The Oligocene Bridge Creek Flora of the John Day Formation, Oregon

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To the memory of

Ralph Works Chaney

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Abbreviations

CMM	Cold month mean temperature
Ma	Megannum; indicates million year age on radioisotopic time scale
MART	Mean annual range of temperature
MAT	Mean annual temperature
JODA	Refers to collections at John Day Fossil Beds National Monument, John Day, Oregon
PSU	Collections at Portland State University, Portland, Oregon
USNM	Collections at the U.S. National Museum of Natural History, Smithsonian Institution, Washington, D.C.
UCMP	Collections at the University of California Museum of Paleontology, Berkeley, California
UF	Collections at the University of Florida, Museum of Natural History, Gainesville, Florida
UO	Collections at University of Oregon Condon Museum, Eugene, Oregon

Abstract

The Oligocene Bridge Creek flora of the lower John Day Formation in north-central Oregon provides a good example of the type of vegetation that became widespread in the Northern Hemisphere following the Eocene-Oligocene boundary. To provide a better understanding of this important transition, we conducted a comprehensive systematic revision of the Bridge Creek flora based on about 20,000 megafossil specimens from the John Day and Crooked River basins. Revision of the flora has involved analysis of the original type collections of L. Lesquereux, J. S. Newberry, F. H. Knowlton, R. W. Chaney, R. W. Brown, and others, as well as extensive new collections of leaves, fruits, and seeds from seven assemblages. Each assemblage is based on one to several localities in close geographic and stratigraphic proximity. The age of the flora is about 32.2–33.6 Ma, based on $^{40}Ar/^{39}Ar$ dates from three assemblages. The flora is more diverse than previously recognized, with 91 genera and 110 species known from leaves and 52 genera and 58 species known from reproductive structures (cones, flowers, fruits, or seeds). Minimum diversity is estimated at 125 species. The minimum diversity of individual assemblages is as high as 65 species. The flora includes at least 34 families of angiosperms, three families of conifers, three families of ferns, and one of horsetails. *Metasequoia* is the most common conifer and is found in all assemblages of the Bridge Creek flora. Most diverse among the angiosperms are families of deciduous dicotyledons, including Platanaceae, Ulmaceae, Fagaceae, Betulaceae, Juglandaceae, Rosaceae, and Sapindaceae. At least 11 genera are extinct, but the majority are extant, with the greatest representation today in the deciduous forests of eastern Asia and eastern North America. Broad-leaved evergreens are rare in the flora. The flora is physiognomically and taxonomically most similar to modern Mixed Mesophytic forest, and an estimate of paleoclimate is based on the distribution of this vegetation type in mesic regions of Asia today. The mean annual temperature is estimated at 9–11°C and the mean annual range of temperature 22–25°C. Elevation of the region during deposition of the Bridge Creek flora is estimated at 700–1200 m above modern sea level. Comparison with fossil floras of Europe and Asia indicates that the Bridge Creek flora is one of the oldest in the mid-latitudes of the Northern Hemisphere that shows dominance by extant genera of the Mixed Mesophytic forest. The majority of Bridge Creek genera were widely distributed around the Northern Hemisphere by

latest Oligocene time. Comparison with other fossil assemblages in western North America indicates that the Bridge Creek flora was derived from a variety of sources, including taxa that were already present in Eocene floras (some lowland, others upland), immigrants from other regions, and new taxa that radiated after climatic cooling near the end of the Eocene.

INTRODUCTION

The early Oligocene Bridge Creek flora of the John Day Formation in north-central Oregon provides a classic example of the temperate deciduous forest that developed in the mid-latitudes of the Northern Hemisphere immediately following the major temperature decline of the latest Eocene to earliest Oligocene. The Bridge Creek flora has been the subject of many systematic studies (e.g., Newberry 1883, 1898; Lesquereux, 1883; Knowlton, 1902; Chaney, 1927) and has figured prominently in the development of theories of paleoclimatic change and patterns of plant dispersal in the Tertiary of western North America (Chaney, 1947, 1948a; Wolfe and Hopkins, 1967; Wolfe, 1971, 1981b). Although the megafossil flora has attracted attention for more than a century, the precise systematic affinities of many of its elements have remained uncertain and poorly documented. The lack of a thorough, well-illustrated taxonomic treatment has limited the potential for detailed comparisons with other Tertiary floras of the Northern Hemisphere.

In the many years that have elapsed since Chaney's (1927) monograph, additional large collections have been made and approaches to the identification of fossil plants have changed considerably. Advances in techniques and methods of analysis of fossil plant remains (e.g., Dilcher, 1974; Hickey and Wolfe, 1975; Manchester and Crane, 1983; Crepet and Nixon, 1989), together with increased attention to characters observed to be diagnostic among modern relatives, have enabled more reliable systematic determinations. Whereas previous treatments have dealt mainly with leaves, with only limited attention to reproductive structures, we have examined fruits and flowers in detail. In many instances, reproductive structures provide greater resolution of systematic affinities. In a previous paper dealing only with the assemblage from the town of Fossil, Oregon, we provided preliminary revisions (Manchester and Meyer, 1987), but many other assemblages and taxa remained unrevised. The primary purpose of the present study is to provide a comprehensive systematic treatment of the megafossil flora, introducing many new taxa, along with a critical review of previously described species. With at least 125 species now recognized, the Bridge Creek flora is one of the largest and most thoroughly collected Oligocene floras in North America.

The name *Bridge Creek flora* is applied to the combined fossil plant assemblages of several lacustrine deposits in the lower part of the John Day Formation of the John Day and Crooked River basins (Fig. 1). Each assemblage is

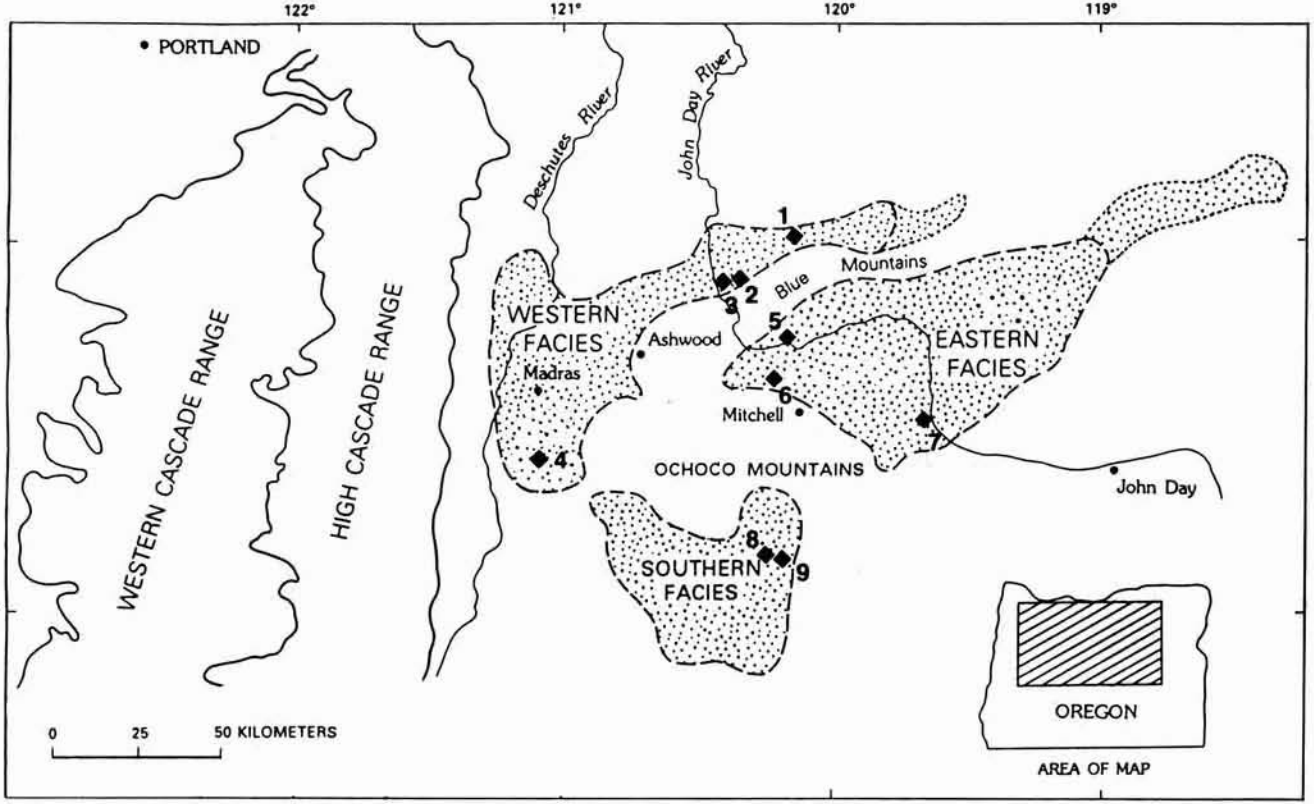

Figure 1. Index map showing the distribution of the three facies of the John Day Formation with assemblages of the Bridge Creek flora indicated by diamonds. Western facies: 1. Fossil, 2. Cove Creek, 3. Iron Mountain, 4. Gray Butte Canal (not treated here). Eastern facies: 5. Twickenham (not treated here), 6. Painted Hills, 7. Butler Basin. Southern facies: 8. Lost Creek, 9. Crooked River. Base map modified from Robinson et al. (1984).

based on one to several adjacent localities (collection sites) and shows some differences in floristic composition while at the same time sharing many taxa in common with other assemblages. The earliest collections were made from the Painted Hills assemblage at localities near Bridge Creek which are now protected as the Painted Hills unit of John Day Fossil Beds National Monument. In addition to the assemblages from Fossil and the Painted Hills, the present study includes other important assemblages such as Cove Creek, Iron Mountain, Crooked River, Lost Creek, and Butler Basin.

This revision of the Bridge Creek flora, based on leaf, fruit, and seed impressions and compressions, provides a more complete basis for comparison between the Oligocene of western North America and floras of similar age elsewhere in the Northern Hemisphere. There are marked generic similarities, for example, with lacustrine floras of central Europe, including such shared taxa as *Tetraclinis*, *Alnus*, *Ostrya*, *Fagus*, *Ulmus*, and *Acer*. This work also provides an overview of the geologic occurrence, vegetation, climate, and origin of the flora, as well as multiple organ reconstructions and phylogenetic relationships of component taxa.

PREVIOUS INVESTIGATIONS

Taxonomic revision of the Bridge Creek flora involves nomenclatural complexities resulting from more than a century of previous studies that have assigned new species names and recombinations. The historical context of these earlier works is important not only for appreciating the variety of previous contributions but also for understanding priorities in the taxonomic nomenclature and the development of ideas concerning ecologic interpretations. Many of the new species that we describe here have been named in recognition of these earlier workers who have contributed to the understanding of the Bridge Creek flora.

The rich paleontologic resources of the John Day Basin were first discovered by soldiers who found mammalian teeth and bones while searching for railroad routes to the Pacific coast in 1861 (Knowlton, 1902). Some of these fossils were examined by Oregon's pioneering geologist Rev. Thomas Condon, who accompanied a group of soldiers through the area the following year. During that trip in 1862, Condon discovered the fossil plant-bearing shales near Bridge Creek (at Painted Hills) and returned for further collecting over the following years. These fossil plant collections were later sent to J. S. Newberry of Columbia University for examination.

Using Condon's collection, Newberry (1883) presented brief descriptions but no illustrations of 13 new species from the Bridge Creek locality (here treated as the Painted Hills assemblage), which he considered to be of Miocene age. More complete descriptions with figures of these and one new species, along with 11 other taxa in the Painted Hills assemblage, were published in Newberry (1898), a posthumous work edited by A. Hollick. These collections were added to the U.S. National Museum, where they remain.

Another collection from the Painted Hills assemblage was made about 1870 by C. D. Voy, a collector from San Francisco (Knowlton, 1902), and was acquired by the University of California. This collection was sent to Leo Lesquereux, a paleobotanist who worked by commission for state and national geologic surveys. In his monograph on the Cretaceous and Tertiary floras, which was similar in many respects to Newberry's work, Lesquereux (1883) included 11 species from the Bridge Creek flora, of which five were described and figured as new species. Lesquereux also considered the Bridge Creek material to be of Miocene age. The specimens from the John Day Basin published by Lesquereux (1883) are still housed at the University of California Museum of Paleontology.

Lesquereux (1883) described many of the same taxa that Newberry (1883) described, although they were based on different specimens and assigned different names. Because both works were published in 1883, the precise date of issue determines the publication with nomenclatural priority. As noted by Knowlton (1902), Newberry's paper shows a final signature date of March 21, 1883, while Lesquereux's manuscript was received October 12, 1882, but was not transmitted to the Secretary of the Interior for approval (preceding the actual publication) until November 1, 1883. Thus, in those cases where each worker had described the same taxon under different names, the name given by Newberry has priority. Newberry (1883) did not provide illustrations of the specimens on which his species were based until 1898; nevertheless, the International Code of Botanical Nomenclature (Greuter, 1988) allows in Article 38 that, prior to 1912, fossil species did not require a figure to be validly published.

Knowlton (1902) was the first to focus an entire study on the fossil plants of the John Day Basin, including not only those from the John Day Formation but also the older Clarno and younger Mascall formations. Knowlton examined all of the material then available from the Bridge Creek locality, including Newberry's and Lesquereux's collections as well as new specimens that had been referred to the U.S. Geological Survey and the large collections at the University of California that had recently been made by vertebrate paleontologist J. C. Merriam in 1900. Knowlton recognized 46 taxa in his checklist and described ten new species from the Bridge Creek flora. He was conservative in retaining species that had been described by Newberry or Lesquereux, and it is noteworthy that he made only two new combinations. Many of the taxa that he split (especially Betulaceae and *Quercus*) are grouped by synonymy in our work. Knowlton visited the region accompanied by Merriam in 1901, and he was the first to list localities other than the "classic" Bridge Creek (Painted Hills) locality that are now known to be part of the John Day Formation. Merriam's field work during 1899 and 1900 resulted in the first description of lithostratigraphic units in the John Day Basin (Merriam, 1901). At that time, Knowlton considered the Bridge Creek locality to be a part of the Clarno Formation and of late Eocene age. Knowlton (1902) provided a good historical review of the contributions of Condon, Newberry, Lesquereux, and others, and much of his discussion has been summarized here.

R. W. Chaney of the University of California at Berkeley made major additional collections from a number of localities in the John Day and Crooked River basins beginning in 1920. Chaney (1925a) was the first to use the term *Bridge Creek flora,* to consider it as an ecological plant community, to demonstrate that it occurred within the John Day "Series" (now Formation), and to refer to it as Oligocene in age. In his monographic treatment of the flora, which dealt primarily with the Crooked River localities, Chaney (1927) recognized 44 taxa (30 of which were illustrated; see Appendix) including 11 new species. In addition to these geologic and taxonomic contributions, Chaney was the first to address broader questions and to formulate ideas relating to taphonomy, paleoecology, and paleobiogeography, with much of this early focus on comparisons with the modern redwood forest. Later, Chaney (1948a,b, 1952) recognized stronger Asiatic affinities of the

Bridge Creek flora and referred to it frequently in his writings supporting the Arcto-Tertiary Geofloral concept. Although many of Chaney's concepts are no longer supported, he perhaps did more than any other individual to bring attention to the Bridge Creek flora.

