. 3, pl. 14, fig. 3, 1922. Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. I, 72, pl. 15, fig. 4, pl. 16, figs. 1, 2, 4, 1938; Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

[1] Lesquereux, L., Rept. U. S. Geol. Surv. Terr., vol. 7, 255, pl. 47, figs. 4, 5, 1878. Knowlton, U. S. Geol. Surv. Prof. Paper 130, 162, pl. 13, fig. 4, pl. 20, fig. 11, pl. 27, figs. 1–4, 1922. Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. I, 72, pl. 15, figs. 1, 2, 1938.

There are 2 nearly complete specimens and several incomplete impressions which are essentially similar to the type and figured specimens referred to this species. The specimen here figured, though somewhat broken and wrinkled, shows the characteristic features of shape, size, and venation. In a second specimen, from Locality P3857, the lobing is somewhat more pronounced. A third specimen, from Locality P3859, previously identified as *Cissites lobatus* Dorf,[1] is now regarded as an incomplete specimen of *Dombeyopsis trivialis.*

At the present time this species is described or reported from only the Laramie, the Medicine Bow, and the type Lance formations. It is not known to occur, or to be confused with any comparable leaves, in beds of indisputable Paleocene age.

I am as yet uncertain of the relationship of this species to modern forms; as previously pointed out, the resemblance to the leaves of the modern *Dombeya* is remote.

Occurrence—Localities P3652, P3853, P3857, P3859.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 2545, 2546, 2547.

Family CAPRIFOLIACEÆ

Genus VIBURNUM (Tournefort) Linné

Viburnum marginatum Lesquereux

(Plate 14, Fig. 3; Plate 15, Figs. 1, 5)

Viburnum marginatum Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1872), 395, 1873; U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1873), 382, 410, 1874; U. S. Geol. and Geog. Surv. Terr., Bull., vol. 1, 380, 1875; U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1874), 306, 1876; U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1876), 510, 1878; Rept. U. S. Geol. Surv. Terr., vol. 7, 223, pl. 38, figs. 1, 4 only, 1878; Bull. Harvard Coll. Mus. Comp. Zoöl., vol. 16, 51, 1888. Knowlton, Bull. Geol. Soc. Amer., vol. 8, 145, 1897; Jour. Geol., vol. 19, 361, 370, 371, 1911. Berry, Canada Geol. Surv. Mem. 182, 57, 1935. Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. I, 73, pl. 15, figs. 3, 5, pl. 17, figs. 4, 5, 1938. Brown, U. S. Geol. Surv. Prof. Paper 189, 252, pl. 59, fig. 7, 1939. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

Platanus heerii Lesquereux. Ward, U. S. Geol. Surv. 6th Ann. Rept., 552, pl. 40, figs. 8, 9, 1885; U. S. Geol. Surv. Bull. 37, 34, pl. 15, figs. 3, 4, 1887.

Platanus platanoides (Lesquereux) Knowlton (in part), U. S. Geol. Surv. Prof. Paper 101, 323, pl. 95, fig. 4, 1917; U. S. Geol. Surv. Prof. Paper 130, 146, pl. 13, fig. 1, 1922.

Platanus guillelmæ heerii Knowlton, U. S. Geol. Surv. Prof. Paper 101, 323, pl. 96, fig. 5, pl. 97, fig. 1, pl. 98, fig. 2, 1917.

Platanus marginata (Lesquereux) Heer. Knowlton, U. S. Geol. Surv. Prof. Paper 155, 81, pl. 36, figs. 2, 3, 1930.

Platanus aceroides latifolia Knowlton (in part), U. S. Geol. Surv. Prof. Paper 155, 76, pl. 33, fig. 1, 1930.

About 30 well-preserved impressions of clearly defined leaves of this species were collected from five of the Lance Creek localities. They differ in no essential details from the original types and numerous figured specimens previously reported. A full description and discussion of this species was given in my paper on the Medicine Bow flora, cited above. I have subsequently encountered 5 excellent unlabeled specimens of this species in the Vermejo collection at the U. S. National Museum (specimens Nos. 51287, 51288, 51289, 51290, 51293).

It is becoming increasingly more apparent that *Viburnum marginatum* is an ideal index species for Lancian age in the Rocky Mountain region. The widespread occurrences of this species are confined to the sediments lying conformably above the beds of the Fox Hills or late Pierre age and below the non-dinosaur-bearing "Fort Union." In terms of dinosaurian zones, *V. marginatum* is restricted to the *Triceratops* zone. Geographically the species is distributed from southern Colorado to as far north as southern Saskatchewan. Its remains, moreover, are usually abundant and its characters are well defined and easily recognized.

Occurrence—Localities P3652, P3853, P3855, P3857, P3859.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 2548, 2549, 2550, 2550*a* (counterpart).

Viburnum montanum Knowlton

(Plate 15, Figs. 2, 3)

Viburnum montanum Knowlton, U. S. Geol. Surv. Bull. 163, 73, pl. 19, figs. 1, 2, 1900; U. S. Geol. Surv. Prof. Paper 101, 276, pl. 52, fig. 2, 1917. Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. I, 75, pl. 17, fig. 2, 1938; Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

[1] Dorf, E., Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

Viburnum? problematicum Knowlton, U. S. Geol. Surv. Bull. 163, 71, pl. 19, fig. 4, 1900; U. S. Geol. Surv. Prof. Paper 101, 276, pl. 49, fig. 9, 1917.
Viburnum whymperi Heer. Knowlton, Proc. Washington Acad. Sci., vol. 11, 207, 1909.

There are 5 nearly complete specimens, from three localities, which I cannot distinguish from the type and figured specimens of *Viburnum montanum* or *V.? problematicum*. As was pointed out in my discussion of these species in the report on the Medicine Bow flora, there is a likelihood that the collection of a larger suite of leaves of this form would show that several other species, such as *V. contortum* Lesquereux and *V. speciosum* Knowlton, are actually synonymous.

From an examination of the Lance Creek collections at the U. S. National Museum it is clear that the specimens assigned by Knowlton to *V. whymperi* Heer are in reality referable to *V. montanum*.

Occurrence—Localities P3652, P3854, P3857.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 2551, 2552; No. 2553.

DICOTYLEDONES, Position Uncertain

Anona? robusta Lesquereux

(Plate 15, Fig. 4)

Anona robusta Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 8, 124, pl. 20, fig. 4, 1883. Knowlton, U. S. Geol. Surv. Prof. Paper 130, 143, pl. 17, fig. 7, 1922. Brown, U. S. Geol. Surv. Prof. Paper 189, 251, pl. 54, fig. 2, 1939.
Ficus uncata Lesquereux. Knowlton, U. S. Geol. Surv. Prof. Paper 101, 301, pl. 76, fig. 2, 1917. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

The collections contain 5 well-preserved though incomplete specimens, of which the best is figured, which agree in essential characteristics with the specimens referred by Lesquereux and Brown to *Anona robusta*. I had provisionally called the Lance Creek specimens *Ficus uncata*. Both the description and the original type specimens of the latter species show, however, that the secondary veins are prominently branched on their lower sides. This is not the case in the Lance Creek specimens nor in the Raton specimen which Knowlton referred to *F. uncata*.

As here conceived, this species is now known from the Laramie and Raton formations and from the Lance of both Wyoming and Montana. I have not seen any species in the true "Fort Union" or other beds of known Paleocene age with which this leaf form might be confused.

The modern relationships of this species are doubtfully known. The original reference to *Anona* is a reasonable one, though there are genera of both the Magnoliaceæ and the Moraceæ which seem equally comparable.

Occurrence—Localities P3853, P3855.

Collection—U. C. Mus. Pal., Plesiotype No. 2554.

Apeibopsis? discolor (Lesquereux) Lesquereux

Apeibopsis? discolor (Lesquereux) Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 7, 259, pl. 46, figs. 4–7, 1878. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.
Rhamnus discolor Lesquereux (in part), U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1872), 398, 1873.
Liriodendron sp., Brown, U. S. Geol. Surv. Prof. Paper 189, 251, pl. 52, fig. 7, 1939.

There are 10 specimens, from three localities, which are sufficiently complete and well preserved to be identified with this species. On consulting the type specimens at the U. S. National Museum, it appeared evident that the incomplete Colgate leaves which Brown referred to *Liriodendron* sp. cannot be distinguished from the original types of *Apeibopsis? discolor* from the Black Buttes flora or from the Lance Creek specimens.

I suspect that the single specimen from Black Buttes which Lesquereux named *Ficus haydenii* [1] is in reality conspecific with those from the same locality referred to *Apeibopsis? discolor*. In view of the fact that the type specimen of *Ficus haydenii* is at present not to be found, however, it seems advisable to await its discovery before making a final allocation.

[1] Lesquereux, L., Rept. U. S. Geol. Surv. Terr., vol. 7, 197, pl. 30, fig. 1, 1878.

The genus *Apeibopsis* was originally defined by Heer[1] on the basis of globular, capsular fruits and large, ovate, entire-margined leaves. Both the fruits and the leaves were said to resemble those of the living *Apeiba* Aubl., of tropical America. In his original discussion of *Apeibopsis? discolor,* Lesquereux questioned the reference to *Apeibopsis* of Heer and remarked that he could not compare either his specimens or those of Heer to any living species of *Apeiba.*

Occurrence—Localities P3651, P3652, P3857.

Collection—U. C. Mus. Pal., No. 2555.

Celastrus? taurinensis Ward

(Plate 16, Fig. 1)

Celastrus taurinensis Ward, U. S. Geol. Surv. 6th Ann. Rept., 555, pl. 52, figs. 15, 16, 1885; U. S. Geol. Surv. Bull. 37, 79, pl. 34, figs. 5, 6, 1887. Hollick, Geol. Surv. Louisiana, Spec. Rept. 5, 285, pl. 46, fig. 1, 1899. Knowlton, Proc. Washington Acad. Sci., vol. 11, 213, 1909. Berry, U. S. Geol. Surv. Prof. Paper 91, 267, pl. 60, figs. 1–3, 1916; Canada Geol. Surv. Mem. 182, 42, 1935. Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. I, 65, pl. 12, figs. 1–3, 1938; Bull. Geol. Soc. Amer., vol. 51, 218, 220, 221, 222, 225, 226, 228, 232, 1940.

Celastrus ovatus Ward, U. S. Geol. Surv. 6th Ann. Rept., 555, pl. 53, fig. 7, 1885; U. S. Geol. Surv. Bull. 37, 81, pl. 36, fig. 1, 1887.

Celastrus wardii Knowlton and Cockerell, U. S. Geol. Surv. Bull. 696, 160, 1919.

Celastrus curvinervis Ward, U. S. Geol. Surv. 6th Ann. Rept., 555, pl. 53, figs. 9, 10, 1885; U. S. Geol. Surv. Bull. 37, 82, pl. 36, figs. 3, 4, 1887.

Aralia taurinensis (Ward) Sanborn, Carnegie Inst. Wash. Pub. No. 465, I, 27, pl. 10, figs. 1, 2, 4, 1935.

There are only 5 specimens in the Lance Creek collections which are referable to this species. Although the figured specimen is lacking most of the left half of the leaf, its restored shape and its venation and marginal characters are essentially similar to the characters of the figured and type specimens of *Celastrus taurinensis* from the "Fort Union" formation. All the type and figured specimens of the species here cited, moreover, are of the same character.

As was pointed out in my discussion of the Medicine Bow specimens referred to this species, it is unfortunate that leaf impressions of this form are rare in the Lance-Laramie floras. Only a larger suite of better-preserved specimens could settle the point as to whether or not the more lanceolate shape of the late Cretaceous examples is consistent enough to be used as a specific feature of distinction from the abundant Paleocene forms.