H. L. Mason, also of the University of California, examined conifers from the Bridge Creek flora and published concurrently with Chaney's early contribution (Mason, 1927), recognizing six taxa but no new species. A later publication by Mason (1947) was instrumental in discrediting the geofloral concept supported by Chaney.

Following Chaney's (1927) monograph, most taxonomic work relevant to the Bridge Creek flora has been in studies that have revised particular genera or families occurring in western Tertiary floras. LaMotte (1936) dealt with *Tilia* and described one new species along with one new combination. The works of R. W. Brown of the U.S. Geological Survey (Brown, 1935, 1937a,b,c, 1939, 1940, 1946, 1959), although generally unfocused taxonomically, have collectively treated 22 taxa from the Bridge Creek flora, including four described as new species, one new name, and five new combinations. Master's theses completed at the University of California at Berkeley have considered Bridge Creek occurrences of Juglandaceae (Wolfe, 1959), Betulaceae (Klucking, 1959), and *Mahonia* (Schorn, 1966). In their monographic revisions of Tertiary elms and maples of the Pacific Northwest, T. Tanai and J. A. Wolfe recognized five species of *Ulmus* (Tanai and Wolfe, 1977) and seven species of *Acer* (Wolfe and Tanai, 1987) in the Bridge Creek flora. Additional Bridge Creek taxa have been included in investigations of Betulaceae (Manchester and Crane, 1987), Ulmaceae (Manchester, 1987a), Juglandaceae (Manchester, 1987b, 1991), Sterculiaceae (Manchester, 1992), and Tiliaceae (Kvaček et al., 1991; Manchester, 1994a). In addition, the flora has often been cited in interpretations of regional paleovegetation and paleoclimate (e.g., Wolfe, 1971, 1981b).

GEOLOGIC SETTING AND AGE

The John Day Formation, originally defined by Merriam (1901), is exposed over an extensive area in north-central Oregon (Fig. 1) and lies unconformably above the Eocene Clarno Formation and unconformably below the Miocene Columbia River Basalt Group. It spans the period from late Eocene to early Miocene and ranges in age from about 39 to 19 Ma (Woodburne and Robinson, 1977; Robinson et al., 1984; Bestland and Retallack, 1994a,b; using an Eocene-Oligocene boundary of 34 Ma per Berggren et al., 1992; Prothero and Swisher, 1992). The fossil leaf localities occur in lower Oligocene fine-grained, bedded lacustrine tuffs in the lower part of the formation, stratigraphically below the succession of upper Oligocene to Miocene beds that produce the well-known John Day vertebrate faunas (Woodburne and Robinson, 1977). The western part of the John Day Formation was mapped by Robinson (1975), and correlations between stratigraphic sequences within the formation have been summarized by Woodburne and Robinson (1977), Robinson et al. (1990), and Bestland et al. (1997).

Rocks of the John Day Formation were deposited in a back-arc setting and were derived from at least three separate source areas, each producing lithologically distinct strata (Robinson and Brem, 1981; Robinson et al., 1984, 1990). Minor basalt and trachyandesite flows were derived from local sources near their outcrop areas. Rhyolitic ash-flow tuffs and lava flows erupted from volcanic vents (including a possible caldera; Hammond, 1989) east of the present-day Cascade Range, along the western margin of the John Day Formation outcrop area. Rhyolitic to andesitic tuff is abundant and widespread throughout the formation and probably represents distal deposition of pyroclastic material originating from arc volcanism in the area of the western Cascade Range (Hay, 1962; Peck, 1964; Robinson et al., 1984). This tephra, which becomes finer grained eastward and more distal from its source (Waters, 1954; Robinson et al., 1990), includes fine-grained volcanic ash that was redeposited in lacustrine basins, often incorporating plant debris from the surrounding forests.

The unconformity at the base of the John Day Formation represents a deeply weathered surface, in some areas preserved as a saprolite (Waters, 1954), with hills forming relief in excess of 100 m (Chaney, 1927; Hay, 1962, 1963; Fisher, 1964). During the earliest stages of John Day deposition, deformation resulted in a pronounced regional northeast-trending fold (present orientation) that produced the Blue Mountains uplift in the area where the John Day Formation outcrops. This topographic barrier appears to have begun developing by late Eocene or early Oligocene time. The existence of this paleotopographic high before deposition of the bulk of the John Day Formation and its continued development later is indicated by the distribution and variability in thickness of the formation and its stratigraphic relationships to the Clarno Formation and Columbia River Basalt Group (Fisher, 1967; Walker and Robinson, 1990). The laterally extensive basal John Day ash-flow tuff (member A, $^{40}Ar/^{39}Ar$ dated as 39.2 and 39.72 Ma by C. Swisher, *in* Bestland and Retallack, 1994a,b) onlaps and barely crosses this axis of uplift and is less folded than the unconformably underlying Clarno(?) rocks (Swanson and Robinson, 1968), suggesting that the uplift was present but still relatively low about 39–40 Ma. Stratigraphically higher members of the John Day Formation were attenuated against the flanks of this barrier as it was further uplifted, separating western and eastern facies of the formation (Fisher, 1967; Robinson et al., 1990). Other smaller uplifts developed in the area (Fisher, 1967), and lakes were formed in the intervening structural depressions during the early Oligocene.

On the basis of both the differences in thickness and the distribution of individual ash-flow sheets, the John Day Formation has been divided into three geographically separate facies (Fig. 1) that are generally similar in lithologic composition (Robinson et al., 1984, 1990). Each of these facies contains important Oligocene fossil plant assemblages. The western facies includes the assemblages at Fossil, Cove Creek, Iron Mountain, and Gray Butte (the latter not considered in this study). The eastern facies includes the fossil plant assemblages at Painted Hills, Butler Basin, and Twickenham (the latter not considered in this study). The southern facies includes the Lost Creek and Crooked River assemblages (Chaney, 1927).

The western facies was deposited west of the Blue Mountains uplift and has been divided into nine informal members (A–I; Peck, 1964) composed of tuffaceous claystones, coarse-grained lapilli tuffs, and many interbedded ash-flow tuffs and rhyolitic to basaltic lava flows. The composite thickness is estimated at 1200 m. The widespread basal ash-flow tuff of member A defines the base of the John Day Formation and has been K/Ar dated as 37.1 ± 1.0 and 37.4 ± 1.1 Ma (summarized in Robinson et al., 1990) and $^{40}Ar/^{39}Ar$ dated from a locality near Clarno in the western facies as 39.22 ± 0.03 Ma (C. Swisher, *in* Bestland and Retallack, 1994a).

Within the western facies, localities of the Iron Mountain and Cove Creek assemblages northeast of Clarno occur in tuffaceous shales of member F, above the member A welded tuff and member B basalt and below the member F basalt (Robinson, 1975; D. Blackwell, pers. comm., 1987). Four radiometric dates for the basal ash-flow sheet of overlying member G range from 27.0 ± 0.3 to 30.5 ± 0.4 Ma (average 28.5 Ma; Robinson et al., 1990). A tuff presumed to be in member G has been $^{40}Ar/^{39}Ar$ dated from the Painted Hills area (in the eastern facies) at 29.8 Ma (C. Swisher, *in* Bestland and Retallack, 1994a). More recently, Bestland and Retallack (1994a) assigned the leaf-bearing shales of the Iron Mountain assemblage to the "middle and upper Big Basin member," geographically extending the usage of this member from the eastern facies. The Iron Mountain assemblage has been $^{40}Ar/^{39}Ar$ dated as 33.62 ± 0.19 Ma from plagioclase in a coarse-grained tuffaceous sandstone

Table 1
Radiometric Dates for Assemblages of the Bridge Creek Flora

Assemblage	Isotopes	Age (Ma)	Context	Source
Painted Hills	K/Ar	32.3	Whole-rock basalt	1
Painted Hills	K/Ar	31.8	Sanidine tuff, interbedded	1, 2
Painted Hills	$^{40}Ar/^{39}Ar$	32.99 ± 0.11	Biotite tuff, below	3
Painted Hills	$^{40}Ar/^{39}Ar$	32.66 ± 0.03	Tuff, above	3
Iron Mountain	$^{40}Ar/^{39}Ar$	33.62 ± 0.19	Tuff (plagioclase), interbedded	3
Fossil	$^{40}Ar/^{39}Ar$	32.58 ± 0.13	Sanidine tuff, interbedded	4

Sources: (1) Evernden et al. (1964); (2) Hay (1962); (3) C. Swisher, *in* Bestland and Retallack (1994a,b); (4) McIntosh et al. (1997).

interbedded with the leaf-bearing tuffs (C. Swisher, *in* Bestland and Retallack, 1994a; E. Bestland, pers. comm., 1994).

The rocks surrounding the John Day Formation locality at Fossil, Oregon, are mapped as part of the Clarno Formation (Robinson, 1975; Riseley, 1989), but the stratigraphic relationship of the fossil outcrop at Fossil to other units of the John Day Formation needs further study. The stratigraphic sequence in this area near and east of Fossil forms a northern subfacies distinct from that of the remainder of the western facies to the southwest and was apparently separated from it by a paleotopographic high in the Clarno Formation (Robinson et al., 1990). Sanidine crystals extracted from the lacustrine plant-bearing tuffs at the locality in Fossil have been $^{40}Ar/^{39}Ar$ dated as 32.58 ± 0.13 Ma (McIntosh et al., 1997) (Table 1).

The eastern facies, deposited east of the Blue Mountains uplift, consists of a composite section of 700–750 m of tuffaceous claystones, fine-grained tuffs, a prominent ash-flow tuff in the middle of the section, and basalt flows in the lower part of the section (Robinson et al., 1990). This facies was divided into three "divisions" (based on red, green, and buff color differences) by Merriam (1901), into three members (lower, middle, and upper) at Painted Hills by Hay (1962, 1963), and into four members (Big Basin, Turtle Cove, Kimberly, and Haystack Valley) in the Kimberly to Picture Gorge area by Fisher and Rensberger (1972). In Hay's division, the lower and upper members are separated by the Picture Gorge ignimbrite of the middle member. The Picture Gorge ignimbrite has been K/Ar dated at 26.9 ± 2.3 and 25.5 Ma (summarized in Robinson et al., 1990) and $^{40}Ar/^{39}Ar$ dated at 28.65 ± 0.05 and 28.65 ± 0.07 Ma (C. Swisher, *in* Bestland and Retallack, 1994b). Hay's division is preferred by some workers (e.g., Robinson et al., 1990) because it avoids defining units on the basis of diagenetic characteristics, although these divisions are otherwise simplistic. The four units recognized by Fisher and Rensberger are petrofacies with limited stratigraphic value, and at least some of the defined units (e.g., Turtle Cove and Kimberly members) are based on features of diagenesis and paleosol formation, but they are otherwise well-defined and recognizable in the field (T. Fremd, writ. comm., 1993).

Within the eastern facies, the ash-flow tuff of member A occurs in the Painted Hills area (Hay, 1962, 1963; Swanson and Robinson, 1968; Robinson, 1975; Woodburne and Robinson, 1977; Bestland and Retallack, 1994b), where it has been $^{40}Ar/^{39}Ar$ dated as 39.72 ± 0.03 Ma (C. Swisher, *in* Bestland and Retallack, 1994b). In the lowermost 75 m of Hay's lower member at Painted Hills, a sequence of tuffs, tuffaceous claystones, and minor basalts (all corresponding to part of the Big Basin member of Fisher and Rensberger) includes thinly bedded epiclastic tuffaceous shales containing the classic Bridge Creek flora. These shales were deposited in a lacustrine basin surrounded by hilly terrain, as evidenced by bedding attitudes and lithologic facies changes (Hay, 1962). Their association with basalts suggests that the lake basin(s) may have formed from local damming by lava flows (Fisher and Rensberger, 1972). Within this sequence at Painted Hills, two samples collected by R. Hay have provided K/Ar dates relevant to the associated flora (Table 1). One of these is from a basalt flow 35 m above the base of the formation, giving a whole rock K/Ar date of 32.3 Ma. The other is from a tuff 50 m above the base of the formation, interbedded between beds containing the flora, and provides a sanidine K/Ar date of 31.8 Ma (dates corrected to new constant; Hay, 1962, 1963; Evernden et al., 1964). More recently, $^{40}Ar/^{39}Ar$ dates of 32.99 ± 0.11 Ma and 32.66 ± 0.03 Ma have been obtained from a biotite tuff 3–5 m stratigraphically below the leaf-bearing tuffs at Painted Hills and from a tuff well above the leaf beds, respectively (C. Swisher, *in* Bestland and Retallack, 1994b; E. Bestland, pers. comm., 1994). An air-fall tuff layer higher in the lower member (about 250 m above the base of the formation) is believed to correlate with the basal ash-flow of member G (27.0–30.5 Ma and 29.8 Ma; see above) of the western facies (Hay, 1963; Peck, 1964; Woodburne and Robinson, 1977). Near Picture Gorge, east of the Painted Hills area, the lower (Big Basin) member includes similar lacustrine shales containing the Butler Basin assemblage (Fisher, 1964; Fisher and Rensberger, 1972).

The southern facies, situated south of the Ochoco Mountains along the Crooked River, is the least studied of the three facies. It lies east of the axis of the Blue Mountains uplift and is lithologically similar to the eastern facies, although no formal members have been described. The lower part of the formation consists of red to yellow tuffaceous claystones and lacustrine tuffaceous shales (Chaney, 1927) similar to the lower or Big Basin member of the eastern facies (Robinson et al., 1990). The lacustrine shales contain the Crooked River and Lost Creek assemblages. Waters (1968) has produced a reconnaissance geologic map of the quadrangle in which these fossil plant localities occur. Two ash-flow tuffs that cannot be correlated with ash flows of the eastern or western facies have been recognized; one of these in the lower part of the formation has provided a radiometric date of 32.1 ± 0.7 Ma (Robinson et al., 1990).

The spatial orientation of the region containing the John Day Formation has been affected by regional tectonism resulting in continued clockwise rotation of the area between 48 and 9 Ma about a pole situated in southwestern

Washington (see Wells and Heller, 1988). Although the Cascade and Coast ranges to the west have rotated about 50° (about 30° in the western Cascades since the early Oligocene; see Hammond, 1989), the Clarno Formation shows rotation of only 16° and the John Day Formation would presumably be less than that. In addition, large-scale tectonic rotation of the North American plate has resulted in a southward latitudinal shift of this part of the continent. Such rotations should be considered in paleogeographic reconstructions or in comparisons between coeval floras of the region.

In summary, the geologic and radiometric evidence indicates that the Bridge Creek flora is of early Oligocene age (^{40}Ar/^{39}Ar dates range from 32.2 to 33.6 Ma). The flora inhabited areas of low to moderate relief within a region divided by higher elevations of the Blue Mountains uplift. Lake basins developed as structural depressions or from local damming by basalt flows and were filled by reworked tuffaceous sediments derived from volcanism near the ancestral Cascades to the west. The size of these basins is unknown, but the extent of present outcrops indicates that some were at least 2–3 km across and may have been much larger. The separate lake basins were approximately contemporaneous, as suggested by their ^{40}Ar/^{39}Ar dates (ranging within 1.4 m.y.), stratigraphic position in the formation, lithologic similarities, and numerous shared fossil plant species. Further work is needed, particularly within the southern facies, to establish more firmly the age relationships among the different floral assemblages in the lower part of the John Day Formation. These assemblages have many species in common, yet overall differences exist, including the presence of unique taxa in some. Although these differences may be due to such factors as ecology, altitude, topography, succession, and local microclimate, it remains possible that there are also differences in age.

COLLECTIONS

Approximately 20,000 megafossil specimens were examined for this investigation, including specimens recovered from new field work and those in collections assembled by previous workers. Major collections examined during the course of this study include those at the University of California Museum of Paleontology and the U.S. National Museum of Natural History and those we assembled at the Florida Museum of Natural History (detailed later). Smaller collections were surveyed at the University of Oregon Condon Museum, Portland State University, the University of Idaho, John Day Fossil Beds National Monument, and the Field Museum.

The quality of locality data are variable for some of the older collections. Some records for localities in the Iron Mountain and Cove Creek assemblages are vague, and it has been difficult in some cases to determine equivalencies between old collection sites and more recent ones. In addition, the accuracy of specimen labels varies, and we have noted instances in which corresponding counterparts of individual specimens show conflicting locality labels. Lithologic features are often helpful in confirming the general source of specimens for which museum records are unclear. For example, we consider UCMP locality 5507 to be Cove Creek rather than Iron Mountain because the matrix is more yellowish and slightly coarser grained than in Iron Mountain specimens. Nevertheless, it should be noted that by including these earlier collections, the present treatment of the Bridge Creek flora may perpetuate certain locality errors that have gone unrecognized.

Collections that we made during the late 1970s and 1980s with the help of student research teams are housed at the Florida Museum of Natural History, Gainesville, Florida. Our collecting efforts concentrated on localities representing the Fossil, Cove Creek, Iron Mountain, Gray Ranch, and Lost Creek assemblages. Small collections were also obtained from Butler Basin, Painted Hills, and Gray Butte Canal. Selective collecting has favored unusual specimens over more common ones. Thus, quantitative studies based strictly on existing museum collections would probably reflect this bias in collecting.

DIVERSITY AND TAXONOMIC COMPOSITION

The Bridge Creek flora comprises 91 genera and 110 species known from leaves and 52 genera and 58 species known from reproductive structures (Table 2). Of these, 34 leaf taxa and eight taxa known from reproductive structures remain unidentified and are treated as incertae sedis.

Estimating the total species diversity of the Bridge Creek flora is complicated by the co-occurrence of leaves and reproductive organs that are unattached and cannot always be correlated with one another. An estimate of minimum diversity can be calculated as follows. First, fossil species within which multiple organs have been placed (e.g., *Metasequoia*) are counted as one species. Second, families and/or genera where fruits have been treated separately from the leaves (e.g., *Ulmus*, *Platanus*, and Hamamelidaceae) are assessed based on the organ having the greatest diversity (e.g., *Ulmus* has four leaf species and two fruit species, hence, four species of *Ulmus* are counted). Third, species within different organ genera of the same family that are hypothesized to represent a single biological species (e.g., *Asterocarpinus* and *Paracarpinus*; *Tetraclinis* and *Fokieniopsis*) are counted as one. Finally, among unknown leaf and fruit types, only the fossil leaf types are counted because they outnumber the diversity of unknown fruit types. According to this method, the total minimum diversity for the Bridge Creek flora is 125 species, including 15 species known only from reproductive structures with no associated foliage and 110 species known from leaves. Similarly, the minimum number of genera is 106.

The minimum estimated diversity within individual assemblages of the Bridge Creek flora ranges from only 20 species at Butler Basin (known only from small collections) to 55 at Crooked River and 65 at Fossil (see Table 4; p. 21). All of the assemblages are lacustrine and are probably biased toward lake side vegetation; hence, these values would underestimate the regional diversity of the flora. These new diversity figures indicate that the flora is considerably more diverse than previously recognized. The Bridge Creek flora includes at least 34 families of angiosperms, three of conifers, three of ferns, and one of horsetails. *Metasequoia* is the dominant conifer and is found at all assemblages of the Bridge Creek flora. Dominant among the angiosperms are families of Platanaceae, Ulmaceae, Fagaceae, Betulaceae, Juglandaceae, Tiliaceae, Rosaceae, and Sapindaceae. The absence of Salicaceae is notable.

Table 2

Systematic List of Species of the Bridge Creek Flora

SPHENOPSIDA
EQUISETACEAE
- *Equisetum* sp. (stem)

PTERIDOPHYTA
PTERIDACEAE
- *"Pteris" silvicola* Hall (leaf)

cf. THELYPTERIDACEAE/DRYOPTERIDACEAE
- Gen. et sp. indeterminate (leaf)

POLYPODIACEAE
- cf. *Polypodium* C. C. Hall (leaf)

CONIFERAE
TAXACEAE
- *Torreya masonii* n. sp. (leaf)

CUPRESSACEAE
- *Calocedrus schornii* n. sp. (leaf, ovulate cone)
- *Cunninghamia chaneyi* Lakhanpal (leaf, cone scale)
- *Metasequoia* sp. (foliage, ovulate cone, seed, pollen cone)
- *Sequoia affinis* Lesquereux (leaf)
- *Tetraclinis potlachensis* (Brown) n. comb. (ovulate cone, seed)
- *Fokieniopsis praedecurrens* (Knowlton) n. comb. (foliage)

PINACEAE
- *Abies* sp. (ovulate cone scale)
- *Keteleeria ptesimosperma* n. sp. (seed)
- *Pinus johndayensis* n. sp. (foliage, ovulate cone, seed, pollen cone)

ANGIOSPERMAE
LAURACEAE
- *Cinnamomophyllum bendirei* (Knowlton) Wolfe (leaf)
- *Cinnamomophyllum knowltonii* n. sp. (leaf)
- *Litseaphyllum presanguinea* (Chaney and Sanborn) Wolfe (leaf)

NYMPHAEACEAE
- *Nuphar* sp. (rhizome)
- cf. *Nuphar* (fruit, seed)
- Nymphaeaceae gen. et. sp. indeterminate (leaf)

BERBERIDACEAE
- *Mahonia simplex* (Newberry) Arnold (leaf)

MENISPERMACEAE
- cf. *Menispermum* (endocarp)

CERCIDIPHYLLACEAE
- *Cercidiphyllum crenatum* (Unger) Brown (leaf, fruit)

HAMAMELIDACEAE
- *Fothergilla praeovata* (Chaney) n. comb. (leaf)
- *Liquidambar* sp. (leaf)
- *Parrotia brevipetiolata* n. sp. (leaf)
- Hamamelidaceae gen. et sp. indet. (infructescence)

PLATANACEAE
- *Platanus condonii* (Newberry) Knowlton (leaf)

(*Continued*)

Table 2 (*continued*)

- *Platanus exaspera* n. sp. (leaf)
- *Platanus* sp. (infructescence, fruit)

ULMACEAE
- *Cedrelospermum lineatum* (Lesquereux) Manchester (leaf, fruit)
- *Ulmus chaneyi* Tanai and Wolfe (leaf)
- *Ulmus speciosa* Newberry (leaf)
- *Ulmus* sp. 1 (leaf)
- *Ulmus* sp. 2 (leaf)
- *Ulmus* sp. A (fruit)
- *Ulmus* sp. B (fruit)
- *"Zelkova" hesperia* Brown (leaf)

FAGACEAE
- *Fagus pacifica* Chaney (leaf, fruit)
- *Quercus berryi* Trelease (leaf)
- *Quercus consimilis* Newberry (leaf)
- *Quercus* spp. (fruit)

BETULACEAE
- *Alnus heterodonta* (Newberry) n. comb. (leaf)
- *Alnus newberryi* n. sp. (leaf)
- *Alnus* spp. (variable leaf morphotypes)
- *Alnus* spp. (infructescence, fruit, staminate catkin)
- *Betula angustifolia* Newberry (leaf, bract, fruit)
- *Ostrya oregoniana* Chaney (leaf, fruit)
- *Asterocarpinus perplexans* (Cockerell) Manchester and Crane (fruit)
- *Paracarpinus chaneyi* Manchester and Crane (leaf)

MYRICACEAE
- *Comptonia columbiana* Dawson (leaf)

JUGLANDACEAE
- *Carya* sp. 1 (leaflet)
- *Carya* sp. A (fruit)
- *Cruciptera* sp. (fruit)
- *Juglandiphyllites cryptatus* (Knowlton) n. comb. (leaflet)
- *Juglans wheelerensis* n. sp. (leaflet)
- *Palaeocarya* cf. *olsonii* (Brown) Manchester (fruit)
- *Pterocarya* sp. (leaflet)
- *Pterocarya occidentalis* Manchester (fruit)

STYRACACEAE
- *Flectorivus microdontos* n. gen. et sp. (leaf)

TILIACEAE
- *Craigia oregonensis* (Arnold) Kvaček, Bůžek and Manchester (fruit)
- *Plafkeria obliquifolia* (Chaney) Wolfe (leaf)
- *Tilia circularis* (Chaney) n. comb. (bract, fruit)
- *Tilia pedunculata* Chaney (bract, fruit)
- *Tilia aspera* (Newberry) LaMotte (leaf)
- *Tilia fossilensis* n. sp. (leaf)
- *Tilia lamottei* n. sp. (leaf)

(*Continued*)

Table 2 (*continued*)

STERCULIACEAE
  Florissantia speirii (Lesquereux) Manchester (flower, fruit)
GROSSULARIACEAE
  Ribes sp. (leaf)
HYDRANGEACEAE
  Hydrangea sp. (infructescence, calyx)
ROSACEAE
  Amelanchier covea (Chaney) Chaney and Axelrod (leaf)
  Amelanchier grayi Chaney (leaf)
  Crataegus merriamii (Knowlton) n. comb. (leaf)
  cf. *Malus* or *Pyrus* (leaf)
  cf. *Pyracantha* (leaf)
  Rosa hilliae Lesquereux (leaf)
  Rosa sp. (fruit)
  Rubus ameyeri n. sp. (leaf)
  Rubus fremdii n. sp. (leaf)
  Rubus sp. (fruit)
  Rosaceous prickly stems
LEGUMINOSAE
  Cercis maurerae n. sp. (fruit)
  Cladrastis oregonensis Brown (leaflet)
  Cladrastis sp. (fruit)
  cf. *Cladrastis* (leaflet)
  Micropodium ovatum (Lesquereux) Brown (fruit)
  Leguminosae gen. et. sp. indet. (leaflet)
LYTHRACEAE
  Decodon brownii n. sp. (leaf)
COMBRETACEAE
  Terminalia oregona (Lakhanpal) n. comb. (fruit)
ANACARDIACEAE
  Rhus lesquereuxii n. sp. (leaf)
  Rhus sp. (fruit)
  Toxicodendron wolfei n. sp. (leaflet)
MELIACEAE
  Cedrela merrillii (Chaney) Brown (leaf, seed)
SAPINDACEAE
  Acer ashwillii Wolfe and Tanai (leaf)
  Acer cranei Wolfe and Tanai (fruit)
  Acer glabroides Brown emend. Wolfe and Tanai (leaf)
  Acer kluckingii Wolfe and Tanai (leaf)
  Acer manchesteri Wolfe and Tanai (leaf)
  Acer oligomedianum Wolfe and Tanai (fruit)
  Acer osmontii Knowlton (leaf, fruit)
  Acer sp. 1 (leaf)
  Acer sp. 2 (leaf)
  Acer sp. A (fruit)
  Acer sp. B (fruit)

(*Continued*)

Table 2 (*continued*)

- *Acer* sp. C (fruit)
- *Aesculus* sp. (leaf)
- *Dipteronia* sp. (fruit)

- CORNACEAE
  - *Cornus* sp. (leaf)
- AUCUBACEAE
  - *Aucuba smileyi* n. sp. (leaf)
- ICACINACEAE
  - *Palaeophytocrene* sp. (endocarp)
- RHAMNACEAE
  - *Paliurus blakei* (Chaney) n. comb. (leaf)
  - *Hovenia oregonensis* n. sp. (leaf)
- VITACEAE
  - *Vitis* sp. (seed)
- OLEACEAE
  - *Fraxinus* sp. (fruit)
- CAPRIFOLIACEAE
  - *Diplodipelta reniptera* (Becker) Manchester and Donoghue (fruit)
- RUBIACEAE
  - *Pinckneya dilcheri* n. sp. (seed)
- BIGNONIACEAE
  - *Catalpa* sp. (seed)
- UNKNOWN DICOTYLEDONOUS LEAVES
  - Unknown dicotyledonous leaf spp. 1–31
- ZINGIBERACEAE
  - *Zingiberopsis* sp. (leaf)
- UNKNOWN MONOCOTYLEDONOUS LEAVES
  - *Typhoides buzekii* n. gen. et sp. (leaf)
  - Unknown monocotyledonous leaf
  - *"Potamogeton" parva* Brown (leaf)
- FRUITS AND SEEDS OF UNDETERMINED AFFINITIES
  - *Beckerosperma ovalicarpa* n. gen. et comb. (seed)
  - *Potanospira fryi* n. gen. et sp. (seed/fruit)
  - *Saportaspermum occidentalis* n. gen. et sp. (seed)
  - Unknown fruit spp. A-E

ASSEMBLAGES OF THE BRIDGE CREEK FLORA

We use the term *Bridge Creek flora* to refer collectively to those fossil plant assemblages of the lower John Day Formation that follow the Eocene-Oligocene climatic cooling and are dominated by deciduous species. The Bridge Creek assemblages are similar in floristic composition, with numerous species in common, indicating a relatively uniform regional flora. Some differences are evident, however, when the taxonomic compositions of individual assemblages are compared; such differences, particularly if they result from dissimilarities in age, may be a basis for considering certain assemblages as distinct floras. Because there is no evidence at this time to demonstrate significant age variation between assemblages, we have chosen to follow the precedent established by previous workers (e.g., Chaney, 1925a, 1927, 1952; Wolfe and Tanai, 1987) in referring to the Bridge Creek flora in a broad sense, but excluding similar floras that are not within the John Day Formation (e.g., Rujada, Willamette, and Lyons floras of western Oregon).