The uncertain botanical affinity of this species has been pointed out in my previous report.

Occurrence—Locality P3651.

Collection—U. C. Mus. Pal., Plesiotype No. 2556.

Cinnamomum? affine Lesquereux

(Plate 16, Fig. 2)

Cinnamomum affine Lesquereux (in part), Rept. U. S. Geol. Surv. Terr., vol. 7, 219, pl. 37, figs. 1–4, 7 only, 1878. Knowlton, U. S. Geol. Surv. Prof. Paper 130, 145, pl. 8, fig. 4, pl. 17, fig. 6, 1922. Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. I, 60, pl. 9, figs. 3, 4, 1938. Brown, U. S. Geol. Surv. Prof. Paper 189, 250, pl. 53, figs. 1, 2, 1939. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

This species is represented in the collections by the single complete figured specimen and several fragments. Although somewhat larger than the type and figured specimens of this species, the Lance Creek specimen does not differ otherwise in the essential characters of shape, venation, and margin. As in the specimens from the Medicine Bow and Colgate floras, the indistinct pair of veins below the lateral primaries appears to be a rather constant feature of the larger leaves of this species. This feature has also been observed recently on a Laramie specimen referable to this species.[2]

As has been previously pointed out, the resemblance of the leaves of this species to those of the modern genus *Cinnamomum* is not very close. It does not seem advisable, however, to make any change of name until a positive generic or family relationship is found.

Occurrence—Locality P3652.

Collection—U. C. Mus. Pal., Plesiotype No. 2557.

[1] Heer, O., Fl. Tert. Helvetiæ, vol. 3, 37–41, pl. 109, figs. 9–11, pl. 118, figs. 24–29, 1859.

[2] U. S. National Museum collections, specimen No. L7.

Cissus? lobato-crenata Lesquereux

(Plate 16, Fig. 3)

Cissus lobato-crenata Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 7, 240, pl. 41, figs. 1–3, 1878. Knowlton, U. S Geol. Surv. Prof. Paper 155, 114, pl. 49, figs. 3, 4, 1930. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

There are 3 specimens, of which the best is figured, which are referable to this species. Its original description by Lesquereux was as follows:

"Leaves subcoriaceous, subcordate at the base, broadly enlarged above it, rapidly narrowed to an obtuse point, crenate and short-lobed all around, three-nerved from the base; primary and secondary nerves branching, all the divisions craspedodrome."

As is shown in the figured specimen, the Lance Creek specimens differ from the original description, and from the type specimens, only in their wedge-shaped rather than subcordate bases. In view of the variations expected and observed in the leaves of living species, this slight difference is not considered sufficient for specific distinction. The general shape, the venation, and the obtusely lobed crenate margins are here regarded as the usable diagnostic features of the leaves of this species.

In addition to its occurrence in the type Lance formation, this species has previously been recorded in the Black Buttes, lower Dawson, and Middle Park floras. There is also an excellent unreported specimen of it in the Laramie collection at the U. S. National Museum.[1]

I have not been able to find any leaves of living species of either *Cissus* or any other genus which bear a close resemblance to those of *Cissus? lobato-crenata.*

Occurrence—Locality P3855.

Collection—U. C. Mus. Pal., Plesiotype No. 2558.

Ficus? ceratops Knowlton

Ficus ceratops Knowlton, Bull. Torrey Bot. Club, vol. 38, 389, figs. 1–4, 1911. Berry, Canada Geol. Surv. Mem. 182, 28, 1935. Brown, U. S. Geol. Surv. Prof. Paper 189, 248, pl. 61, figs. 1–14, 1939. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

Palmocarpon n. sp., Knowlton, Bull. Geol. Soc. Amer., vol. 8, 136, 1897.

Ficus russelli Knowlton, Bull. Torrey Bot. Club, vol. 38, 392, 1911.

Ficus sp., Knowlton, Proc. Washington Acad. Sci., vol. 11, 207, 1909.

I was not successful in obtaining specimens of these fruits in the Lance Creek area. Knowlton, however, made a considerable collection of them from this same region and from the true Lance (Hell Creek formation) of eastern Montana. He at first regarded these as the seeds of a palm, but subsequently compared them to the fruits of *Ficus.* I have examined Knowlton's specimens in the collections at the U. S. National Museum, but can offer no further suggestions as to their botanical affinities. Brown has recently made a large collection of these figlike casts from the Hell Creek formation of Montana. He suggests that they may be the underground tubers of *Equisetum.* This is a tenable view, but is not fully supported by the appearance and character of true attached *Equisetum* tubers in the Lance Creek flora (plate 6, fig. 3); these differ considerably from the specimens of *Ficus? ceratops* in shape and surface markings.

To my knowledge, the only occurrence of this species outside the Lance formation of Wyoming and Montana is in the Whitemud formation of Saskatchewan, as reported by Berry.

Occurrence—U. S. Geol. Survey, "*Ceratops* beds, Lance Creek, Converse County, Wyoming. Collected by J. B. Hatcher, June 1881."

Collection—U. S. National Museum, No. 40258.

Ficus? trinervis Knowlton

(Plate 16, Figs. 4, 6)

Ficus trinervis Knowlton, U. S. Geol. Surv. Bull. 163, 42, 1900. Cockerell, Bull. Amer. Mus. Nat. Hist., vol. 24, 89, 1908. Knowlton, Proc. Washington Acad. Sci., vol. 11, 197, 1909. Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. I, 56, pl. 6, figs. 1, 4, 1938; Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

[1] Specimen No. 4367, with specimen of *Rhamnus cleburni.*

Cinnamomum affine Lesquereux (in part), Rept. U. S. Geol. Surv. Terr., vol. 7, 219, pl. 37, fig. 5 only, 1878. Ward, U. S. Geol. Surv. 6th Ann. Rept., 553, pl. 67, figs. 1–3, 1885; U. S. Geol. Surv. Bull. 37, 50, pl. 24, figs. 3–5, 1887.
Ficus prætrinervis Knowlton (in part), U. S. Geol. Surv. Prof. Paper 101, 263, 304, pl. 41, figs. 1–3 only, pl. 42, fig. 1, 1917; U. S. Geol. Surv. Prof. Paper 98, 338, 1916; U. S. Geol. Surv. Prof. Paper 155, 71, pl. 28, fig. 8 only, 1930.
Ficus haddeni Knowlton, U. S. Geol. Surv. Prof. Paper 101, 260, pl. 38, figs. 6, 7, 1917.
Malapœnna louisvillensis Knowlton, U. S. Geol. Surv. Prof. Paper 130, 144, pl. 7, fig. 5, 1922.
Ficus neoplanicostata Knowlton (in part), U. S. Geol. Surv. Prof. Paper 155, 69, only pl. 29, figs. 3, 4, 1930.
Cinnamomum sp., Knowlton, U. S. Geol. Surv. Prof. Paper 155, 87, pl. 39, fig. 1, 1930.
Ficus post-trinervis Knowlton, U. S. Geol. Surv. Prof. Paper 130, 136, pl. 6, figs. 1, 2, 1922. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

The 2 figured specimens are the best of 7 specimens which I believe referable to this species. The minor variations shown in the angle of divergence of the lateral secondaries are not regarded as of specific importance. The essential features of the leaves of this species, discussed in my report on the Medicine Bow flora, are present in all the Lance Creek specimens.

Continued work with type specimens at the U. S. National Museum has shown that the Laramie leaf specimens referred by Knowlton to *Ficus post-trinervis* are not distinguishable in any observable features from the specimens which he designated as the cotypes of *F. trinervis*.

The leaves of this species are widespread, though apparently nowhere particularly abundant, in the late Cretaceous sediments of the Rocky Mountain region. In addition to its occurrence in the type Lance formation, it is known also from the Mesaverde (Ericson-Almond), Vermejo, Black Buttes, Medicine Bow, Fruitland, Laramie, Denver, Dawson, and Raton floras.

The systematic status of this species is still in doubt.

Occurrence—Localities P3854, P3859.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 2559, 2560.

Quercus? viburnifolia Lesquereux

(Plate 16, Figs. 5, 7, 8)

Quercus viburnifolia Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 7, 159, pl. 20, figs. 11, 12, 1878; U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1876), 505, 1878; Bull. Harvard Coll. Mus. Comp. Zoöl., vol. 16, 46, 1888. Knowlton, Proc. Washington Acad. Sci., vol. 11, 191, 207, 1909; U. S. Geol. Surv. Prof. Paper 130, 127, 1922; U. S. Geol. Surv. Prof. Paper 155, 50, pl. 16, figs. 3–8, pl. 17, fig. 1, 1930. Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. I, 53, pl. 6, figs. 3, 5, 7, 1938; Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.
Alnus auraria Knowlton and Cockerell. Knowlton, U. S. Geol. Surv. Prof. Paper 155, 49, pl. 15, fig. 6, 1930.
Betula fallax Lesquereux (in part). Knowlton, U. S. Geol. Surv. Prof. Paper 155, 50, pl. 15, figs. 7–9, pl. 16, figs. 1, 2, 1930.
Celastrus gaudini Lesquereux (in part). Knowlton, U. S. Geol. Surv. Prof. Paper 155, 99, pl. 45, fig. 9 (not figs. 3, 4), 1930.
Fraxinus sp., Knowlton, U. S. Geol. Surv. Prof. Paper 155, 124, pl. 58, fig. 7, 1930.
Populus denverensis Knowlton, U. S. Geol. Surv. Prof. Paper 155, 61, pl. 23, fig. 5, 1930.
Quercus purdonensis Knowlton, U. S. Geol. Surv. Prof. Paper 155, 52, pl. 17, fig. 2, 1930.
Quercus whitei Lesquereux. Knowlton, U. S. Geol. Surv. Prof. Paper 155, 53, pl. 17, fig. 3, pl. 18, fig. 1, 1930.
Viburnum contortum Lesquereux ?. Knowlton, U. S. Geol. Surv. Prof. Paper 155, 127, pl. 55, fig. 1, 1930.

Leaves of this species are not rare in the collections; over 15 specimens were obtained from six localities. Their occurrence in the beds of this region had previously been reported by Knowlton,[1] whose specimens I have seen at the U. S. National Museum.

In addition to its occurrence in the type Lance flora, this species is known from the Black Buttes, Laramie, Medicine Bow, Hell Creek, Dawson, and Denver floras; it has not been reported from beds either older or younger than post-Montanan Cretaceous.

The leaves of this species do not seem to me to be *Quercus*-like. Although they may reasonably be referred to the family Fagaceæ, I have not seen any modern leaves in this family which are strictly comparable. In the absence of positive resemblances, it does not seem advisable to change the generic reference at the present time.

Occurrence—Localities P3652, P3853, P3854, P3855, P3857, P3859.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 2561, 2562, 2563.

[1] Knowlton, F. H., Proc. Washington Acad. Sci., vol. 11, 207, 1909.

Rhamnus? minutus Knowlton

(Plate 17, Fig. 12)

Rhamnus minutus Knowlton, U. S. Geol. Surv. Bull. 696, 548, 1919; U. S. Geol. Surv. Prof. Paper 130, 155, pl. 17, fig. 2, 1922. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

There are 3 nearly complete specimens of small, linear, coriaceous leaves which are similar in essential details to the type and figured specimen of this Laramie species. Its resemblance to *Rhamnus salicifolius* Lesquereux [1] has been pointed out by Knowlton, who noted, however, the difference from that species in margin and tertiary venation. No other comparable leaves have come to my attention.