This treatment of the Bridge Creek flora is based on seven distinct assemblages that are, for the most part, separated geographically (Fig. 1) and have some floristic or ecological differences. These assemblages are Painted Hills, Fossil, Cove Creek (including Knox Ranch and Pentecost Ranch), Iron Mountain, Crooked River, Lost Creek, and Butler Basin. Each assemblage is based on one to several localities (i.e., collection sites) in close geographic and stratigraphic proximity. As discussed earlier, three of the assemblages (Painted Hills, Fossil, and Iron Mountain) have been dated recently by the $^{40}Ar/^{39}Ar$ method, providing dates within the range of 32.24 to 33.62 Ma. The other assemblages have no direct radiometric dates, but probably are similar in age based on their stratigraphic position and floristic similarity.

Many of the older names for localities are informal, nongeographic, and/or outdated (e.g., based on ephemeral ranch names). Some localities have had different numbers assigned to the same collection site, even within a single institution's numbering system. In addition, different names have been used at various times and by different investigators for the same sites. In an attempt to prevent further confusion, a cross-reference of former and current names is presented in Table 3. Rather than perpetuate the use of names based on ranches that long ago have changed ownership or ceased to exist, we have introduced some new assemblage names based on local geographic names.

Table 3
Equivalence of Assemblage Names

Older Locality Names	Current Names
Allen Ranch	Painted Hills
Bridge Creek (sensu stricto[1])	Painted Hills
Cant Ranch	Butler Basin - 00248
Clarno's Ferry[2]	Iron Mountain
Chapman Ranch	Iron Mountain
Dugout Gulch[3]	Iron Mountain I - 00241
Gray Ranch (part)	Crooked River I, II 00258, 2589
Gray Ranch (part)	Lost Creek
Knox Ranch	Cove Creek I, 00245
Mitchell[4]	Painted Hills
Pentecost Ranch	Cove Creek II, 00246
Post (part)	Crooked River
Post (part)	Lost Creek, 00255
Slanting leaf beds[3]	Iron Mountain II - 00240
Wade Ranch	Painted Hills

[1] As applied to the classic locality, per Newberry (1898), Knowlton (1902), and Brown (1935–1959).

[2] 1.5 miles east of Clarno's Ferry per Knowlton (1902), 2 and 2.5 miles northeast of Clarno's Ferry per Chaney (1927).

[3] Informal name.

[4] 9 miles northwest of Mitchell, per Brown (1937b).

Differences exist between the floristic composition of assemblages, and these may be due in part to possible differences in ecology, successional stage, climate, elevation, or age. Table 4 provides a checklist showing the distribution of taxa among each of the Bridge Creek assemblages that we investigated, including a tabulation of the total number of leaf and reproductive species combined as well as estimates of the total minimum species diversity using the method explained earlier. The comparatively small collection sizes for Butler Basin, Cove Creek, and Lost Creek may account for the apparent lack of diversity in those assemblages. We have not dealt in detail with the assemblages from Kennedy Ranch (Wolfe and Tanai, 1987), Twickenham (Chaney, 1948a), and Gray Butte Canal (Ashwill, 1983), but a preliminary overview indicates that the Twickenham and Canal assemblages contain many of the same species found in other assemblages of the Bridge Creek flora (Table 4).

PAINTED HILLS

This assemblage includes localities formerly referred to as "Allen Ranch," "Wade Ranch," and "Bridge Creek" in and near the Painted Hills Unit of John Day Fossil Beds National Monument, and localities in E ½ sec. 2, T. 11 S., R. 20 E. (Chaney, 1948a, his pl. 7, fig. 1). The assemblage occurs within the eastern facies of the John Day Formation and includes all of the earliest collections from the classic Bridge Creek flora *sensu stricto* collected by Condon and included in the monographs of Lesquereux (1883) and Newberry (1898). These early monographs did not provide specific locality data, but characteristics of preservation and the distinctive tan shale indicate that the specimens must have come from the sites indicated above. Although leaf impressions are abundant in this shale, typically the preservation is only fair, with venation higher than secondaries often lacking. Nevertheless, many of the name-bearing type specimens come from this assemblage, often frustrating comparisons with better preserved specimens of apparently similar species from other localities. The largest collections are housed at the U.S. National Museum and the University of California Museum of Paleontology. Locality numbers include UCMP 811, 3741, PA-417, and PA-425; USNM 8641 and 9329; and UOCM 2734. The assemblage is associated with K/Ar dates of 31.8 and 32.3 Ma and ^{40}Ar/^{39}Ar dates of 32.66 and 32.99 Ma (Table 1).

The Painted Hills assemblage has a minimum diversity of 38 species (Table 4). The assemblage is dominated by *Alnus, Betula, Quercus,* and *Metasequoia* (Chaney, 1925a, 1948a). Unique to this assemblage in the Bridge Creek flora are *Cunninghamia, Menispermum, Liquidambar, Betula, Dipteronia,* and *Micropodium ovatum.* The apparent absence of *Asterocarpinus* fruits and *Paracarpinus* leaves in this assemblage contrasts with their presence in all other Bridge Creek assemblages examined in this study.

FOSSIL

This assemblage is based on collections from a single locality behind Wheeler High School in Fossil, Oregon, in SW ¼, NW ¼, sec. 33, T. 6 S., R. 21 E. It occurs within the western facies of the John Day Formation. The locality was discovered in 1949 and was the subject of our initial study (Manchester and Meyer, 1987). Subsequent to that publication, a stratum of dark shale with especially well-preserved leaves and pollen was discovered high in the exposed section. The dark shale horizon was thoroughly collected in 1987 and 1988 and provided many of the most informative specimens now housed at the Florida Museum of Natural History. This dark shale was found to be rich in dispersed pollen, but a detailed palynological study remains to be done. The largest collections from Fossil are housed at the Florida Museum of Natural History and the University of California Museum of Paleontology. Locality numbers include UCMP 3738, P-4907, P-5203, PA-15, and PA-422; UF 250; USNM 9420; and UOCM 2669. The tuffaceous shale in which the fossils occur has a ^{40}Ar/^{39}Ar date of 32.58 Ma (Table 1).

The assemblage at Fossil has been well-collected and appears more diverse than any other, with a minimum diversity of 65 species. The assemblage is dominated by leaves of *Alnus* and *Paracarpinus* and by fruits of *Craigia, Acer,* and *Asterocarpinus.* Taxa not known from other assemblages of the Bridge Creek flora include cf. *Polypodium, Abies,* cf. *Pyracantha, Terminalia,* and fruits of *Fraxinus.* Although *Florissantia* flowers occur in nearly all assemblages of the Bridge Creek flora, the only specimens recovered with pollen still intact within the stamens were collected from the dark shale layer at Fossil (Manchester, 1992).

Table 4
Distribution of Taxa in Assemblages of the Bridge Creek Flora

Species	Assemblages							Leaf Margin^3
	PH	FO	CC^1	IM^2	CR	LC	BB	
Equisetum sp. (stem)	x			*				
"Pteris" silvicola (leaf)		x			x			
cf. *Thelypteridaceae/Dryopteridaceae* (leaf)					x			
cf. *Polypodium* (leaf)		x						
Torreya masonii (leaf)		x	kp	x		x	x	
Calocedrus schornii (cone, leaf)							x	
Cunninghamia chaneyi (leaf, cone scale)	x							
Metasequoia sp. (leaf, cone, seed)	x	x	ckp	x	x	x	x	
Sequoia affinis (leaf)						x		
Tetraclinis potlachensis (cone, seed)						x		
Fokieniopsis praedecurrens (leaf)						x		
Abies sp. (cone scale)		x						
Keteleeria ptesimosperma (seed)				*				
Pinus johndayensis (foliage, ovulate cone, seed, pollen cone)		x	ckp	x		x	x	
Cinnamomophyllum bendirei (leaf)	x	x		x			x	e
Cinnamomophyllum knowltonii (leaf)			k					e
Litseaphyllum presanguinea (leaf)					x			e
Nuphar sp. (rhizome)		x		x			x	
cf. *Nuphar* (fruit, seed)		x	c					
Nymphaeaceae gen. et. sp. indet. (leaf)		x						
Mahonia simplex (leaf)	x	x	kp	x	x	x		n
cf. *Menispermum* (endocarp)	x							(n)
Cercidiphyllum crenatum (leaf)	x	x	kp	x		x	x	n
Fothergilla praeovata (leaf)					x			n
Liquidambar sp. (leaf)	x							n
Parrotia brevipetiolata (leaf)		x	p					n
Hamamelidaceae gen. et sp. indet. (infructescence)		x			x			

(continued)

Table 4 (*continued*)

Species	Assemblages							Leaf Margin[3]
	PH	FO	CC[1]	IM[2]	CR	LC	BB	
Platanus condonii (leaf)	x	x					x	n
Platanus exaspera (leaf)	x	x			x	x		n
Platanus sp. (infructescence, fruit)	*x*	*x*			*x*	*x*		
Cedrelospermum lineatum (leaf, fruit)		x	k	x	x		x	n
Ulmus chaneyi (leaf)		x						n
Ulmus speciosa (leaf)	x	x		x	x			n
Ulmus sp. 1 (leaf)	x				x			n
Ulmus sp. 2 (leaf)		x	p					n
Ulmus sp. A (fruit)					*x*			
Ulmus sp. B (fruit)		*x*			*x*			
"Zelkova" hesperia (leaf)					x			n
Fagus pacifica (leaf, fruit)	x	x			x		x	n
Quercus berryi (leaf)	x				x	x		n/e
Quercus consimilis (leaf)	x	x	k	x	x	x	x	n/e
Quercus spp. (fruit)	*x*	*x*			*x*	*x*		
Alnus heterodonta (leaf)	x	x	ckp	x	x	x	x	n
Alnus newberryi (leaf)	x	x						n
Alnus spp. (catkin, fruit)	*x*	*x*	*k*	*x*	*x*	*x*		
Betula angustifolia (leaf, bract, fruit)	x							n
Ostrya oregoniana (leaf, fruit)					x			n
Asterocarpinus perplexans (fruit)		x	cp	x	x	x		
Paracarpinus chaneyi (leaf)		*x*	*kp*	*x*	*x*	*x*		n
Comptonia columbiana (leaf)						x		n
Carya sp. 1 (leaflet)		x						n
Carya sp. A (fruit)		*x*	p					
Cruciptera sp. (fruit)		x			x			
Juglandiphyllites cryptatus (leaflet)	*x*	*x*						n
Juglans wheelerensis (leaf)		x						n
Palaeocarya cf. *olsonii* (fruit)	x	x		x	x	x		
Pterocarya sp. (leaflet)							*x*	n
Pterocarya occidentalis (fruit)							x	
Flectorivus microdontos (leaf)					x			n

(*continued*)

Table 4 (*continued*)

Species	Assemblages							Leaf Margin[3]
	PH	FO	CC[1]	IM[2]	CR	LC	BB	
Craigia oregonensis (fruit)	*x*	x	ckp	x	x		x	
Plafkeria obliquifolia (leaf)	x	*x*	*ckp*	*x*	*x*			e
Tilia circularis (bract)		x	k	x	x		x	
Tilia pedunculata (bract)			cp	x	x			
Tilia aspera (leaf)	x							n
Tilia fossilensis (leaf)		*x*	*k*					n
Tilia lamottei (leaf)			*kp*	*x*	*x*			n
Florissantia speirii (flower, fruit)	x	x	ckp	x	x	x		
Ribes sp. (leaf)		x		x				n
Hydrangea sp. (flower)	x	x		x	x			(n)
Amelanchier covea (leaf)			cp					n
Amelanchier grayi (leaf)				x	x			n
Crataegus merriamii (leaf)	x	x	ckp	x	x	x	x	n
cf. *Malus* or *Pyrus* (leaf)		x					x	n
cf. *Pyracantha* (leaf)		x						n
Rosa hilliae (leaf)	x		p	x	x	x		n
Rosa sp. (fruit)	*x*			*x*	*x*	*x*		
Rubus ameyeri (leaf)				x				n
Rubus fremdii (leaf)					x			n
Rubus sp. (fruit)					*x*			
Rosaceous prickly stems		*x*	*k*	*x*	*x*	*x*		
Cercis maurerae (fruit)	x	x	ckp	x	x			(e)
Cladrastis oregonensis (leaflet)	x	x		x	x	x		e
Cladrastis sp. (fruit)		*x*						
cf. *Cladrastis* (leaflet)		x						e
Micropodium ovatum (fruit)	*x*							
Leguminosae gen. et sp. indet. (leaflet)	x	x	p					e
Decodon brownii (leaf)		x		x				e
Terminalia oregona (fruit)		x						(e)
Rhus lesquereuxii (leaf)	x	x		x		x		n
Rhus sp. (fruit)		*x*						

(*continued*)

Table 4 (*continued*)

Species	Assemblages							Leaf Margin[3]
	PH	FO	CC[1]	IM[2]	CR	LC	BB	
Toxicodendron wolfei (leaflet)			p	x		x		e
Cedrela merrillii (leaf, seed)		x	cp	x	x	x		e/n
Acer osmontii (leaf, fruit)	x	x	ckp	x	x	x		n
Acer ashwillii (leaf)		x		*x*			x	n
Acer glabroides (leaf)		x	c		x			n
Acer kluckingii (leaf)			c					n
Acer manchesteri (leaf)				*x*	x			n
Acer sp. 1 (leaf)			p	*x*	x			n
Acer sp. 2 (leaf)		x			x			n
Acer cranei (fruit)	x	*x*	*kp*	*	*x*	x		
Acer oligomedianum (fruit)					*x*	x		
Acer sp. A (fruit)	x	*x*	*p*	x	*x*	x	*x*	
Acer sp. B (fruit)				x	*x*			
Acer sp. C (fruit)	x	*x*	*k*	x		x		
Aesculus sp. (leaf)			p					n
Dipteronia sp. (fruit)	x							(n)
Cornus sp. (leaf)		x	p				x	e
Aucuba smileyi (leaf)				x				n
Palaeophytocrene sp. (fruit)				x				
Paliurus blakei (leaf)					x			n
Hovenia oregonensis (leaf)		x	c	x	x	x		n
Vitis sp. (seed)					x			(n)
Fraxinus sp. (fruit)		x						(e/n)
Diplodipelta reniptera (fruit)					x			
Pinckneya dilcheri (seed)					x			(e)
Catalpa sp. (seed)		x			x			(e)
Unknown dicotyledonous leaf sp. 1					x			n
Unknown dicotyledonous leaf sp. 2		x						n
Unknown dicotyledonous leaf sp. 3		x						n
Unknown dicotyledonous leaf sp. 4	x							n
Unknown dicotyledonous leaf sp. 5				x				n
Unknown dicotyledonous leaf sp. 6	x							n

(*continued*)

Species	Assemblages							Leaf Margin[3]
	PH	FO	CC[1]	IM[2]	CR	LC	BB	
Unknown dicotyledonous leaf sp. 7		x						n
Unknown dicotyledonous leaf sp. 8		x						e
Unknown dicotyledonous leaf sp. 9					x			e/n
Unknown dicotyledonous leaf sp. 10						x		e
Unknown dicotyledonous leaf sp. 11	x		c					e/n
Unknown dicotyledonous leaf sp. 12					x			n
Unknown dicotyledonous leaf sp. 13			c					n
Unknown dicotyledonous leaf sp. 14				x				n
Unknown dicotyledonous leaf sp. 15		x						n
Unknown dicotyledonous leaf sp. 16		x						e
Unknown dicotyledonous leaf sp. 17		x						e
Unknown dicotyledonous leaf sp. 18		x						e
Unknown dicotyledonous leaf sp. 19					x			n
Unknown dicotyledonous leaf sp. 20				x				n
Unknown dicotyledonous leaf sp. 21					x			e
Unknown dicotyledonous leaf sp. 22					x			e
Unknown dicotyledonous leaf sp. 23					x			e
Unknown dicotyledonous leaf sp. 24						x		e
Unknown dicotyledonous leaf sp. 25		x						e
Unknown dicotyledonous leaf sp. 26					x			n
Unknown dicotyledonous leaf sp. 27		x			x			n
Unknown dicotyledonous leaf sp. 28							x	e
Unknown dicotyledonous leaf sp. 29		x						e
Unknown dicotyledonous leaf sp. 30					x			n
Unknown dicotyledonous leaf sp. 31		x						e
Zingiberopsis sp. (leaf)				x				
Typhoides buzekii (leaf)		x	ckp	x	x	x		
Unknown monocotyledonous leaf	x	x						
"Potamogeton" parva (leaf)					x			
Beckerosperma ovalicarpa (seed)		*x*	*k*	*x*	*x*	*x*		
Potanospira fryi (seed)		*x*			*x*			
Saportaspermum occidentalis (seed)		*x*		*x*	*x*	*x*		
Unknown fruit sp. A		*x*			*x*			
Unknown fruit sp. B					*x*			

(continued)

Table 4 (*continued*)

Species	Assemblages							Leaf Margin[3]
	PH	FO	CC[1]	IM[2]	CR	LC	BB	
Unknown fruit sp. C					*x*			
Unknown fruit sp. D					*x*			
Unknown fruit sp. E				*x*				
Total	45	86	45	56	78	39	22	
Minimum number of species (adjusted for multiple plant organs[4])	38	65	35	44	55	30	20	

Abbreviations: PH = Painted Hills, FO = Fossil, CC = Cove Creek, IM = Iron Mountain, CR = Crooked River, LC = Lost Creek, and BB = Butler Basin.

[1] Specific localities of the Cove Creek Assemblage are indicated when known: c = Cove, k = Knox Ranch, and p = Pentecost Ranch.

[2] Asterisks (*) indicate locality UCMP 4210, which is thought to be from Iron Mountain, although collection records are ambiguous as to whether it was collected at Iron Mountain or Cove Creek.

[3] Leaf margin is shown for dicotyledons only and is indicated as e = entire or n = nonentire; where it can be inferred from modern taxa, the leaf margin for species known only from fruits is indicated by (e) or (n).

[4] Minimum number excludes possible redundancies due to representation of more than one organ corresponding to the same genus (and potentially to the same species). This total excludes each of the taxa indicated by italics (e.g., *x*, *c*, *p*, *k*).

COVE CREEK

The Cove Creek assemblage includes localities formerly referred to as Knox Ranch and Pentecost Ranch and others within the upper drainages of Cove Creek. These localities occur in member F of the western facies or in landslide deposits that contain rocks of member F.

In compiling locality data for each taxon presented in the systematic descriptions, we have retained the Knox Ranch and Pentecost Ranch collecting sites as separate subgroups of the Cove Creek assemblage (Table 4). Some compositional differences can be noted between these two collecting sites, although this may in part reflect the relatively small collection sizes. Some of the earlier localities referred to simply as "Cove Creek" (precise coordinates unspecified) may have included material from Pentecost Ranch (e.g., UCMP 125 and 127; and USNM 6880). The checklist column for Cove Creek in Table 4 includes the sum of Pentecost Ranch plus Knox Ranch taxa as well as those from other Cove Creek sites.

Locality UF 247 is in the SW ¼ sec. 17, T. 7 S., R. 20 E. The Knox Ranch locality is west of the abandoned house (standing in 1990) and consists of a single collecting site occurring along ~30 m of outcrop in and near a primitive road cut in sec. 20, T. 7 S., R. 20 E. This site was discussed by Arnold (1952) and Brown (1959). The Pentecost Ranch locality occurs near the old ranch site (house burned in the 1984) in SW ¼ sec. 19, T. 7 S., R. 20 E. Locality numbers for the collecting site near the abandoned Knox Ranch house include UCMP P-5405, PA-12, and apparently 5507; UF 245; USNM 9440; and UOCM 2668. Locality numbers at the former Pentecost Ranch site are UCMP PA-2; UF 246; and UOCM 2762. Localities known only as Cove Creek are UCMP 125 and 127; UF 247; and USNM 6880.

The dominant leaves at Cove Creek are *Alnus* and *Paracarpinus*. Most noteworthy in the Cove Creek assemblage is the abundance of *Pinus johndayensis*, which is much more common here than in any other assemblage. *Quercus* is rare and is absent altogether from the Pentecost Ranch site. In the Bridge Creek flora, *Aesculus* and unknown leaf type 13 are known only from the Cove Creek assemblage.

IRON MOUNTAIN

The Iron Mountain assemblage includes localities previously referred to as "Dugout Gulch," "Slanting Leaf beds," "Chapman Ranch," and "Clarno NE" (2.5 miles NE of Clarno's Ferry). It includes localities in S ½ sec. 22 and N ½ sec. 27, T. 7 S., R. 19 E., along the base of Iron Mountain (Knowlton, 1902; Chaney, 1927, 1948a, his pl. 7, fig. 2; Wolfe and Tanai, 1987). Although the localities occur over a distance of nearly 2 km, they are clearly along strike and most collections have been made within about 10 meters of section. The assemblage occurs in the western facies of the John Day Formation. The earlier informal names do not appear on published maps of the region, and we apply the name Iron Mountain because the strata form the base of the mountain. Our use of the term *Iron Mountain* differs from that of Wolfe (1992), who applied this name to an undescribed leaf assemblage (also known as the Hancock Canyon assemblage; Manchester, 1990) from the Eocene Clarno Formation 1.5 km south of the mountain. Locality numbers included in the Iron Mountain assemblage are UCMP 132, 3739, PA-421; UF 240, 241; and UO 2675. Records for UCMP locality P-4210 contain conflicting information, indicating that it may be from either Iron Mountain or Cove Creek; however, the character of the matrix suggests that it is probably from the Iron Mountain assemblage. In Table 4, we have considered P-4210 as Iron Mountain (indicated by * rather than x if the taxon is not confirmed at Iron Mountain from other locality numbers); the locality is indicated as "Iron Mountain (P-4210)" in the text and plate descriptions. The Iron Mountain assemblage is associated with an ^{40}Ar/^{39}Ar age of 33.62 Ma (Table 1).

The most common taxa in the Iron Mountain assemblage are *Metasequoia, Alnus,* and *Asterocarpinus/Paracarpinus,* followed by *Acer* and *Cercidiphyllum*. *Pinus, Quercus,* and *Ulmus* are very rare. *Toxicodendron,* although uncommon, is found more frequently here than in other assemblages. The only known Bridge Creek specimens of *Keteleeria, Palaeophytocrene, Aucuba, Rubus ameyeri, Zingiberopsis,* and unknown fruit D are from Iron Mountain.

The largest collections from this assemblage are at the Florida Museum of Natural History and the University of California Museum of Paleontology.

CROOKED RIVER

The Crooked River assemblage, formerly referred to as Gray Ranch (part) and Post (part), includes several localities within an area of about 1 km^2 in the W ½ sec. 36, T. 16 S., R. 20 E., east of the old Gray Ranch house and north of the Crooked River. This area is within the southern facies of the John Day Formation. The preservation of venation often is excellent. In addition, pollen has been recovered directly from staminate *Alnus* catkins, and dispersed pollen is abundantly preserved in the shale at some sites (e.g., UF 258A).

This assemblage was the focus of Chaney's (1927) documentation of the Bridge Creek flora and, consequently, is the source of many type specimens for Bridge Creek species. Many of the localities are from a single hillside illustrated by Chaney (1927, his pl. 2, figs. 1, 2). Of the localities he documented, only those in sec. 36 are considered here to be part of the Crooked River assemblage. The locality in sec. 26, for example, belongs to the Lost Creek assemblage. We were unable to revisit Chaney's Ream Ranch locality UCMP 137 south of the Crooked River to determine whether it represents the same assemblage. Its alliance with the Crooked River assemblage, however, is suggested by the presence of *Ostrya oregoniana*, Pteridaceae ("*Pteris*" *sylvicola* Hall of Chaney), and *Cedrelospermum lineatum*. Locality numbers include UCMP 135, 136, 3748, 3749, 3751, and 3927–3930; UF 258 and 258A; and USNM 8778 and 8778A.

Large collections from this assemblage are housed at the University of California Museum of Paleontology, the Florida Museum of Natural History, and the U.S. National Museum. *Alnus heterodonta* is the most abundant species, followed by *Quercus berryi*. Unique to the assemblage are Thelypteridaceae/Dryopteridaceae, *Litseaphyllum*, *Fothergilla*, *Ostrya*, *Flectorivus*, *Rubus fremdii*, *Paliurus*, *Vitis*, *Diplodipelta*, *Pinckneya*, unknown leaf species 1, 9, 12, 21, 22, 23, and 26, and unknown fruit species B, C, and E.

LOST CREEK

The Lost Creek assemblage occurs in white shales that crop out in the center of sec. 26 and in the SE ¼ sec. 27, T. 16 S., R. 20 E., in the southern facies of the John Day Formation. The locality in sec. 26 was formerly included as part of Gray Ranch (Chaney, 1927). Although in close proximity to localities of the Crooked River assemblage, the Lost Creek assemblage is distinct in some notable aspects of taxonomic composition. Many taxa commonly found in the Crooked River assemblage are not known from Lost Creek (Table 4). *Cercidiphyllum* is common at Lost Creek, yet apparently absent from Crooked River, and there are five species of conifers in Lost Creek but only one in Crooked River. Within the Bridge Creek flora, *Sequoia*, *Tetraclinis*, and *Comptonia* have been confirmed only from the Lost Creek assemblage. *Sequoia* and

Tetraclinis were probably canopy trees and may have been conspicuous members in the plant association represented by the Lost Creek assemblage. Locality numbers include UCMP 3750; and UF 243, 243A, 244, and 255.

BUTLER BASIN

The Butler Basin assemblage includes localities previously referred to as Cant Ranch in sec. 30 and 31, T. 11 S., R. 26 E., and adjacent sec. 6, T. 12 S., R. 26 E., in the eastern facies of the John Day Formation near Picture Gorge. The collections are not large but include *Calocedrus* and *Pterocarya* as unique taxa. Locality numbers include UCMP 3931 and P-4211; UF 248; USNM 6881; and UOCM 2750.

COMPARISONS WITH OTHER FLORAS

The Bridge Creek flora is the most completely known early Oligocene flora from North America and therefore provides a good basis for comparisons with other Tertiary floras of the western United States and with floras of Europe and Asia. In the following discussions, our reference to the ages of floras uses an Eocene-Oligocene boundary of 34 Ma (Berggren et al., 1992; Prothero and Swisher, 1992) and may thus differ from ages used in previous literature.

OTHER EARLY OLIGOCENE FLORAS OF THE PACIFIC NORTHWEST

Several additional fossil floras of the Pacific Northwest are presumed to be of early Oligocene age. The fossils are usually preserved in lacustrine sediments associated with volcanic sequences that were deposited during the early stages of Cascade volcanism. Floras of the western Cascade Mountains that have similarities with the Bridge Creek flora include the Willamette (preliminary list in Lakhanpal, 1958), Rujada (Lakhanpal, 1958), and Lyons (Meyer, 1973) floras of western Oregon; the Montague flora of northern California (preliminary list in Brown, 1959); and the Gumboot Mountain flora (unpublished, loc. UCMP PA-393) of the southern Washington Cascades. This section presents a brief review of each of these floras, as currently known. Preliminary taxonomic lists for some of these and other floras of the western Oregon Cascades were given by Wolfe *in* Peck et al. (1964). The following summary also includes preliminary work on additional assemblages of the John Day Formation that could be considered part of the Bridge Creek flora but which have not been treated in detail in this monograph.

The Willamette flora occurs in dark gray lacustrine shales located just west of the western Cascades near Eugene, Oregon. Although it has not been monographed, the taxonomic composition has been considered by Lakhanpal (1958) and Wolfe (*in* Peck et al., 1964), and some taxa have been treated in detail by Brown (1959). On the basis of our analyses of collections at USNM, UCMP, and UF, we recognize many taxa in common with the Bridge Creek flora, including *Cunninghamia chaneyi*, *Metasequoia* sp., *Sequoia affinis*, *Fokieniopsis*, *Keteleeria* (Brown, 1959, pl. 24, fig. 5; H. E. Schorn, pers. comm., 1992), *Pinus*, *Platanus exaspera*, *Platanus condonii*, *Ulmus*, *Quercus consimilis*, *Plafkeria obliquifolia*, *Florissantia*, *Hydrangea*, *Crataegus merriamii*, *Cercis maurerae*, *Terminalia oregona* (*Terminalia* sp. of Brown, 1959, pl. 24, fig. 15), *Acer* sp. C fruit, and *Palaeophytocrene*. In addition, the flora contains several shared genera that in our opinion could not be demonstrated as conspecific with the Bridge Creek taxa: *Equisetum*, *Cinnamophyllum*, *Alnus*, *Cruciptera* (Manchester, 1991), and *Palaeocarya willamettensis* (Manchester, 1987b).

The Lyons flora, located southeast of Lyons, Oregon, was included on a list by Wolfe (*in* Peck et al., 1964) and subsequently illustrated and discussed by Meyer (1972, 1973). The specimens are preserved as brown to orange impressions in a buff to white silica-rich tuff and often show excellent details of venation. Taxa in common with Bridge Creek include *Cunninghamia chaneyi*, *Metasequoia* sp., *Sequoia affinis*, *Tetraclinis potlachensis*, *Abies*, *Mahonia simplex*, *Cinnamomophyllum*, *Platanus condonii*, *Alnus*, *Cruciptera* (Manchester, 1991, fig. 17), *Pterocarya*, *Plafkeria obliquifolia*, *Tilia circularis*, *Tilia* cf. *fossilensis*, *Florissantia speirii*, *Hydrangea* sp., *Rosa hilliae*, *Terminalia oregona* (*Terminalia* sp. of Brown, 1959, pl. 24, fig. 14), *Acer* (*A. oligomedianum*, *A. osmontii*; Wolfe and Tanai, 1987), and *Fraxinus*. Some noteworthy differences from the Bridge Creek flora include the presence of *Ginkgo*, *Chamaecyparis*, *Meliosma*, and *Exbucklandia* and the apparent absence of *Cercidiphyllum*, *Fagus*, *Asterocarpinus*/*Paracarpinus*, and *Craigia*.