Although I can suggest no alternative, the generic reference of this species to *Rhamnus* is open to question. I have seen no leaves of existing species of *Rhamnus* which are comparable in observable details.

Occurrence—Localities P3857, P3859.

Collection—U. C. Mus. Pal., Plesiotype No. 2564.

Trapa? microphylla Lesquereux

(Plate 17, Figs. 1, 2, 6)

Trapa? microphylla Lesquereux, U. S. Geol. and Geog. Surv. Terr., Bull., vol. 1 (1875), 369, 1876; U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1874), 304, 1876; Rept U. S. Geol. Surv. Terr., vol. 7, 295, pl. 61, figs. 16–17*a*, 1878. Ward, U. S. Geol. Surv. 6th Ann. Rept., 554, pl. 49, figs. 2–5, 1885; U. S. Geol. Surv. Bull. 37, 64, pl. 28, figs. 2–5, 1887. Knowlton, U. S. Geol. Surv. Mon. 32, pt. 2, 661, pl. 77, figs. 3, 4, 1898; U. S. Geol. Surv. Bull. 163, 62, pl. 5, fig. 7, 1900; U. S. Geol. Surv. Bull. 257, 144, 1905; Proc. Washington Acad. Sci., vol. 11, 189, 202, 207, 1909. Berry, Canada Geol. Surv. Mem. 182, 61, pl. 19, figs. 1–11, 1935. Brown and Houldsworth, Jour. Washington Acad. Sci., vol. 29, no. 1, 36, 1939. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 220, 222, 225, 226, 229, 1940.

There are 35 well-preserved, detached leaflets, from five localities, which cannot be distinguished from the type and figured specimens of this widespread species. Knowlton has previously reported this species from the Lance Creek area; [2] I have seen his excellent specimens in the collections at the U. S. National Museum (specimens No. 1003 [1462]).

Both Berry and Brown have discussed the uncertain systematic status of this species and have fully described its well-defined characters. Leaflets of this form are widespread and abundant in rocks of both Late Cretaceous and Paleocene age in the Rocky Mountain region.

Occurrence—Localities P3853, P3854, P3856, P3858; U. S. Geol. Survey Locality 1462.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 2565, 2566, 2567; Nos. 2568, 2569, 2570.

Phyllites trifoliatus Dorf, n. sp.

(Plate 17, Figs. 3, 4)

Lysimachia sp., Knowlton, Proc. Washington Acad. Sci., vol. 11, 207, 1909.

There is a single specimen and counterpart, borrowed from the U. S. National Museum, which is unlike anything else seen in the collections. There are, moreover, no fossil species in either Cretaceous or Tertiary floras with which the specimen can be compared.

Description—Leaves apparently arranged in trifoliate manner; individual leaflets broadly ovate to elliptic, 1.8–3.9 cm. long by 1–1.5 cm. wide; margins entire; bases and tips acutely wedge-shaped; venation pinnate with 4–6 pairs of subopposite secondaries, coming off the midribs at acute angles and arching sharply upward, becoming essentially parallel to the midribs at their distal ends; tertiary venation very fine, indistinct; texture apparently fairly thick.

I have been unable to find any modern leaves which resemble this species. It may be that the trifoliate arrangement is more apparent than real, so that the leaflets are actually a whorl of spirally arranged leaves of a type seen, for example, in various members of the family Primulaceæ. Until better specimens of this species are obtained, however, it seems best not to make a definite generic assignment.

[1] Lesquereux, L., Rept. U. S. Geol. Surv. Terr., vol. 7, 282, pl. 53, figs. 9, 10, 1878.
[2] Knowlton, F. H., Proc. Washington Acad. Sci., vol. 11, 207, 1909.

Occurrence—U. S. Geol. Survey Locality 1462.
Collection—U. S. National Museum, Holotype Nos. 40259, 40259*a* (counterpart).

Phyllites sp.

(Plate 17, Figs. 9, 14)

Zizyphus ripleyensis Berry. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

The reported presence of *Zizyphus ripleyensis* in the Lance Creek collection was based on the specimen shown in plate 17, figure 9. The recent discovery of a second specimen of precisely similar venation shows, however, that this leaf form is not lanceolate, as might be surmised from figure 9, but is distinctly ovate, as shown in figure 14. This precludes the possibility of its identity with the Ripley species, which is consistently lanceolate or ovate-lanceolate.

I have been unable to find any other described fossil species, either in the Cretaceous or in the Tertiary, which has the characters here observed. The inadequate Laramie specimen of *Zizyphus coloradensis* Knowlton [1] is comparable, but lacks the secondary veins along the midrib, which are so characteristically defined in the Lance Creek specimens.

Occurrence—Locality P3853.
Collection—U. C. Mus. Pal., Nos. 2571, 2572.

Phyllites sp.

(Plate 17, Figs. 5, 13)

There are several fragmentary leaf impressions from two localities which are of a different form from any others in the Lance Creek collections. The figured specimens show the upper part of a leaf with numerous parallel secondaries ending in a doubly serrate margin. Other poorly preserved impressions indicate that these leaves are ovate-lanceolate and asymmetrical at the base. This combination of leaf characters suggests ulmaceous affinities. It is unfortunate that the lack of adequate material prevents a full description. In observable features there is a suggestion of resemblance to the Denver specimen referred to *Ulmus antecedens* Lesquereux,[2] and to the Raton specimen of *Ulmus* sp.[3]

Occurrence—Localities P3855, P3858.
Collection—U. C. Mus. Pal., Nos. 2573, 2574.

Phyllites sp.

(Plate 17, Fig. 16)

The figured specimen is the only one of this kind in the Lance collections. I had tentatively regarded it as rather closely similar to the specimen from the Dakota sandstone referred to *Populus microphylla* Newberry.[4] Recently, however, Brown has re-examined the Dakota specimen and states that after cleaning it "shows numerous small teeth instead of the large teeth as illustrated." [5] The general shape and venation of the Lance specimen is suggestive of some of the aberrant leaves of *Cercidiphyllum arcticum* (Heer) Brown,[6] yet the extraordinarily large teeth are not to be seen in any figured specimens of that species.

I have not encountered any modern leaves with which this specimen can be compared.

Occurrence—Locality P3854.
Collection—U. C. Mus. Pal., No. 2575.

Carpites lancensis Dorf, n. sp.

(Plate 17, Figs. 10, 15)

Carpolithus hirsutus Newberry. Brown, U. S. Geol. Surv. Prof. Paper 189, 253, pl. 61, figs. 17–19, 1939. Dorf, Bull. Geol. Soc. Amer., vol. 51, 218, 222, 1940.

[1] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 130, 157, pl. 15, fig. 5, 1922.
[2] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 155, 62, pl. 23, fig. 7, 1930.
[3] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 101, 300, pl. 70, fig. 4, 1917.
[4] Newberry, J. S., U. S. Geol. Surv. Mon. 35, 46, pl. 3, fig. 5, 1898.
[5] Brown, R. W., Jour. Paleontol., vol. 13, 491, 1939.
[6] Ibid., 492, pl. 53, fig. 5, pl. 54, fig. 2.

There are 2 nearly complete specimens of winged fruits which differ in many details from the specimen referred below to *Carpites ulmiformis,* which they resemble in a general way.

Description—Impressions show a perfectly oval samara 13 mm. long and 10–12 mm. wide, apparently completely surrounded by a narrow wing 2–3 mm. wide; seed impression large, 11 mm. long by 7–9 mm. wide, centrally marked by a longitudinal furrow and 2 flanking longitudinal lines; wing marked by numerous straight, spinelike veins; margin entire.

Except for the longitudinal furrow and lines, there is nothing in common between these winged fruits and that of *C. ulmiformis.* No comparable fruits have been described or reported, though there is a general similarity to *Carpolithus hirsutus* Newberry,[1] which was previously regarded as the same. In this species from the Raritan formation the fruits are smaller, are marked by only a single wide groove down the middle, and are distinctly surrounded by bristles rather than a membranous wing. In undescribed collections at the U. S. National Museum there are several winged fruits which are identical with those of *Carpites lancensis;* these were collected by Brown from the Hell Creek formation of Montana and from the true Lance "on Lance Creek, east bank, opposite and above the month of Bull Creek." [2]

The modern relationships or resemblances of these fossil fruits are unknown at the present time.

Occurrence—Localities P3651, P3853.

Collection—U. C. Mus. Pal., Cotypes Nos. 2576, 2577.

Carpites ulmiformis Dorf, n. sp.

(Plate 17, Figs. 17, 18)

Ulmus sp., Knowlton, Bull. Geol. Soc. Amer., vol. 8, 1930, 1897; Proc. Washington Acad. Sci., vol. 11, 207, 1909

This species is based on the single specimen figured, which was collected by Knowlton from near the old "Buck Creek corrals." This locality is in the same vicinity as Locality P3859 of the present report.

Description—This impression consists of an obovate samara 16 mm. long and 13 mm. wide just above the middle; apex openly notched; base acutely elongated into a thin pedicel of indeterminable length; seed impression narrowly ovoid, 6 mm. wide, extending nearly the full length of the samara, marked distinctly by a central furrow, and less distinctly by 2 longitudinal lines on opposite sides of the furrow; wing broad, entire-margined, and reticulate-veined.

I have not seen any described or figured fossil fruit which has the characters of this species. In attempting to allocate this fruit to an existing genus I was at first inclined to follow Knowlton in his original reference to *Ulmus.* After consulting all available species of this genus at the New York Botanical Garden, however, I became convinced that the Lance Creek specimen differs consistently in two respects: (1) it lacks the persistent remnants of the calyx at the base; (2) the prominent furrow and longitudinal lines on the fossil impression have no counterparts, either as lines, furrows, or ridges, in the seeds of the modern species of *Ulmus.* Despite a further concentrated search among living species with winged fruits, I have not been successful in finding a modern analogue.

Occurrence—U. S. Geol. Survey Locality 1479.

Collection—U. S. National Museum, Holotype Nos. 40260, 40260*a* (counterpart).

Carpites verrucosus Lesquereux

(Plate 17, Fig. 7)

Carpites verrucosus Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 7, 305, pl. 60, fig. 23, 1878.

There is a single, nearly perfect impression which agrees in essential details with the specimens and description of this species from the Black Buttes flora. Its original description was as follows:

[1] Newberry, J. S., U. S. Geol. Surv. Mon. 26, 134, pl. 146, figs. 14, 14*a*, 1896. Hollick, A., U. S. Geol. Surv. Mon. 50, 110, pl. 7, figs. 3–8, 1906.

[2] Field label, U. S. National Museum.

"Fruit nearly round, one centimeter across, emarginate in the lower part at its point of attachment to a short broken pedicel; surface flat, covered with small obtuse warts. . . . This seed is surrounded by a flat margin, which may be the borders of a flattened pericarp."

Except for its shape, which is somewhat reniform, the Lance Creek specimen is similar in all observable details to the original Black Buttes specimens. No other comparable fossil forms have been noted. A suite of much larger impressions of somewhat similar nature have been collected from the "Fort Union" formation near Bear Creek, Montana.[1]

I can offer no suggestions as to the systematic relationship of this species. That it belongs to the plant kingdom is shown by the filmy, dark residue of carbon on its surface. Lesquereux has pointed out its resemblance to the flattened drupe of a *Magnolia*.

Occurrence—Localities P3651, P3859.

Collection—U. C. Mus. Pal., Plesiotype No. 2578.