The Rujada flora was monographed by Lakhanpal (1958) and also included on a taxonomic checklist by Wolfe *in* Peck et al. (1964). The material is poorly preserved and details of diagnostic characters are often not present. We do not agree with some of the systematic affinities indicated by Lakhanpal, but we do recognize many taxa common to the Bridge Creek flora, including *Sequoia affinis*, *Cunninghamia chaneyi*, *Pinus*, *Keteleeria*, *Abies*, *Platanus* (including *P. condonii*), *Quercus*, *Alnus*, *Palaeocarya*, *Plafkeria obliquifolia*, *Crataegus merriamii*, and *Terminalia oregona*. The structure illustrated as a monocotyledonous sheath (Lakhanpal, 1958) is very similar to the monocotyledonous plant from the assemblages at Fossil (pl. 73, fig. 5) and Painted Hills. The flora also contains some entire-margined leaves that may represent evergreen taxa, such as *Exbucklandia oregonensis*.

Considerably farther south, the Montague flora of Brown (1959; USGS loc. 9423) is also considered to be approximately coeval with the Bridge Creek flora. The fossil plants occur in an outcrop of shale 10 miles north of Montague, California. Genera in common with the Bridge Creek flora include *Cunninghamia*, *Quercus*, *Palaeocarya*, *Ulmus*, *Cercidiphyllum*, *Platanus*, *Cercis*, *Cornus*, and *Florissantia*.

The northernmost early Oligocene assemblage having strong similarities to the Bridge Creek flora is the Gumboot Mountain flora south of Mount St. Helens, Washington (UCMP loc. PA-367; H. W. Meyer and H. E. Schorn, unpublished data, 1980). On the basis of the small collections examined, we recognize the following taxa that are shared with the Bridge Creek flora: *Cunninghamia*, *Metasequoia*, *Sequoia*, *Abies*, *Pinus*, *Platanus*, Fagaceae, *Pterocarya*, *Tilia*, *Florissantia*, *Ribes*, Rosaceae, and *Acer* (*A. osmontii*; Wolfe and Tanai, 1987). The Gumboot assemblage also contains *Exbucklandia* in common with the floras of the western Cascades.

Other assemblages in the John Day Formation of north-central Oregon but not included in this work are Twickenham and Gray Butte Canal. The assemblage at Twickenham (Chaney, 1948a) occurs in the eastern facies of the John Day Formation and can also be considered as a component of the Bridge Creek flora. Although we did not conduct a complete analysis of the assemblage, large collections at UCMP indicate that it includes many typical Bridge Creek taxa (*Metasequoia* sp., *Cercidiphyllum crenatum, Ulmus chaneyi, Plafkeria obliquifolia, Florissantia speirii,* and *Rhus lesquereuxii*). The shale from this locality is dominated by the remains of *Metasequoia*, but a number of angiosperms are also present. The elms (4 spp.) and maples (2 spp.) of the Twickenham assemblage were treated by Tanai and Wolfe (1977) and Wolfe and Tanai (1987), respectively. Taxa shared with other assemblages of the Bridge Creek flora include *Metasequoia, Cercidiphyllum crenatum, Ulmus chaneyi, Ulmus pseudoamericana, Ulmus* sp. 1, *Plafkeria obliquifolia, Florissantia speirii,* and *Rhus lesquereuxii*. A new species of *Amelanchier* with leaves larger than those known from the other Bridge Creek assemblages is common at Twickenham. A preliminary examination of the collections indicates that several as yet unidentified taxa are apparently unique to the Twickenham assemblage.

The Canal flora near Gray Butte, Oregon (Ashwill, 1983), situated in the western facies of the John Day Formation, represents a typical Bridge Creek assemblage, with *Metasequoia* sp., *Alnus, Asterocarpinus perplexans / Paracarpinus chaneyi, Crataegus merriamii,* and *Craigia oregonensis*.

OLIGOCENE FLORAS OF THE WESTERN U.S. INTERIOR

Floras from the Rocky Mountain region of southwestern Montana which may be contemporaneous with Bridge Creek include the Mormon Creek, Metzel Ranch, and York Ranch assemblages of Becker (1960, 1972, 1973). Although not thoroughly dated, geologic correlation with an associated radiometric date of 31.1 Ma and biostratigraphic correlations with Orellan mammals (Wing, 1987) suggest an early Oligocene age. The Ruby flora of Montana may be as young as Whitneyan, or about 29–31 Ma (Wing, 1987). In the southern Rocky Mountains of Colorado and New Mexico, floras that are radiometrically coeval with Bridge Creek are not known, and the Eocene-Oligocene transition is broadly bracketed between the latest Eocene Florissant flora (34.05–34.2 Ma) (discussed later with Eocene floras) and the Oligocene Hillsboro (28.1–30.6 Ma) and Platoro (28.9–30.6 Ma) floras (Meyer, 1986). Although some differences between the Florissant and these younger southern Rocky Mountain floras are apparently the result of deposition at different elevations (Meyer, 1986, 1992), much of the change can be accounted for by worldwide climatic cooling documented elsewhere.

Assemblages from the Dunbar Creek Member of the Renova Formation and equivalents (see Wing, 1987, fig. 3) in southwestern Montana may be of similar age to Bridge Creek and were described and illustrated in monographic works by H. F. Becker. Although we do not agree with some of the systematic affinities proposed by Becker, we do recognize many taxa common to the Bridge Creek flora. The Mormon Creek assemblage (Becker, 1960) includes *Cedrelospermum, Acer, Fraxinus, Diplodipelta,* and *Beckerospermum* in common with Bridge Creek. The Metzel Ranch assemblage (Becker, 1972) shares *Mahonia simplex, Cercidiphyllum* (leaves), *Cedrelospermum, Alnus, Plafkeria, Acer, Fraxinus, Diplodipelta reniptera,* and possibly *Hovenia* with Bridge Creek. In the York Ranch assemblage (Becker, 1973), the only taxa that we recognize as common to Bridge Creek are *Sequoia affinis, Acer,* and possibly *Cruciptera.*

When considered collectively, assemblages of the Dunbar Creek Member do not show striking floristic similarities to the Bridge Creek flora. They lack coniferous diversity and include some important dicotyledonous genera not found in the Bridge Creek flora, such as *Populus, Salix,* and *Ailanthus.* They are further distinguished by having different species of *Quercus* and *Acer.* These differences from the Bridge Creek might be attributed to barriers that limited floristic exchange or to differences in floristic provinces, floristic sources, climatic regimes, elevation, and/or age.

The Ruby flora (Becker, 1961, 1966) of the Passamari Member of the Renova Formation, also in southwestern Montana, may be younger than the Mormon Creek and Metzel floras (Wing, 1987), but shows more similarity to Bridge Creek, as indicated by the presence of *Abies, Pinus, Metasequoia, Sequoia affinis, Alnus, Ulmus, Cercidiphyllum* (leaves only), *Rosa hilliae, Diplodipelta reniptera, Dipteronia, Acer, Fraxinus, Florissantia speirii,* and possibly *Quercus* and *Ribes.* The Ruby flora differs from Bridge Creek in the presence of *Fagopsis, Nyssidium, Populus, Salix, Cercocarpus, Porana tenuis,* and "*Lomatia*" leaves. Many of these elements also occur in Eocene floras, such as Florissant.

Radiometrically dated Oligocene floras from the southern Rocky Mountains are 2–5 m.y. younger than the Bridge Creek flora. These floras show little similarity to Bridge Creek and indicate that the southern continental interior had a significantly different climate, vegetation, and elevation than the west coast during the Oligocene. These floras include the Hillsboro of New Mexico (radiometrically bracketed between 28.1 and 30.6 Ma), the similar and perhaps older Hermosa flora of New Mexico, and the Creede flora of Colorado (dated at 27.2 Ma). The Hillsboro and Hermosa floras (Axelrod and Bailey, 1976; Meyer, 1986) are almost totally dominated by *Pinus crossii*, a species related to the extant bristlecone and foxtail pines. The floras indicate subalpine-taiga vegetation with a mean annual temperature near 0°C. The paleoelevation of the Hillsboro flora is estimated at about 3000 m (Meyer, 1986, 1992). The Creede flora (Axelrod, 1987; Wolfe and Schorn, 1989, 1990) contains a more diverse mixed coniferous assemblage that includes several genera of Rosaceae. Although the flora shares such genera as *Abies* (different organs), *Pinus, Mahonia, Ribes, Crataegus, Cercis* (different organs), and *Catalpa* (different organs) in common with Bridge Creek, none of these is conspecific. Creede is also interpreted as an upland flora with a paleoelevation of about 1800 m (Meyer, 1986), although other estimates have ranged from 1100 m (Axelrod, 1987) to possibly as much as 2500 m (Wolfe and Schorn, 1989). The Platoro flora of Colorado is floristically comparable to Creede and apparently grew at a similar elevation (Meyer, 1986), although it is 1–3 m.y. older than Creede and known only from a small collection. All these floras show affinities with the modern flora of the Rocky Mountains, demonstrating that floral (at the generic level) and vegetational modernization occurred much earlier in the continental interior than on the west coast, as pointed out by Leopold and MacGinitie (1972).

EOCENE FLORAS OF THE WESTERN UNITED STATES

Comparisons with Eocene floras of western North America are relevant in assessing the sources of taxa that comprise the Bridge Creek flora. Within the immediate vicinity of the John Day Basin, Eocene floras of the Clarno Formation are unconformably separated from those of the John Day Formation. Radiometric evidence suggests a gap of at least 5.6 m.y. between the latest possible deposition of the Clarno Formation (preceding emplacement of the John Day Formation ash-flow tuff member A, 39.2–39.7 Ma) and the oldest date obtained from a Bridge Creek assemblage (33.6 Ma). A larger gap of about 12 m.y. separates the Bridge Creek flora from most of the well-known Clarno floras (e.g., Nut Beds, West Branch Creek, and lacustrine assemblages in the Cherry Creek vicinity) (Manchester, 1990). Comparison with Clarno floras thus provides an indication of Bridge Creek taxa that were already in the region by the middle Eocene but does not resolve floristic changes near the Eocene/Oligocene boundary. To consider floras of the late Eocene for an indication of the taxa that were regionally present immediately preceding the Bridge Creek flora, it is helpful to examine fossil floras from other areas of western North America. These include lowland floras of the west coast (e.g., LaPorte and Goshen), and upland floras of the Rocky Mountain region (e.g., Florissant).

Although the lacustrine floras of the Clarno Formation have not yet been monographed, large collections at UCMP, UF, and USNM provide a basis for our comparison. The assemblages of West Branch Creek and White Cliffs (~44.6–46.8 Ma) include the following genera in common with the Bridge Creek flora: *Torreya, Sequoia, Pinus, Cinnamomophyllum, Litseaphyllum, Platanus, Cedrelospermum, Ulmus, Quercus, Alnus, Comptonia, Cruciptera, Palaeocarya, Plafkeria, Florissantia, Ribes, Hydrangea, Terminalia, Dipteronia, Palaeophytocrene, Fraxinus,* and *Potanospira*.

The Clarno Nut Beds flora (~43.7, 43.8 Ma) is known from fossil woods, leaves, fruits, and seeds (Manchester, 1981, 1994b). The flora includes *Pinus, Cinnamomophyllum, Litseaphyllum, Cedrelospermum lineatum, Quercus, Cruciptera, Juglans, Palaeocarya, Hydrangea, Decodon, Cornus, Palaeophytocrene,* and *Vitis* in common with the Bridge Creek flora. The Nut Beds flora differs from the Bridge Creek flora in the presence of many broad-leaved evergreen taxa and a diversity of lianas, including 12 genera of Menispermaceae, five genera of Icacinaceae, and four genera of Vitaceae.

The LaPorte flora of northern California is composed predominantly of broad-leaved evergreen taxa (Potbury, 1935; Doyle et al., 1988) not found in the Bridge Creek flora. Although the available K/Ar date (33.2 Ma) suggests an age comparable to the Bridge Creek flora, the warmer aspect of the LaPorte flora is thought to indicate a pre-Bridge Creek age (Wolfe and Hopkins, 1967; Wolfe, 1981a). Better resolution of the age of the LaPorte flora using $^{40}Ar/^{39}Ar$ dating is needed. Genera in common include *Ulmus* (~*Chaetoptelea*), cf. *Vitis* (seed), and *Quercus* (Tiffney, *in* Doyle et al., 1988).

The Goshen flora of western Oregon (Chaney and Sanborn, 1933) is believed to be comparable in age to the LaPorte flora (Wolfe, 1981a) and also has a greater preponderance of broad-leaved evergreens than the Bridge Creek flora. This flora has relatively little in common with the Bridge Creek, but does include the following shared genera: *Litseaphyllum, Florissantia, Platanus*, and *Plafkeria*.

The very diverse Florissant flora of Colorado (34.05–34.2 Ma), formerly considered to be early Oligocene in age (MacGinitie, 1953; Manchester and Crane, 1987; Wing, 1987), is now placed in the latest Eocene according to current chronostratigraphic placement of the Eocene-Oligocene boundary at 34 Ma (Berggren et al., 1992; Prothero and Swisher, 1992). This flora, which was at relatively high elevation (estimated at 2450 m [Meyer, 1992], 2255 to 4133 m [Wolfe, 1994], and 2300 to 3300 m [Gregory, 1994]), includes many genera shared with the younger Bridge Creek flora: *Torreya, Abies, Pinus, Sequoia, Mahonia, Cedrelospermum, Ulmus, Quercus, Asterocarpinus/Paracarpinus, Carya, Juglans, Florissantia, Ribes, Hydrangea, Amelanchier, Crataegus, Rosa, Rhus, Acer,* and *Dipteronia*.

The Beaverhead Basin floras of southwestern Montana (Becker, 1969) are situated in the "Medicine Lodge Beds," which may correlate with sediments producing Chadronian (late Eocene) vertebrates (~36 Ma) (Wing, 1987). From our evaluation of the taxa illustrated and described from the collected assemblages of the Beaverhead Basin by Becker (1969), we consider the following taxa to be shared with the Bridge Creek flora: *Abies, Pinus, Metasequoia, Sequoia affinis, Nuphar, Betula* or *Alnus, Paracarpinus, Quercus* cf. *consimilis, Rosa* (fruit), *Cercidiphyllum, Acer, Cedrelospermum, Mahonia, Platanus, Craigia, Florissantia speirii, Fraxinus*, and *Dipteronia*.

EUROPEAN FLORAS

Strong taxonomic similarities exist between the Bridge Creek flora and middle to late Tertiary floras of central and eastern Europe. Many taxa are shared at the generic level, and *Cercidiphyllum crenatum* has been assigned to the same species. In addition, close morphological similarities in all of the preserved features indicates that other Bridge Creek taxa may also be conspecific with European fossils, although separate epithets have been used. Examples include *Tetraclinis potlachensis* (~ *T. salicornioides* (Unger) Endlicher), *Ostrya oregoniana* Chaney (~ *O. atlantidis* Unger), *Craigia oregonense* (~*C. bronnii* (Unger) Kvaček, Bůžek, and Manchester), and *Tilia pedunculata* (~*T. longebracteata* Andrae). These similarities indicate probable biogeographic communication via the North Atlantic (Tiffney, 1985).

The precise age of many European Eocene and Oligocene floras is questionable because of the lack of independent radiometric data and correlations with mammalian or invertebrate horizons (Collinson, 1992). These problems apply to some of the floras that are taxonomically most similar to the Bridge Creek flora, such as those of Seifennersdorf (Mai, 1963), Kundratice (Engelhardt, 1885; Bůžek et al., 1978), and Pirskenberges (Knobloch, 1961). Well-preserved fossil floras from Hungary occur in marginal marine sediments that contain age-diagnostic nanoplankton that provide a good basis for global correlation. It is through floristic comparison with the Hungarian floras that the ages of other central and eastern European floras have been estimated (Bůžek et al., 1976, 1978). Many of the best known European Tertiary floras (e.g., those described by Mai and Walther, 1991) are from fruit and seed assemblages from lignites that were deposited in swamps and, because of different taphonomic biases, are of limited utility in comparisons with the lake-deposited Bridge Creek flora. More suitable for comparison with the Bridge Creek flora are the specimens from clastic lacustrine deposits.

The Tard Clay Formation of Hungary contains early Oligocene megafloral assemblages near Budapest (Óbuda: Rásky, 1943, 1966; Hably, 1979) and Eger (Kiseged: Andreánszky, 1959). The fossil plants at both of these localities occur in beds that also contain nanoplankton attributed by A. Nagymarosy to zone NP23 (Hably, 1992). This zone is currently considered to extend from about 30.5 to 34 Ma (Aubry, 1992; Berggren et al., 1992), thus falling within 1–2 m.y. of the age estimated for the Bridge Creek flora. Rásky (1943, 1956, 1966) investigated a variety of well-preserved fossil plants from Óbuda (although she incorrectly attributed the localities to the Eocene Buda Marl Formation; L. Hably, pers. comm, 1994). The Tard Clay flora is dominated by warm-adapted elements and contains numerous taxa not found in the Bridge Creek flora, such as *Tarrietia* (Rásky, 1950), *Hooleya, Tetrapteris* (Rásky, 1956), *Ziziphus*, and *Eotrigonobalanus*. However, there are more than ten shared genera (verified by examination of the specimens by S. Manchester and L. Hably in 1994), including *Pinus, Tetraclinis* (=*Libocedrites*), *Laurophyllum* (~*Litseaphyllum*), *Daphnogene* (~*Cinnamomophyllum*), *Nuphar, Platanus* (2 spp.), *Cedrelospermum, Quercus, Alnus*?, *Comptonia, Palaeocarya, Hydrangea*, and *Craigia*. Notable by their absence from the Óbuda and Kiseged assemblages are such "Arcto-Tertiary" components as *Cercidiphyllum, Fagus, Ostrya, Betula, Ulmus, Pterocarya*, and *Acer*. These genera did not become prevalent in Hungary until the late Oligocene or Miocene (Hably, 1990).

The flora of Kundratice, in the Bohemian Massif, Czech Republic, contains a rich megafossil assemblage (Engelhardt, 1885; Bůžek et al., 1978, 1990). Based on floristic composition and comparison with Hungarian floras, it has been considered to correlate with the Egerian, or late Oligocene (Bůžek et al., 1978). Recently, a date of 32.7 ± 1.6 Ma has been published for this flora, although without details documenting the sample or analytical procedure (Knobloch et al., 1993). If this radiometric date and those for the Bridge Creek flora are correct, then the two floras could be coeval. From the revised overview of the flora provided by Bůžek et al. (1990), the following taxa are shared with the Bridge Creek flora: *Torreya, Tetraclinis, Cercidiphyllum crenatum, Betula, Alnus, Ostrya, Ulmus, Laurophyllum, Daphnogene, Acer* spp., *Rosa, Platanus* (but a different subgenus), *Craigia* (=*Pteleaecarpum*), and *Cornus*.

The late Oligocene flora of Pirskenberges in North Bohemia, carefully described and photographically documented by Knobloch (1961), possesses even more taxa in common with the Bridge Creek flora: *Tetraclinis, Comptonia, Juglans, Carya, Engelhardia, Pterocarya*?, *Betula* (leaves, bracts), *Alnus* (rare), *Cercidiphyllum crenatum, Rosa, Crataegus, Craigia* (=*Pteleaecarpum*), *Aesculus, Acer, Cornus*, and *Vitis*. The late Oligocene or early Miocene Seifennersdorf flora of Saxony (Mai, 1963) includes *Tetraclinis* (=*Hellia*), *Platanus* (but a different subgenus), *Carya, Alnus, Betula, Cercidiphyllum, Cinnamomophyllum, Hydrangea, Craigia* (=*Pteleaecarpum*), *Acer* (3 spp.), and *Vitis* in common with the Bridge Creek flora. The absence of *Metasequoia* from this and other European floras contrasts with the Bridge Creek flora.

ASIAN FLORAS

Few Oligocene leaf floras are known in Asia. The early Oligocene (precise age uncertain) flora of Kiin-Kerish, Kazakhstan (Akhmetiev, 1991) provides a useful point of reference. This flora has some warmer elements than the Bridge Creek flora, such as *Eucommia*, Myrtaceae, and *Firmiana*, but also many genera in common: *Taxus*, *Cercidiphyllum*, *Liquidambar*, *Platanus*, *Ulmus*, *Quercus*, *Betula*, *Alnus*, *Comptonia*, *Acer*, *Rhus*, *Toxicodendron*, *Vitis*, and *Fraxinus*. Neogene floras, which are well-represented in Asia (e.g., Hu and Chaney, 1940; Tanai, 1972; Uemura, 1988; Guo, 1989), indicate that most of the genera found in the Bridge Creek flora were also present in eastern Asia at least by the early Miocene.

STRATIGRAPHICALLY USEFUL TAXA

Climatic cooling near the Eocene-Oligocene boundary (Wolfe, 1994) resulted in major extinctions that produced a flora impoverished in broad-leaved evergreen taxa. Some of the early Oligocene taxa are hold-overs from Eocene lowland floras of the region, although most of these become extinct before the late Oligocene. Other groups, possibly immigrants from other regions, began a pattern of radiation during the early Oligocene that continued and intensified into the Miocene. Consequently, the taxonomic composition of the Bridge Creek and other similar lower Oligocene floras from the Pacific Northwest has significant chronostratigraphic utility within the region.

Several genera make their earliest known North American appearances in the Bridge Creek flora, although some of these also occur in similar, apparently isochronous, floras of the Pacific Northwest. The genera first occurring in North America during this time include *Calocedrus*, *Cunninghamia*, *Tetraclinis*, *Keteleeria*, *Cercidiphyllum* (*sensu stricto*), *Ostrya*, and *Pinckneya*. In addition, the Bridge Creek flora provides the earliest occurrences of *Cedrela* and *Fagus*, confirmed by seeds and fruits. Conversely, genera making last known North American occurrences include *Asterocarpinus*, *Cruciptera*, *Plafkeria*, *Craigia*, *Florissantia*, *Dipteronia*, *Palaeophytocrene*, and *Beckerospermum*. Genera known in North America only from the Bridge Creek flora include *Parrotia*, *Hovenia*, and *Flectorivus*.

At the species level, many elements of the flora are unique to this period of time. Most distinctive among these are *Parrotia brevipetiolata*, *Platanus condonii*, *Flectorivus microdontos*, *Tilia circularis*, *Micropodium ovatum*, and *Hovenia oregonensis*. In addition, all of the Bridge Creek species of *Acer* appear to be confined to the lower Oligocene of Oregon.

The Bridge Creek flora was referred to the lower part of the Angoonian Stage by Wolfe (1977, 1981a). The Angoonian is a provincial biostratigraphic stage defined by Wolfe (1977) from a type section located on Admirality Island in southeastern Alaska. We find it difficult to evaluate the occurrences of species from this type assemblage with those from the Bridge Creek flora using only the taxonomic list given by Wolfe (1977). A complete and descriptive systematic treatment of the Angoonian type assemblage has not been published, and our examination of the specimens revealed very limited similarity with the Bridge Creek flora. It is probable that the Angoonian stage is provincial and applies only to the region near its type area in southern Alaska, with limited utility elsewhere in the Pacific Northwest. Of the Angoonian taxa cited by Wolfe, *Plafkeria obliquifolia* and *Tilia aspera* also occur in the Bridge Creek flora, and although different specific epithets are used, we assume that *Metasequoia* cf. *M. glyptostroboides*, *Alnus carpinoides*, *Fagus* sp., and *Fothergilla* sp. may be related to Bridge Creek species.

In terms of the chronostratigraphic utility of lower Oligocene fossil plants, the Bridge Creek flora is important because its taxa are thoroughly documented and the plant assemblages are directly associated with radiometric age determinations. Although we do not propose formal biostratigraphic units based on the Bridge Creek flora of the John Day Formation, it nevertheless remains a significant benchmark on which correlations can be based, at least within this paleobiogeographic province.

VEGETATION

The Bridge Creek flora is physiognomically and floristically similar to the present-day temperate hardwood deciduous forests of eastern Asia (Wang, 1961) and eastern North America (Braun, 1950; Vankatt, 1979). Most of the Bridge Creek genera no longer occur, however, in the dominantly coniferous forests of the Pacific Northwest. Prior to the discovery of living *Metasequoia*, Chaney (1925a) compared fossils from the Bridge Creek flora with the living redwood forests of California and incorrectly identified many elements of the flora on the basis of gross morphology and his preconception that the floras were essentially identical. Later, he recognized the similarity of the Bridge Creek flora to modern forests of eastern Asia (Chaney, 1948a,b, 1952).

In eastern Asia, broad-leaved deciduous trees dominate several forest types (Wang, 1961; Wolfe, 1979), including the Mixed Mesophytic, Mixed Broad-leaved Deciduous, and Mixed Northern Hardwood forests (*sensu* Wolfe, 1979). In certain areas, however, the character of some of these forest types was inferred from modern vegetation that has been modified by centuries of human activity (Wang, 1961). The type of vegetation inferred for the Bridge Creek flora compares favorably with Mixed Mesophytic forest, particularly as this vegetation type is characterized in China (Wolfe, 1979). Similarities, discussed in more detail later, include proportion of conifers, proportion of evergreen dicots, the proportion of trees and shrubs versus woody climbers, and characteristics such as dicotyledonous leaf size and margin. The vegetation also shares many physiognomic characteristics with Mixed Northern Hardwood forest (*sensu* Wolfe, 1979). We interpret the Bridge Creek flora to represent Mixed Mesophytic forest near the transition with Mixed Northern Hardwood forest. However, the vegetation represented by the Bridge Creek flora was apparently less diverse than the modern Mixed Mesophytic forest of Asia. The paleoclimate indicated by this interpretation of the vegetation is discussed in the next section.

Compared to earlier interpretations, the Bridge Creek flora is relatively high in diversity. Although the minimum diversity for the entire Bridge Creek flora is at present 125 species, this number will increase as collecting continues and when other assemblages (e.g., Twickenham and Gray Butte Canal) are included. The minimum diversity of individual assemblages (excluding the small collection from Butler Basin) ranges from 30 to 65 species (Table 4). The flora is not as rich in species, however, as the early Miocene Collawash flora of western Oregon (156 species from a single assemblage; Wolfe, 1981b), which also represents Mixed Mesophytic forest. Among the extant broad-leaved forests in temperate eastern Asia, the Mixed Mesophytic is the most diverse.

Physiognomically, the Bridge Creek assemblages are dominantly deciduous. Dicotyledonous evergreens comprise only a small proportion of the flora. *Mahonia, Aucuba,* and *Pyracantha* are genera that are evergreen today. *Quercus berryi, Litseaphyllum presanguinea,* and *Cinnamomophyllum knowltonii* are likely to have been evergreen. Taxa that might have been either evergreen or deciduous include *Quercus consimilis, Palaeocarya, Cedrela,* and *Terminalia*. Although the Mixed Mesophytic forest of Asia is dominated by deciduous taxa, broad-leaved evergreens are also present as a minor element (15–30%), mostly as small trees and shrubs. Most of the broad-leaved evergreen taxa are microphyllous (leaves <20 cm^2) although some notophyllous (leaves 20–45 cm^2) species are also present (Wolfe, 1979, 1981b). By comparison, in the Asian Mixed Northern Hardwood forest, all of the trees are broad-leaved deciduous and only a few shrubs are microphyllous broad-leaved evergreen; notophyllous broad-leaved taxa are absent (Wolfe, 1981b). Wolfe (1981b) considered the Bridge Creek flora to represent Mixed Mesophytic forest, although he emphasized (p. 88) that the "reduced broad-leaved evergreen element in the fossil assemblages is anomalous relative to extant vegetation."

Part of the paucity of evergreen taxa may be due to taphonomic biases because deciduous taxa more often inhabit lake-side environments and have leaves that are shed in greater quantity. Deciduous leaves are thus more likely to find their way into lacustrine sediments than evergreen leaves. The low diversity of evergreen taxa in the Bridge Creek flora may also be due to factors related to paleolatitude. Because of tectonic rotation of the North American continent, the early Oligocene position of north-central Oregon is inferred to have been about 4 to 5° latitude farther north of its present location (Smith et al., 1981), indicating a paleolatitude for the various assemblages of about 48 to 50°N. Wolfe (1980, 1981b) has noted that today the diversity of notophyllous broad-leaved evergreens shows a sharp decline between 49 and 50° N latitude along the west coast of North America. This change is not strongly related to changes in temperature and instead may be due to the low intensity and duration of winter light at more northern latitudes. The apparent low diversity of broad-leaved evergreens in the Bridge Creek flora may thus be a function of the higher inferred paleolatitude.

Conifers are relatively low in diversity (9 spp.), but one or more species are present in all assemblages, ranging from one species at Crooked River to five at Lost Creek. *Metasequoia* is present in all assemblages, although in varying abundance, and *Torreya* is present at most. The percentage representation of coniferous species per assemblage varies: 1.9% (Crooked River), 5.4% (Painted Hills, Fossil), 8.8% (Cove Creek), 9.5% (Iron Mountain), 16.7% (Lost Creek), and 21.0% (Butler Basin).