Carpites walcotti Dorf

Carpites walcotti Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. 1, 78, pl. 19, figs. 1, 2, 1938; Bull. Geol. Soc. Amer., vol. 51, 218, 222, 1940.

There are 2 seed impressions and a counterpart from Locality P3855 which agree in every respect with the figured and type specimens of this species. Seeds of this character are at present known only from the Medicine Bow and Lance formations of Wyoming.

The botanical affinities of this nominal species are still unknown.

Occurrence—Locality P3855.

Collection—U. C. Mus. Pal., Nos. 2579, 2583, 2583*a* (counterpart).

Carpites sp.

(Plate 17, Fig. 8)

The figured specimen shows a small, rounded cast of a fruit (?), which is marked by four prominent ridges dividing the cast into four equal segments. It is possible that the fossil may originally have been a partially split husk. It has not been possible to determine its botanical affinities.

To my knowledge there is no record of fossil fruits or seeds with which the present specimen may be compared.

Occurrence—Locality P3854.

Collection—U. C. Mus. Pal., No. 2580.

Carpites sp.

(Plate 17, Fig. 11)

This specimen is a flattened impression of a rounded body, possibly a fruit, extended at both ends into wedge-shaped, ribbed prolongations. The prolongation is larger at one end of the body than at the other. Within a thin rim the central body is almost perfectly circular and is faintly marked by meridional lines. The botanical affinities of this form are unknown, as are also any previous fossil records of comparable remains.

Occurrence—Locality P3855.

Collection—U. C. Mus. Pal., No. 2581.

Palæoaster inquirenda Knowlton

(Plate 17, Fig. 19)

Palæoaster inquirenda Knowlton, U. S. Geol. Surv. Prof. Paper 101, 278, pl. 49, figs. 5, 6, 1917. Dorf, Carnegie Inst. Wash. Pub. No. 508, pt. 1, 77, pl. 19, figs. 3, 6, 1938; Bull. Geol. Soc. Amer., vol. 51, 218, 222, 225, 1940.

Palæoaster? similis Knowlton, U. S. Geol. Surv. Prof. Paper 130, 168, pl. 24, figs. 10, 11, 1922.

[1] Princeton University collection, Nos. 21001–21004.

This clearly defined species is represented in the collection by the figured specimen and several fragments from Locality P3854. The figured specimen has all the essential characteristics of the type and figured specimens of *Palæoaster inquirenda* from the Vermejo and Raton formations. The number of segments is apparently somewhat more variable than is implied in the original description. The Lance Creek specimen has 14 segments, a feature which I do not consider sufficiently important to maintain the specimen as a distinct species.

The botanical status of this species is still doubtful. Knowlton has mentioned its general resemblance to the flowers of *Calycanthus*, *Magnolia*, and *Williamsonia*, and to the fruits of *Liriodendron*. The Dawson (?) specimen referred to *Sterculiocarpus coloradensis* Berry, which is probably conspecific with *Palæoaster inquirenda*, is regarded as sterculiaceous.[1]

Remains of this species are now known in the Vermejo, lower Medicine Bow, Laramie, and lowermost Raton floras, besides being present in the true Lance of both Wyoming and Montana.

Occurrence—Locality P3854.

Collection—U. C. Mus. Pal., Plesiotype No. 2582.

[1] Berry, E. W., Jour. Washington Acad. Sci., vol. 22, 119, figs. 1, 2, 1932.

PLATES

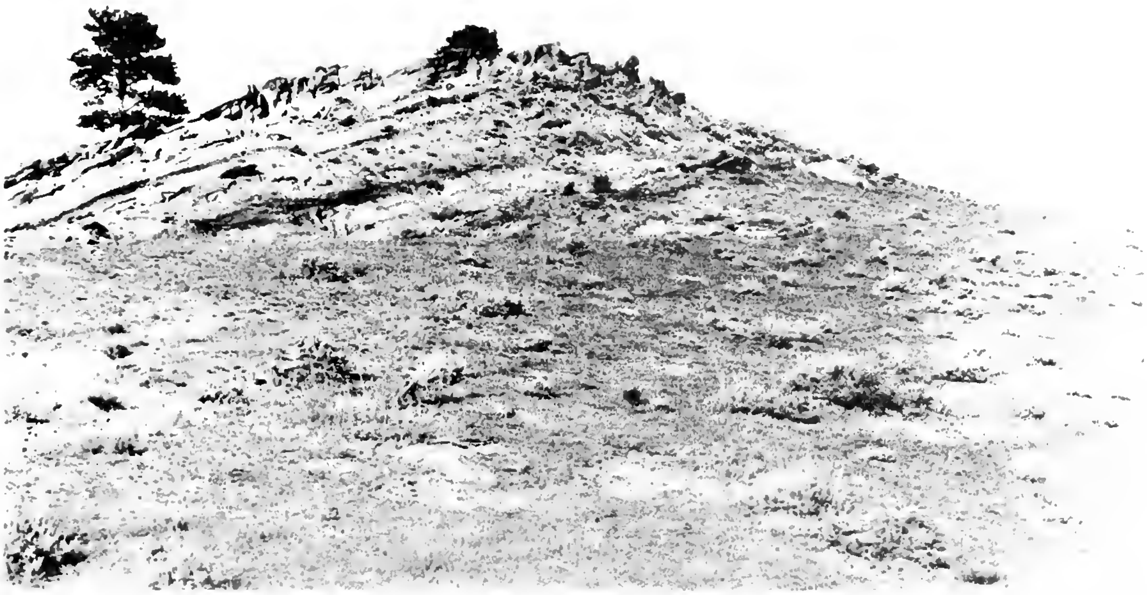


Fig. 1—Locality P3853. Low ridge showing coarse sandstone at summit and underlying sandy shales, lignites, and thin sandstones of lower Lance formation.

Fig. 2 Locality P3853. Nearer view, showing excavations in plant-bearing sandstone ledge in the foreground.

Fig. 1—Locality P3854. Plants occur in ledge of hard siltstone, right center.

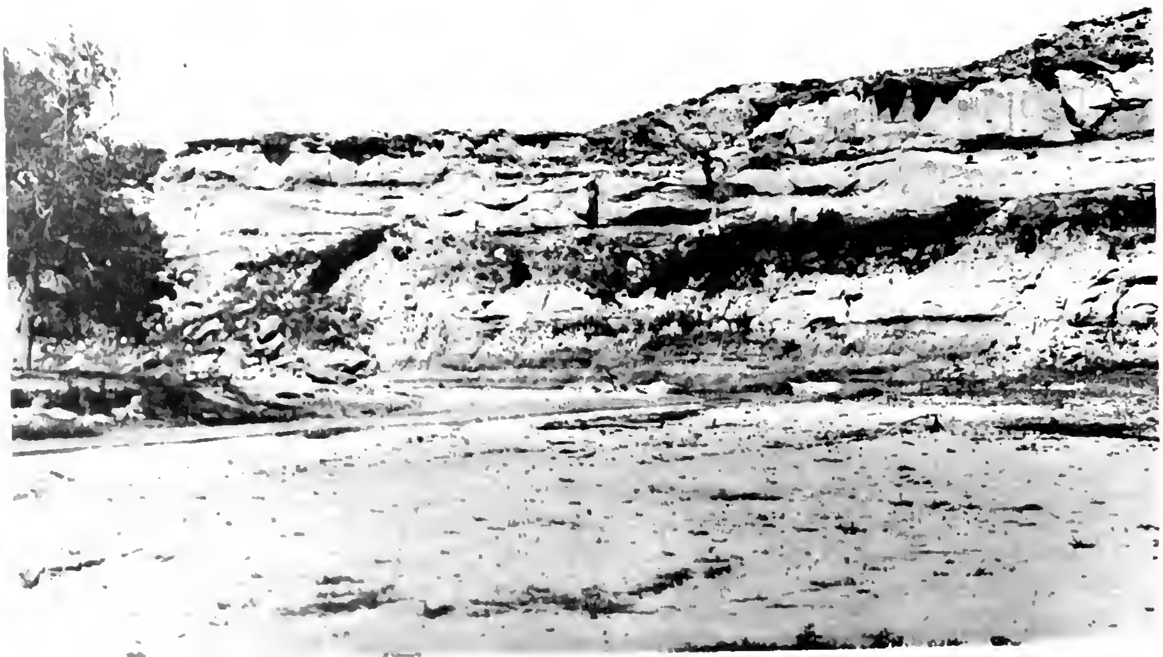
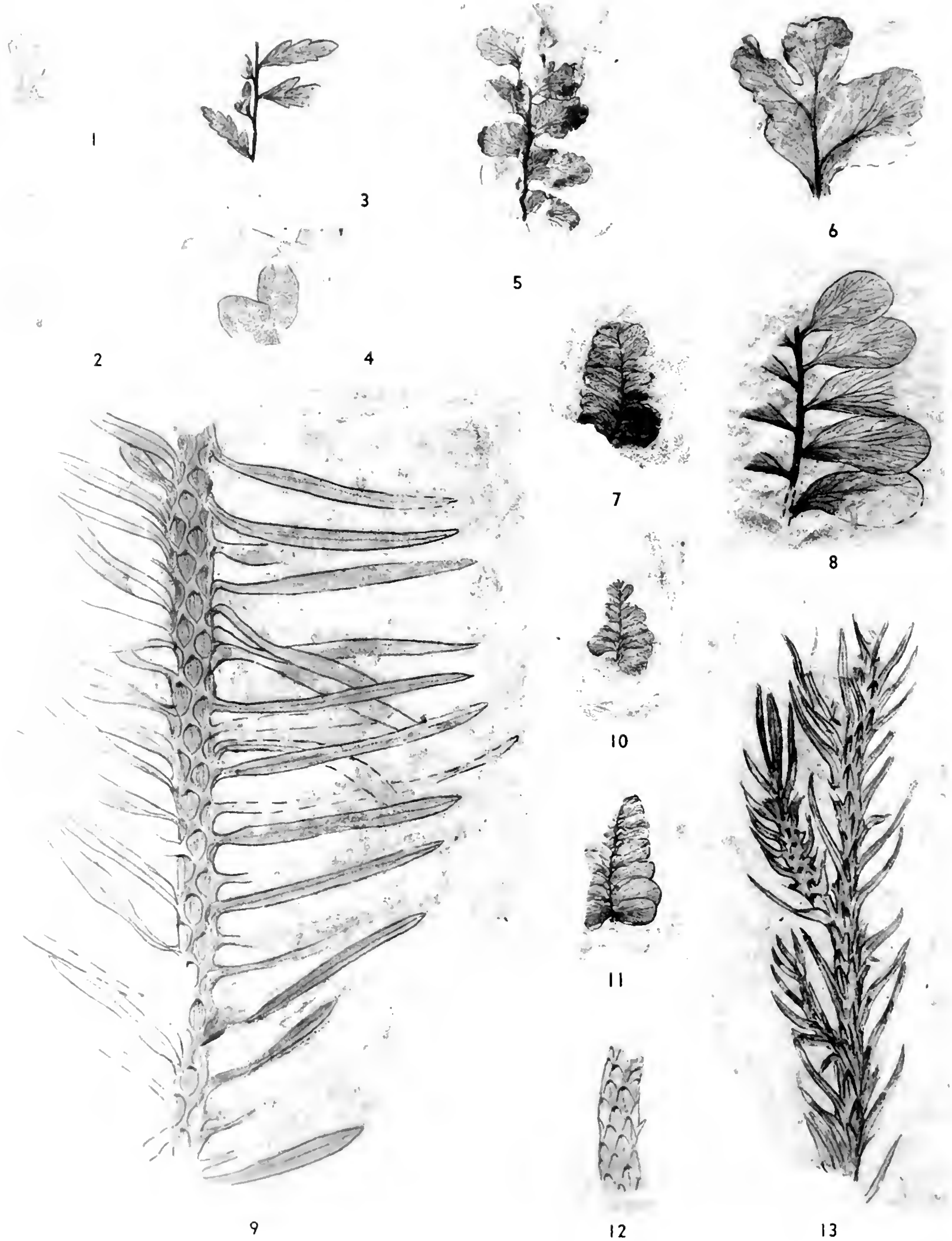


Fig. 2—Locality P3857, showing outcrops in east wall of Lance Creek. Plants and fresh-water mollusks were collected from siltstone bed below upper massive sandstone.

FIG. 1—Locality P3858. Plants occur in large siltstone concretions at base of cliff, left center.

FIG. 2—Locality P3859. Plants occur in thinly bedded siltstone just above line of large concretions, right center.



Figs. 1, 2—*Asplenites tenellum* (Knowlton) Dorf. Plesiotypes. × 2. U. C. Mus. Palæobot., Nos. 2450, 2451.

Fig. 3—*Asplenites tenellum* (Knowlton) Dorf. Plesiotype. U. C. Mus. Palæobot., No. 2452.

Fig. 4—*Salvinia*? sp. U. S. Nat. Mus., No. 40249.

Fig. 5—*Woodwardia*? *crenata* Knowlton. Plesiotype. U. C. Mus. Palæobot., No. 2453.

Fig. 6—*Woodwardia*? *crenata* Knowlton. Plesiotype. × 2. U. C. Mus. Palæobot., No. 2454.

Fig. 7—*Filicites knowltoni* Dorf. Cotype. U. C. Mus. Palæobot., No. 2455.

Fig. 8—*Filicites knowltoni* Dorf. Cotype. × 3. U. C. Mus. Palæobot., No. 2456.

Figs. 9, 12, 13—*Araucarites longifolia* (Lesquereux) Dorf. Plesiotypes. U. C. Mus. Palæobot., Nos. 2474–2476.

Figs. 10, 11—*Filicites knowltoni* Dorf. Cotypes. U. S. Nat. Mus., Nos. 40250, 40250*a*.

FIGS. 1–6—*Araucarites longifolia* (Lesquereux) Dorf. Plesiotypes. U. C. Mus. Palæobot., Nos. 2477–2482.

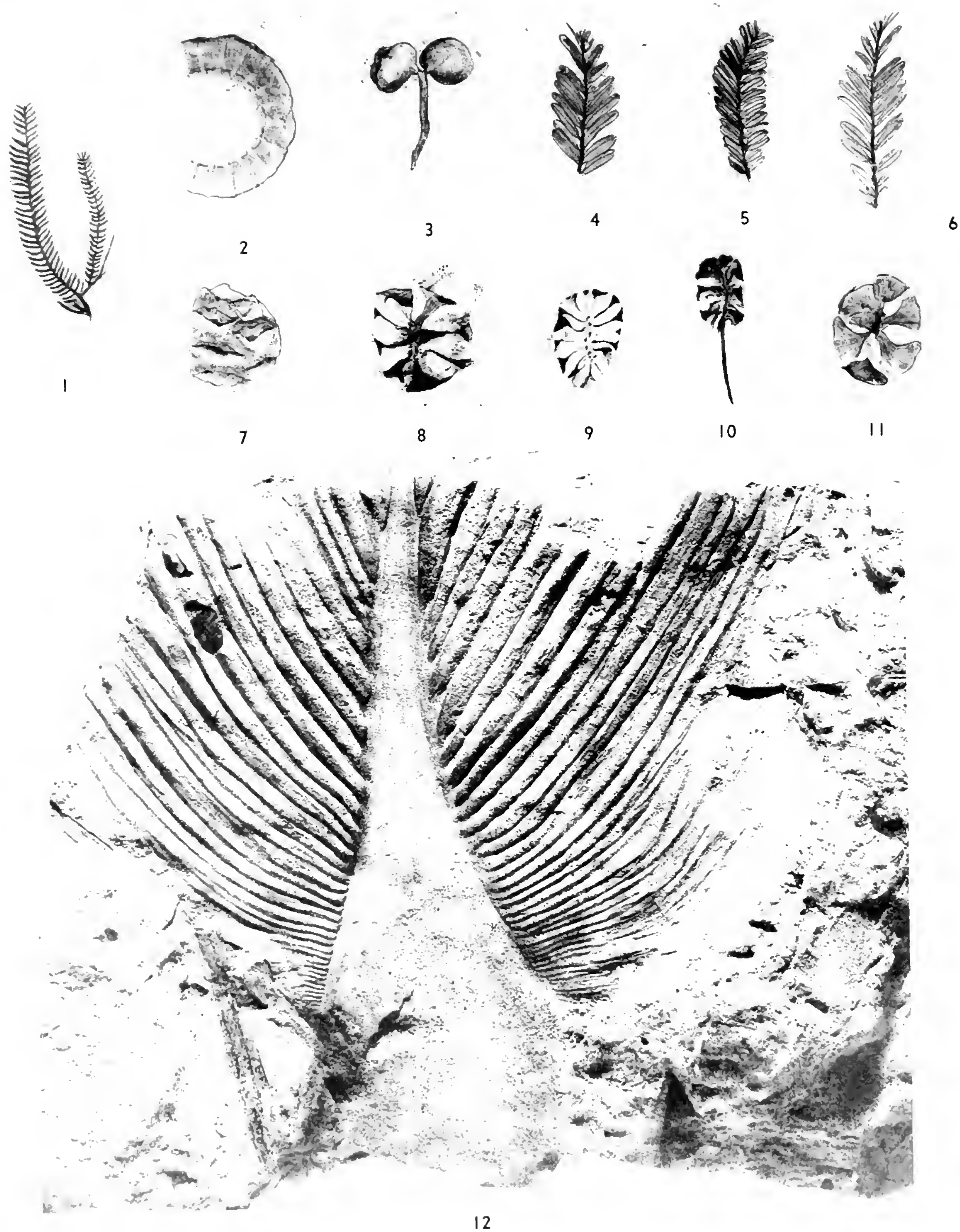


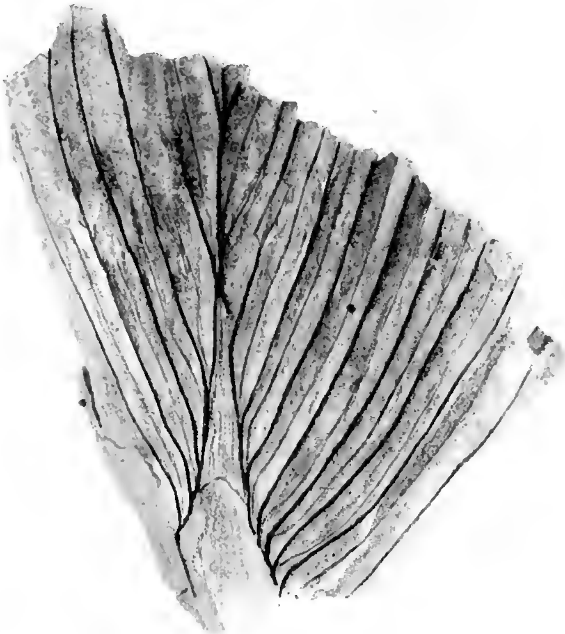
Fig. 1—*Selaginella? falcata* Lesquereux. Plesiotype. U. C. Mus. Palæobot., No. 2459.

Fig. 2—*Equisetum* sp. × 3. U. C. Mus. Palæobot., No. 2457.

Fig. 3—*Equisetum* sp. U. C. Mus. Palæobot., No. 2458.

Figs. 4–11—*Sequoia dakotensis* Brown. Plesiotypes. U. C. Mus. Palæobot., Nos. 2461–2468.

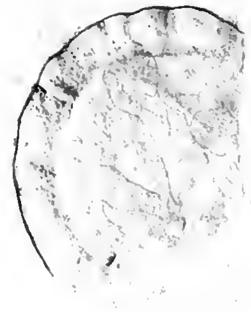
Fig. 12—*Sabalites montana* (Knowlton) Dorf. Plesiotype. U. C. Mus. Palæobot., No. 2486.



1

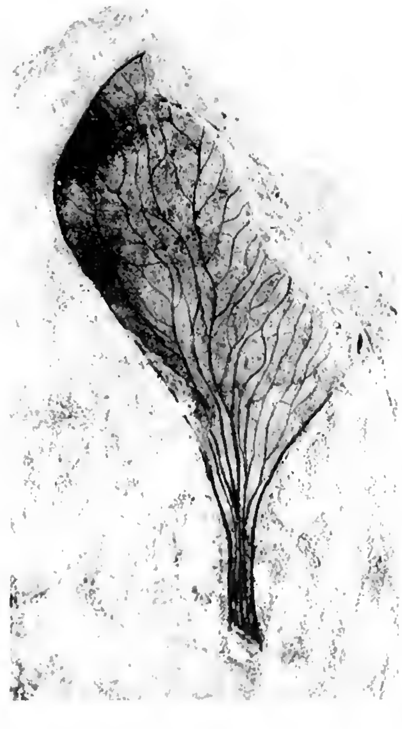
2

3



4

5



6

7

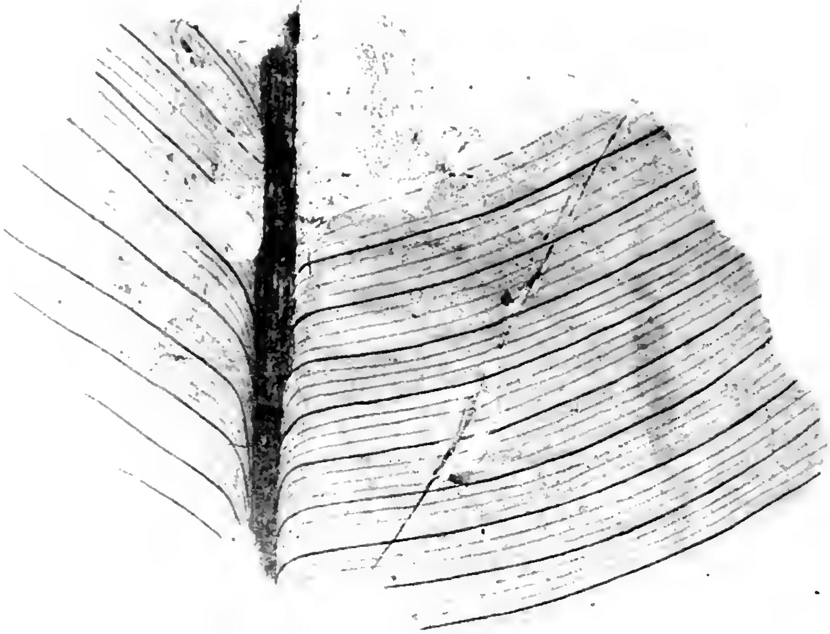
8

Fig. 1—*Sabalites eocenica* (Lesquereux) Dorf. Plesiotype. U. C. Mus. Palæobot., No. 2487.

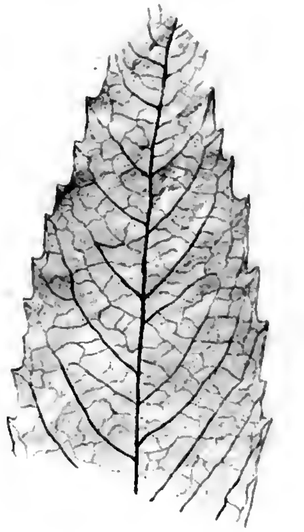
Figs. 2, 8—*Salix lancensis* Berry. Plesiotypes. U. S. Nat. Mus., Nos. 40251, 40252.

Figs. 5, 7—*Salix lancensis* Berry. Plesiotypes. U. C. Mus. Palæobot., Nos. 2493, 2494.

Figs. 3, 4, 6—*Pistia corrugata* Lesquereux. Plesiotypes. U. C. Mus. Palæobot., Nos. 2488–2490.



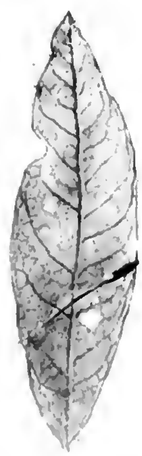
1



2

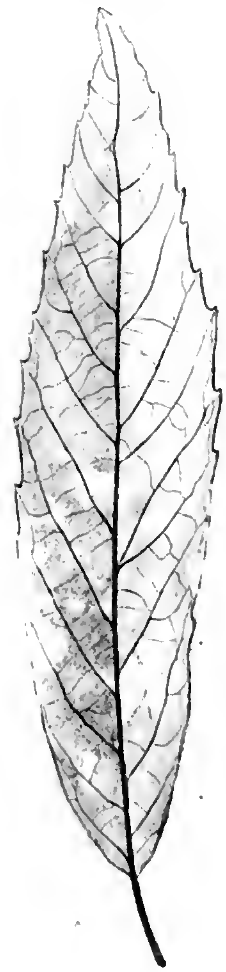
4

3



5

6



7

FIG. 1—*Canna? magnifolia* Knowlton. Plesiotype. U. C. Mus. Palæobot., No. 2492.

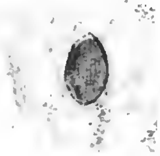
FIGS. 2, 4, 6, 7—*Dryophyllum subfalcatum* Lesquereux. Plesiotypes. U. C. Mus. Palæobot., Nos. 2497–2500.

FIG. 3—*Salix lancensis* Berry. Plesiotype. U. C. Mus. Palæobot., No. 2495.

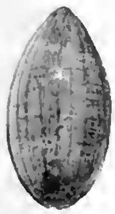
FIG. 5—*Saliciphyllum wyomingensis* (Knowlton and Cockerell) Dorf. Plesiotype. U. C. Mus. Palæobot., No. 2496.

FIGS. 1, 4—*Platanophyllum montanum* (Brown) Dorf. Plesiotypes. U. C. Mus. Palæobot., Nos. 2503, 2504.
FIG. 2 *Laurophyllum coloradensis* (Knowlton) Dorf. Plesiotypes. U. C. Mus. Palæobot., No. 2508.
FIG. 3 *Quercophyllum gardneri* (Knowlton) Dorf. Plesiotype. U. C. Mus. Palæobot., No. 2501.
FIG. 5 *Laurophyllum salicifolium* (Lesquereux) Dorf. Plesiotype. U. C. Mus. Palæobot., No. 2510.
FIG. 6—*Laurophyllum wardiana* (Knowlton) Dorf. Plesiotype. U. C. Mus. Palæobot., No. 2511.

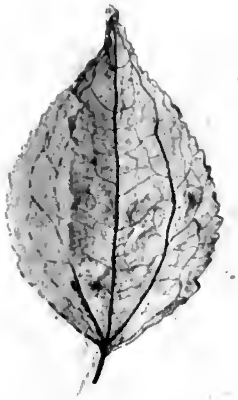
1



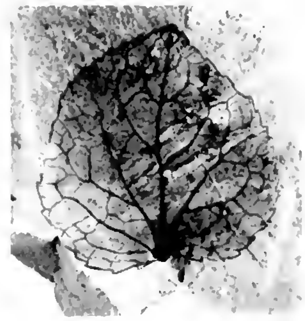
2



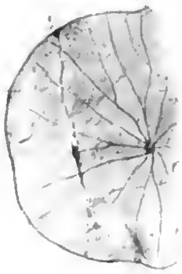
3



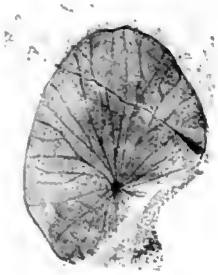
4



5



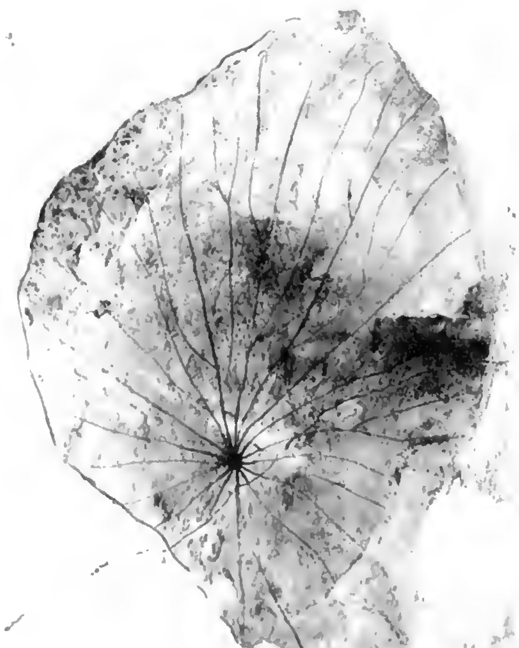
6



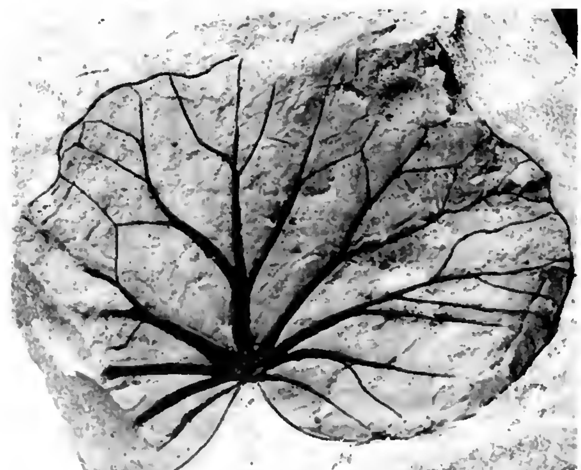
7

8

9



10



11

Fig. 1—*Aristolochites brittoni* (Knowlton) Dorf. Plesiotype. U. C. Mus. Palæobot., No. 2507.

Figs. 2, 4—*Cercidiphyllum ellipticum* (Newberry) Brown. Plesiotypes. U. C. Mus. Palæobot., Nos. 2512, 2514.

Fig. 3—*Cercidiphyllum ellipticum* (Newberry) Brown. Plesiotype. × 3. U. C. Mus. Palæobot., No. 2513.

Fig. 5—*Cercidiphyllum arcticum* (Heer) Brown. Plesiotype. U. C. Mus. Palæobot., No. 2515.

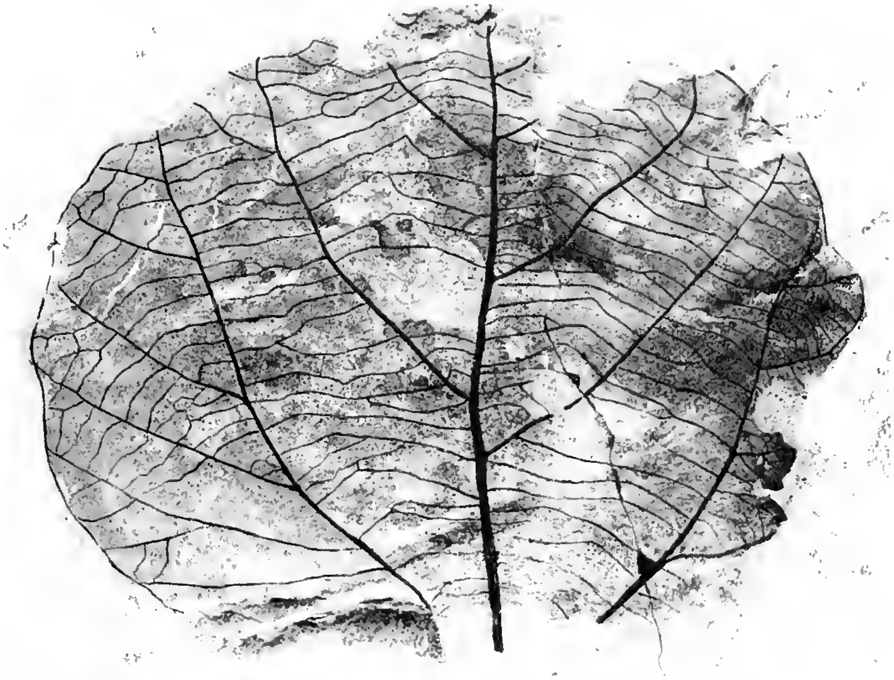
Figs. 6–8—*Nymphaeites dawsoni* (Hollick) Dorf. Plesiotypes. U. C. Mus. Palæobot., Nos. 2516–2518.

Fig. 9—*Nymphaeites browni* Dorf. Cotype. U. S. Nat. Mus., No. 40255.

Fig. 10—*Nelumbo tenuifolia* (Lesquereux) Knowlton. U. S. Nat. Mus., No. 40253.

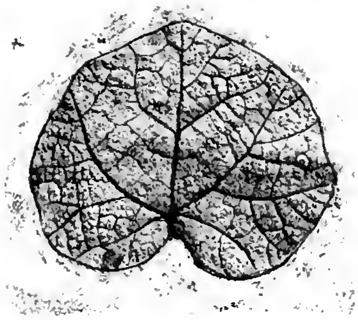
Fig. 11—*Menispermites knightii* Knowlton. Plesiotype. U. C. Mus. Palæobot., No. 2521.

1

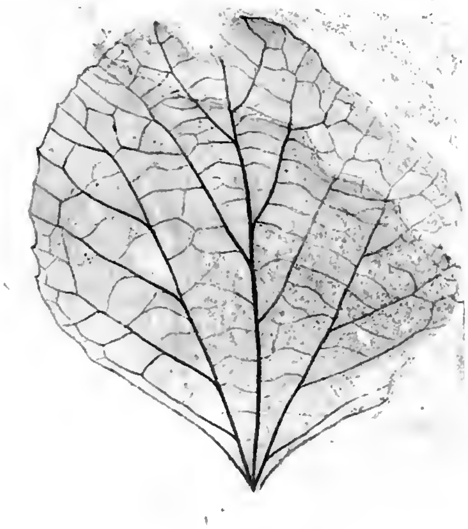


2

3



4



5

6

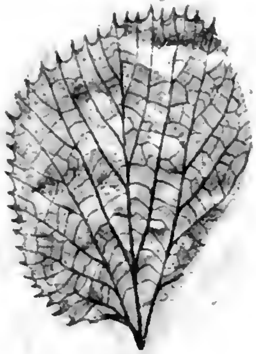
Figs. 1, 3—*Pistacia eriensis* Knowlton. Plesiotypes. U. C. Mus. Palæobot., Nos. 2523, 2524.

Fig. 2—*Menispermites cockerelli* (Knowlton) Dorf. Plesiotype. U. C. Mus. Palæobot., No. 2520.

Fig. 4—*Menispermites belli* Berry. Plesiotype. U. C. Mus. Palæobot., No. 2519.

Figs. 5, 6—*Vitis stantoni* (Knowlton) Brown. Plesiotypes. U. C. Mus. Palæobot., Nos. 2525, 2526.

1

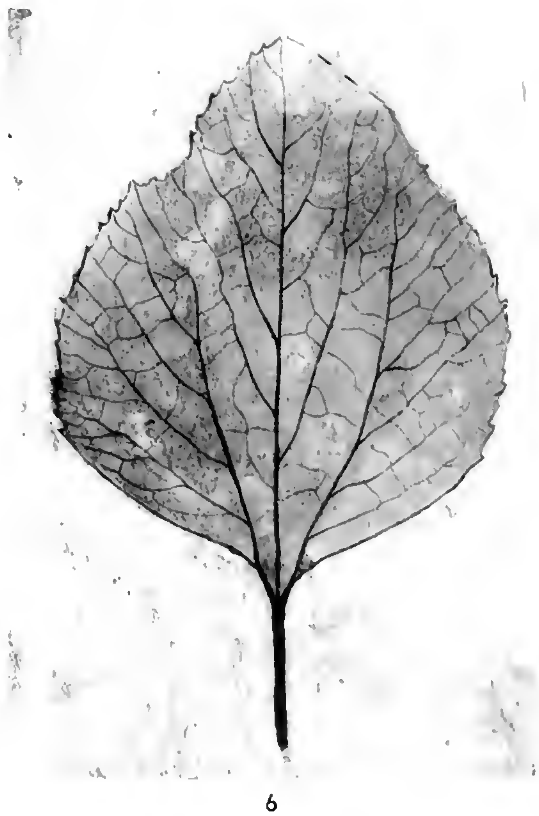


2

3

4

5



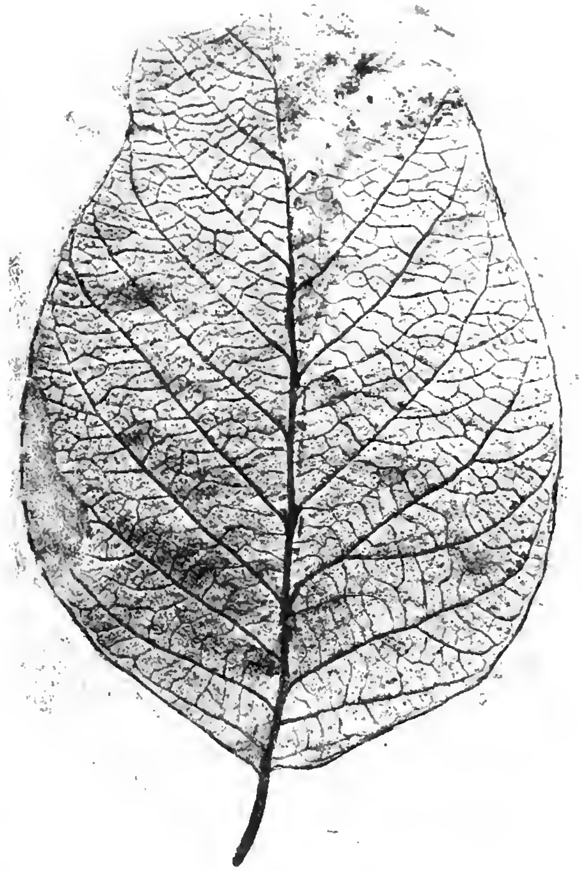
6

FIGS. 1–6—*Vitis stantoni* (Knowlton) Brown. Plesiotypes. U. C. Mus. Palæobot., Nos. 2527–2531.

1

2

3



4

5

6

7

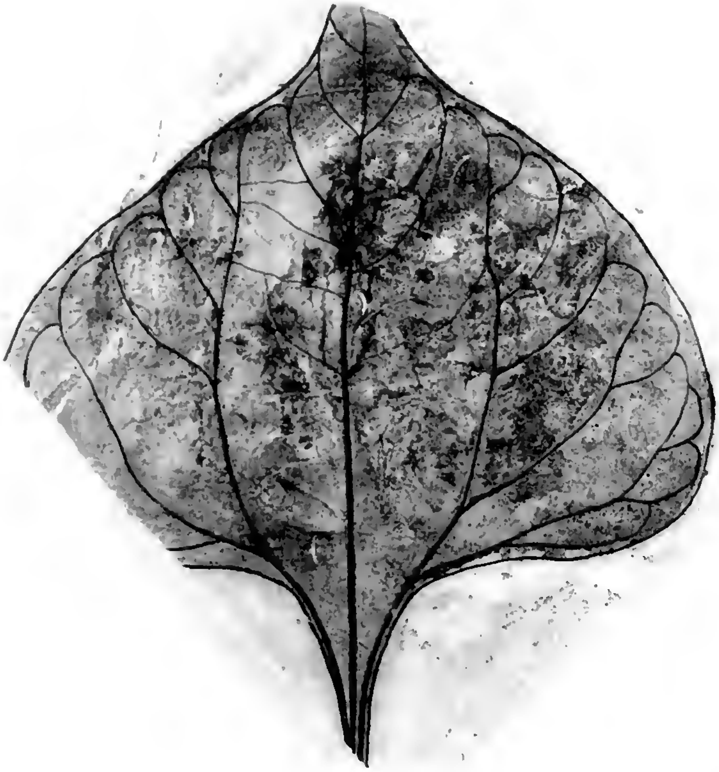
8

FIG. 1—*Dillenites cleburni* (Lesquereux) Dorf. Plesiotype. U. C. Mus. Palæobot., No. 2534.

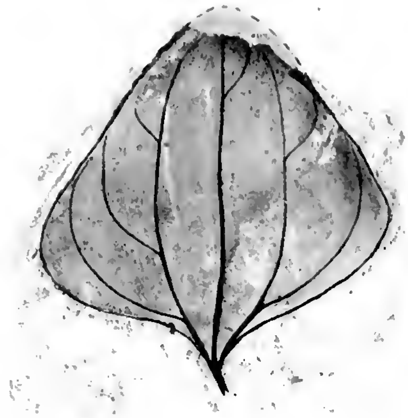
FIGS. 2, 3, 7—*Fraxinus leii* Berry. Plesiotypes. U. C. Mus. Palæobot., Nos. 2537–2539.

FIG. 4—*Araliæphyllum artocarpoides* (Lesquereux) Dorf. Plesiotype. U. C. Mus. Palæobot., No. 2535.

FIGS. 5, 6, 8—*Dombeyopsis trivialis* Lesquereux. Plesiotypes. U. C. Mus. Palæobot., Nos. 2545–2547.

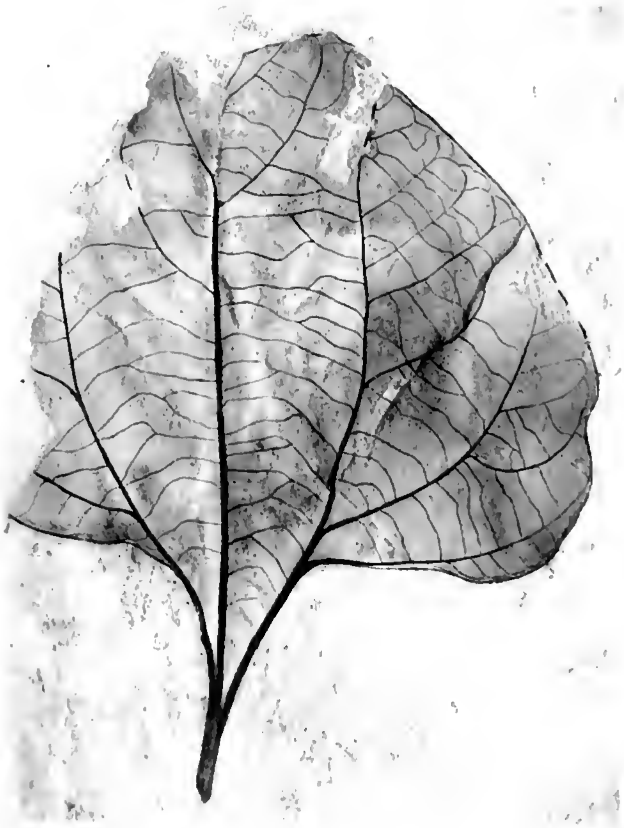


1



2

3

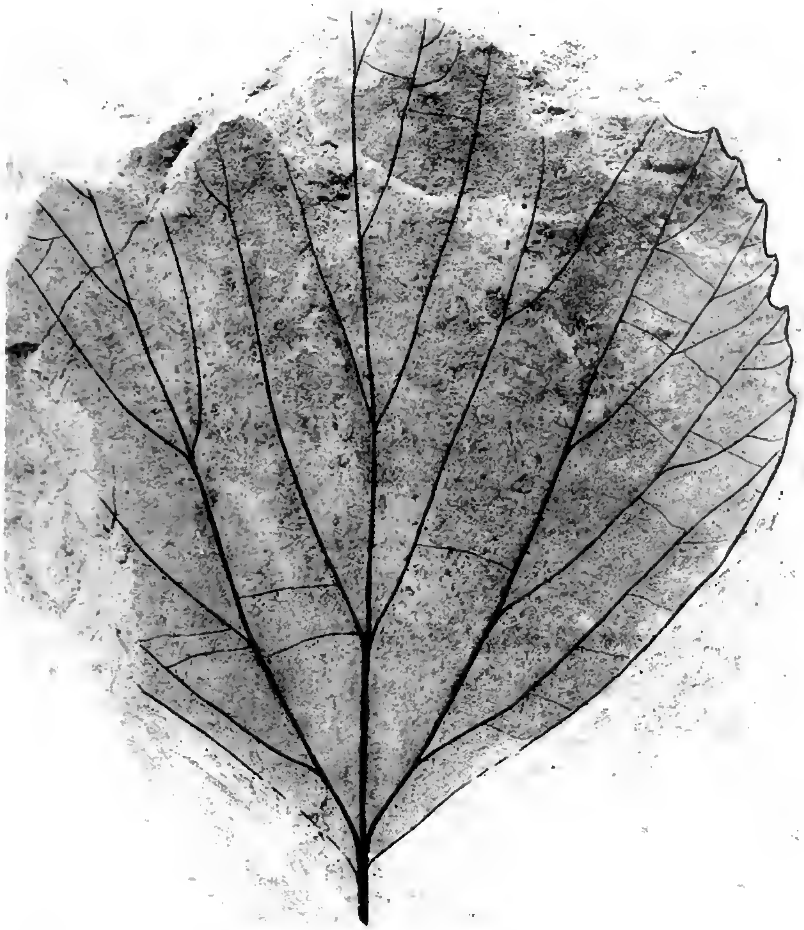


4

Figs. 1, 4 – *Dombeyopsis colgatensis* Brown. Plesiotypes. U. C. Mus. Palæobot., Nos. 2542, 2543.

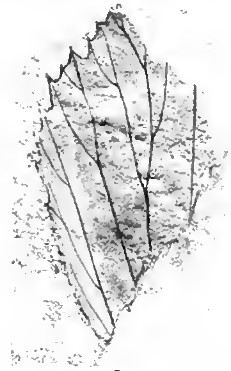
Fig. 2 – *Dombeyopsis obtusa* Lesquereux. Plesiotype. U. C. Mus. Palæobot., No. 2544.

Fig. 3 – *Viburnum marginatum* Lesquereux. Plesiotype. U. C. Mus. Palæobot., No. 2548.

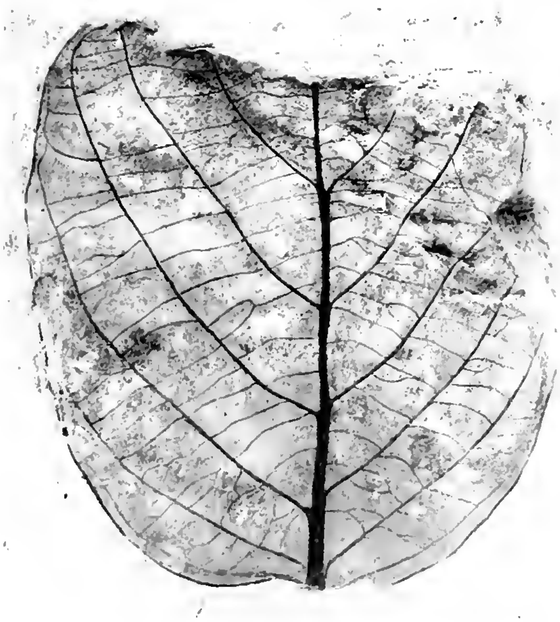


1

2



3



4

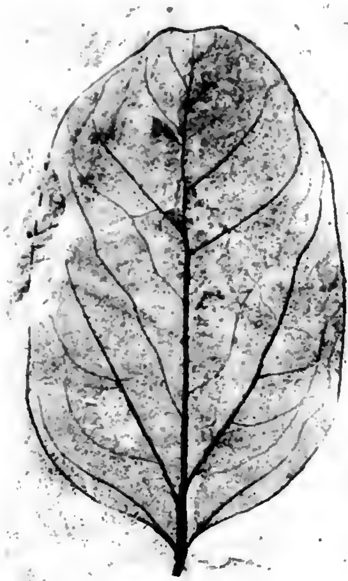
5

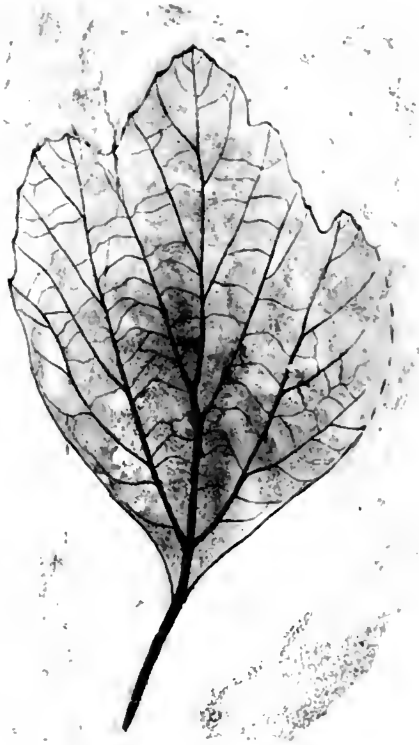
Figs. 1, 5—*Viburnum marginatum* Lesquereux. Plesiotypes. U. C. Mus. Palæobot., Nos. 2549, 2550.

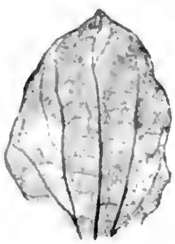
Figs. 2, 3—*Viburnum montanum* Knowlton. Plesiotypes. U. C. Mus. Palæobot., Nos. 2551, 2552.

Fig 4—*Anona? robusta* Lesquereux. Plesiotype. U. C. Mus Palæobot., No 2554.

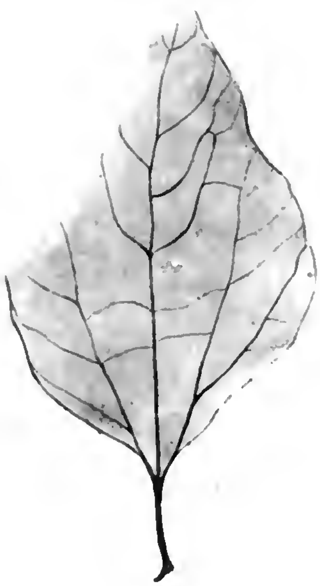

1

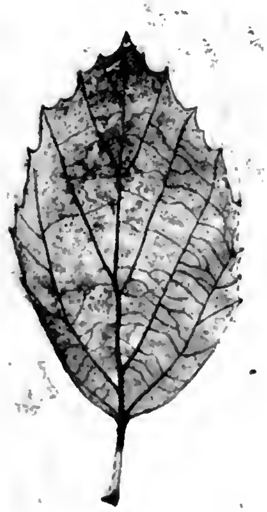

2


3


4


5


6


7

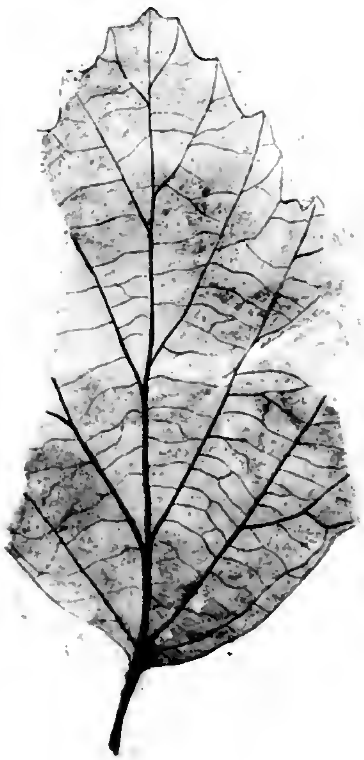
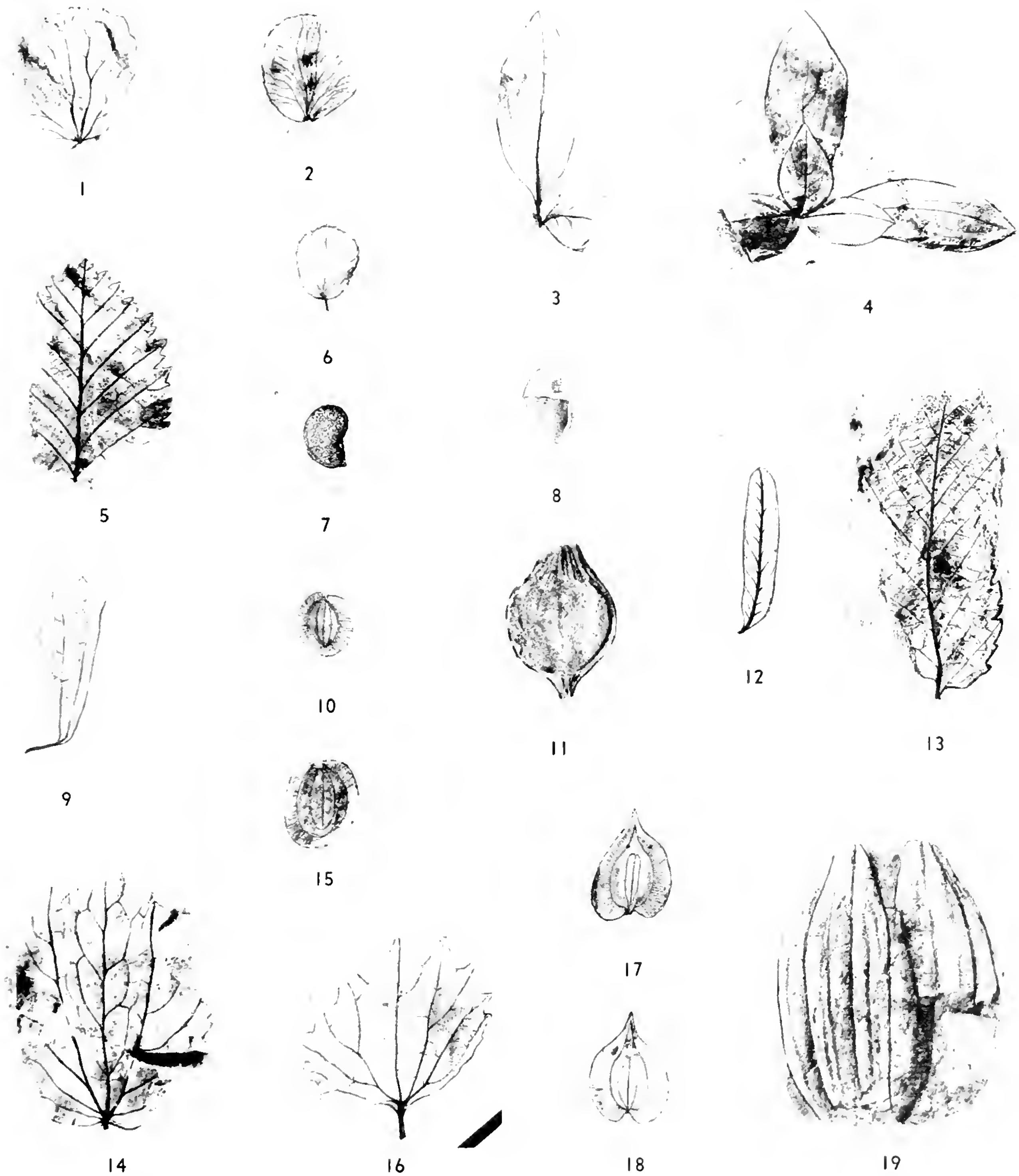

8

FIG. 1. *Celastrus? taurinensis* Ward. Plesiotype. U. C. Mus. Palæobot., No. 2556.
FIG. 2. *Cinnamomum? affine* Lesquereux. Plesiotype. U. C. Mus. Palæobot., No. 2557.
FIG. 3. *Cissus? lobato-crenata* Lesquereux. Plesiotype. U. C. Mus. Palæobot., No. 2558.
FIGS. 4, 6. *Ficus? trinervis* Knowlton. Plesiotypes. U. C. Mus. Palæobot., Nos. 2559, 2560.
FIGS. 5, 7, 8. *Quercus? viburnifolia* Lesquereux. Plesiotypes. U. C. Mus. Palæobot., Nos. 2561–2563.



Figs. 1, 2, 6—*Trapa? microphylla* Lesquereux. Plesiotypes. U. C. Mus. Palæobot., Nos. 2565–2567.

Figs. 3, 4—*Phyllites trifoliatus* Dorf. U. S. Nat. Mus., Nos. 40259, 40259*a*.

Figs. 5, 13—*Phyllites* sp. U. C. Mus. Palæobot., Nos. 2573, 2574.

Fig. 7—*Carpites verrucosus* Lesquereux. Plesiotype. U. C. Mus. Palæobot., No. 2578.

Fig. 8—*Carpites* sp. × 2. U. C. Mus. Palæobot., No. 2580.

Figs. 9, 14—*Phyllites* sp. U. C. Mus. Palæobot., Nos. 2571, 2572

Figs. 10, 15—*Carpites lancensis* Dorf. Cotypes. U. C. Mus. Palæobot., Nos. 2576, 2577.

Fig. 11—*Carpites* sp. U. C. Mus. Palæobot., No. 2581.

Fig. 12—*Rhamnus? minutus* Knowlton. Plesiotype. U. C. Mus. Palæobot., No. 2564.

Fig. 16—*Phyllites* sp. U. C. Mus. Palæobot., No. 2575.

Figs. 17, 18—*Carpites ulmiformis* Dorf. Holotype and counterpart. U. S. Nat. Mus., Nos. 40260, 40260*a*.

Fig. 19—*Palæoaster inquirenda* Knowlton. Plesiotype. U. C. Mus. Palæobot., No. 2582.