On the basis of their modern habits, the following 34 genera (including 46 species) are inferred to represent trees in the Bridge Creek flora: *Torreya, Calocedrus, Cunninghamia, Metasequoia, Sequoia, Tetraclinis, Abies, Keteleeria, Pinus, Cercidiphyllum, Liquidambar, Platanus* (2 spp.), *Ulmus* (4 spp.), *Fagus,*

Table 5
Physiognomic Data and Estimated Mean Annual Temperature among Assemblages of the Bridge Creek flora

Assemblage	Total No.[1]	No. and Percent of Conifers	No. of Species in Margin Count	Percent Entire	MAT (°C)
Painted Hills	37	2/5.4	30	22	8–9°
Fossil	61	4/6.6	53	35	11–12°
Cove Creek	34	3/8.8	28	27	9–10°
Iron Mountain	42	4/9.5	31	23	8–9°
Crooked River	53	1/1.9	45	24	8–9°
Lost Creek	30	5/16.7	18	31	10–11°

[1] excludes *Equisetum*, ferns, and Nymphaeaceae.

Quercus (2 spp.), *Alnus* (or shrub), *Betula* (or shrub), *Ostrya, Juglans, Carya, Pterocarya, Tilia* (2 spp.), *Craigia, Malus/Pyrus* (or shrub), *Cladrastis, Terminalia, Cedrela, Acer* (7 spp.), *Dipteronia, Fraxinus, Pinckneya*, and *Catalpa*. *Asterocarpinus* and *Palaeocarya* were probably also trees, as deduced from their living relatives (*Carpinus, Ostrya; Engelhardia, Oreomunnea*). For the living Mixed Mesophytic forest of China, Wang (1961) notes that there are at least 60 species of canopy trees, and typically 20 to 30 tree species per stand.

Probable understory shrubs and small trees of the flora include *Mahonia, Fothergilla, Parrotia, Comptonia, Ribes, Hydrangea, Amelanchier* (2 spp.), *Crataegus, Rosa, Rubus* (2 spp., scrambling shrub), *Pyracantha, Decodon, Rhus, Cornus, Aucuba, Paliurus*, and *Hovenia*. It is possible that one or more species of *Quercus, Alnus, Betula*, and *Acer* were of low stature as well. The forests of Bridge Creek probably exhibited considerable gradation in tree and shrub stature. A lack of well-defined canopy stratification is a feature of Mixed Mesophytic forest, whereas Mixed Northern Hardwood forest has two stories (Wang, 1961).

Herbs and lianas are relatively rare in the flora. The herbs are represented by only a few remains of *Equisetum* and ferns. Lianas are represented only by *Menispermum, Vitis*, and possibly *Toxicodendron* and *Palaeophytocrene*. Liana diversity is greatest in tropical vegetation, and their low diversity is consistent with the interpretation of Mixed Mesophytic or Mixed Northern Hardwood forest. Gentry (1992) computed the percentage of lianas per site in temperate eastern North America at 6%, versus 19% in continental neotropics. The low proportion of climbers in the Bridge Creek flora appears to be even lower than in modern Mixed Mesophytic forest. Wang (1961) includes fully 20 genera in the Mixed Mesophytic forest of China.

Leaf size and margin characteristics are consistent with Mixed Mesophytic forest. The dicotyledonous leaves of the Bridge Creek flora are roughly evenly

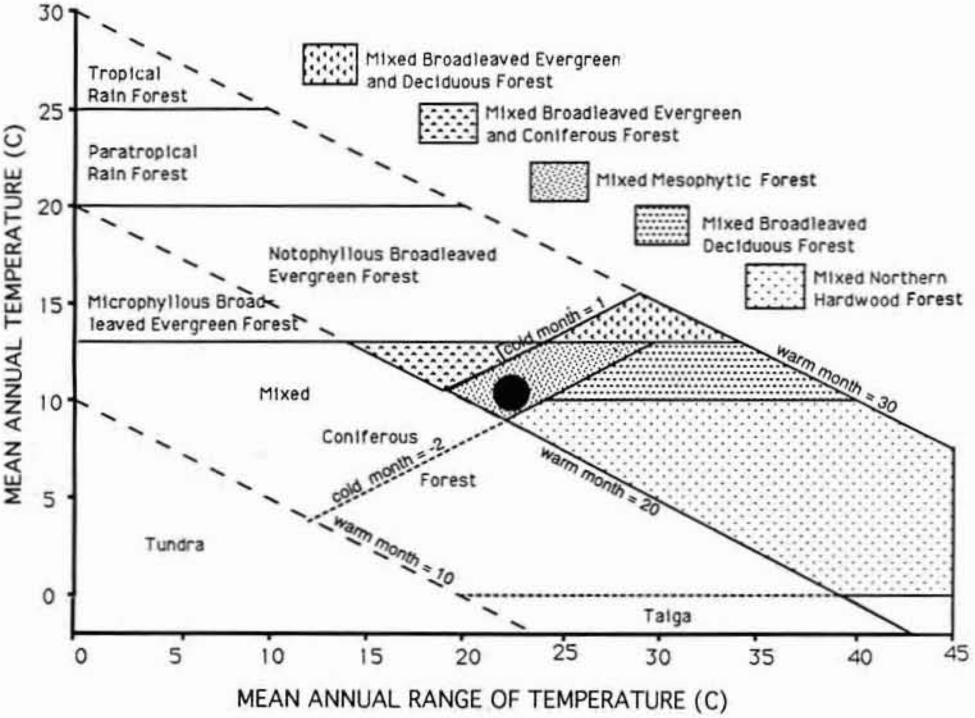

Figure 2. Climagraph showing the estimated position of the Bridge Creek flora in relation to extant vegetation types in eastern Asia mapped according to mean annual temperature, mean cold month temperature, mean warm month temperature and mean annual range of temperature. After Wolfe (1985).

divided between notophylls and smaller size classes, as in the Mixed Mesophytic forest of Asia (Wolfe, 1979). The proportion of entire-margined leaves (leaves that lack teeth or lobes) in Bridge Creek assemblages ranges from 22 to 35% (Table 5). In extant Mixed Mesophytic forest of Asia, it is from 28 to 38%; in Mixed Northern Hardwood forest it is 9 to 24% (Wolfe, 1979). The leaf margin percentages for the Painted Hills, Iron Mountain, and Crooked River assemblages (Table 5) may indicate an ecotonal setting between Mixed Mesophytic and Mixed Northern Hardwood forest (Fig. 2), although these assemblages contain some genera more typical of Mixed Mesophytic forest.

Floristically, the Bridge Creek flora is most similar to the Mixed Mesophytic Forest in the presence of *Torreya, Cunninghamia, Keteleeria, Cedrela, Cercidiphyllum* and *Pterocarya*. Most other extant genera of the fossil assemblage occur today in both Mixed Mesophytic Forest and Mixed Northern Hardwood forest types.

PALEOCLIMATE

Paleoclimatic conditions can be inferred by identifying physiognomic and/or floristic similarities of a fossil assemblage to a modern vegetation type with known climatic parameters. Discussion of paleoclimate requires a working definition of terms because different investigators have applied widely differing concepts of what constitutes such categories as tropical, subtropical, and temperate. For consistency with other paleobotanical literature, we have adopted the following definitions from Wolfe (1979), which are based on modern mean annual temperatures (MAT) of humid to mesic regions of eastern Asia: tropical > 25°C; paratropical 20–25°C; subtropical 13–20°C; temperate 10–13°C; paratemperate 3–10°C; subtemperate < 3°C. These parameters, along with the cold month mean (CMM) and mean annual range of temperature (MART), approximately delimit distinct forest types within mesic vegetation (Fig. 2).

The Bridge Creek vegetation, dominated by dicotyledons rather than conifers, would have experienced warm month temperatures exceeding 20°C. If our assessment of the Bridge Creek vegetation as Mixed Mesophytic forest near the transition with Mixed Northern Hardwood forest is correct, then the climatic parameters of this modern vegetational setting may give a close approximation of the conditions under which the Bridge Creek flora existed. In eastern Asia, Mixed Mesophytic forest occurs in climates where MAT falls in the range of 9–13°C and MART is 20–29° (Fig. 2)(Wolfe, 1979). The annual precipitation in Mixed Mesophytic forest of China is 100–150 cm (Wang, 1961).

It is also tempting to interpret climatic parameters of the fossil vegetation from the distribution of hardwood forests (including Mixed Mesophytic forest) in eastern North America. However, forests of the eastern United States are believed to reflect a climatic phenomenon that would not have been present during the Oligocene in western North America. Today, the eastern United States is susceptible to occasional arctic cold waves that produce extremely low temperatures (Wolfe, 1979). These are typically too limited in duration and frequency to significantly affect averages such as CMM and MAT. However, such low-temperature extremes affect the vegetation by eliminating plants that are intolerant of subfreezing temperatures, such as broad-leaved evergreens that might otherwise be expected on the basis of MAT, MART, and CMM. The "anomalous" lack of broad-leaved evergreen taxa in the vegetation of eastern North America is believed to reflect the extensive ice formation in the Arctic Ocean that did not develop until the late Cenozoic. The modern temperate forests of China do not experience such extreme cold waves because they are shielded by east-west mountain ranges that were uplifted during the Neogene. Therefore, they are thought to be a better guide for the interpretation of Tertiary floras in the Northern Hemisphere (Wolfe, 1979).

Wolfe (1981b) pointed out that the occurrence of notophyllous broad-leaved evergreen leaves is significant in assessing paleoclimate because species having such leaves are generally limited to climates where the cold month mean temperature is above –2°C. Hence, the presence or absence of these broad-leaved evergreen species is particularly significant in assessing temperature parameters of fossil vegetation. The rarity of such notophyllous evergreens in the Bridge Creek flora indicates that winters were cold, with CMM probably near –2°C. The most abundantly represented broad-leaved evergreen in the flora, *Mahonia,* has relatively small leaflets and includes extant species that grow in cold climates with heavy snowfall. *Engelhardia* and *Cedrela* include modern species that are broad-leaved evergreens, but both also include living species that are deciduous. Thus, it cannot be assumed that the fossil species of these genera were evergreens. *Engelhardia* is known in the assemblage only from fruiting material (~*Palaeocarya*); however, judging from their thin textures, we think the leaves of *Cedrela* may have been deciduous. The leaves of *Cinnamomophyllum knowltonii* (known only from the Cove Creek assemblage) are notophyllous and may have been evergreen. The leaves of *Litseaphyllum* (known only from the Crooked River assemblage) and *Aucuba* (known only from the Iron Mountain assemblage) were both probably evergreen, although they are smaller than notophyllous size.

Leaf margin percentages provide another criterion for comparison of floras from different climates. Based on living vegetation, Bailey and Sinnott (1916) observed a correlation between climate and the percentages of species having entire-margined leaves. Successively higher percentages of entire-margined leaves occur in cool temperate, warm temperate, and lowland tropical floras. Further studies have shown that the percentage is influenced by MAT (Wolfe and Hopkins, 1967; Wolfe, 1971) and by rainfall (Dilcher, 1973). Wolfe (1979) indicated a direct correlation between MAT and leaf-margin percentage in mesic climates using published data from eastern Asia, although a much less precise correlation was found in studies of the Carolinas (Dolph and Dilcher, 1979) and Costa Rica (Dolph, 1979). Multivariate analysis of leaf characteristics from well-documented modern sampling sites demonstrates a strong correlation between MAT and the percentage of leaves with no teeth (Wolfe, 1973). Individual assemblages of the Bridge Creek flora range from 22 to 35% entire-margined leaves (Table 5).

Using the simple correlation between leaf margin and MAT proposed by Wolfe (1979), these values correspond to a mean annual temperature of 8–12°C. Our leaf margin percentage of 22–35 is within the range of that published previously for the Bridge Creek flora (25% based on 66 species from several localities; Wolfe and Hopkins, 1967; Wolfe, 1971). However, our estimate for the Crooked River assemblage (24%) is lower than that previously calculated (34% entire margins based on 37 species; Wolfe, 1981b). Also, our estimate for the assemblage at Fossil (35%) is higher than we obtained in an earlier investigation (17% based on 28 species; Manchester and Meyer, 1987). The estimate of 8–12°C for MAT derived from the present leaf margin analysis appears to be reasonable considering the thermal distribution of modern Mixed Mesophytic forest and Mixed Northern Hardwood forest in eastern Asia (Fig. 2).

The climatic distribution of present-day relatives of fossil taxa can be taken as an indication of the range of conditions under which a fossil flora might have existed. There are various problems inherent in using this uniformitarian approach: (1) the climatic tolerances of a taxon may evolve to accommodate climatic change; (2) the current distribution of a taxon is controlled by many factors, only one of which is regional climate (other important factors include historic barriers to dispersal and effects of interspecies competition and pathogens); and (3) any taxa that are misidentified may introduce erroneous climatic data. In spite of this, taxonomically based assessments of paleoclimate can provide a sense of the range of possible climatic conditions under which the fossil flora may have existed.

The occurrence of winter frost is a limiting condition for the distribution of thermophilic taxa. The absence in the Bridge Creek flora of such plants as cycads, palms, Musaceae, and diverse Menispermaceae, which were present in Eocene floras of the region, indicates that winter frost probably occurred. *Palaeophytocrene* is an extinct genus that belongs to a tribe of Icacinaceae that is predominantly tropical today. The genus is abundantly represented in the Clarno Formation, in probable Paratropical Rain forest, yet it is known from only a single specimen in the Bridge Creek flora. Its presence in the Iron Mountain assemblage might indicate that a species survived in the cooler climate of the Bridge Creek flora. *Palaeophytocrene* is also known to occur in the upland middle Eocene Republic flora and in the early Oligocene Willamette flora, both of which are considered to be warm temperate (MAT of 11.4° and 13°C, respectively, per Wolfe, 1994). Some of the extant genera, such as *Pinus*, *Quercus*, *Platanus*, and *Alnus*, include species that extend from tropical to temperate conditions. Of the genera with more restricted extant distributions, *Keteleeria* and *Terminalia* are among the most thermophilic. *Keteleeria*, represented by a single seed from Iron Mountain, predominates in broad-leaved evergreen forests and is rare at the southern border of Mixed Mesophytic forest. Some genera, such as *Abies*, exhibit a decided preference for cooler climates. Among North American species of *Abies*, the southern limit occurs where the mean warm month temperature reaches 21°C (Wolfe and Leopold, 1967). The majority of Bridge Creek genera are represented in the Mixed Northern Hardwood and Mixed Mesophytic forests. Examples include *Tilia*, *Fagus*, *Ostrya*, *Pterocarya*, and *Craigia*.

This assessment of paleoclimate assumes that the Bridge Creek vegetation was physiognomically and floristically "in balance" with the climate at the time of deposition. An alternative scenario is that the flora had not yet recovered from an earlier cooling event in which the flora became impoverished in thermophilic plants. If the broad-leaved evergreen plants were exterminated from the region because of earlier climatic cooling, perhaps within the previous 1 m.y., then such plants could have been locally "unavailable" even if the climate might have attained warmer conditions.

The paleoelevation of the Bridge Creek flora can be estimated using paleotemperatures and lapse rates, although the results are speculative because of the complexity of the variables that need to be considered (Meyer, 1992). Using the estimated MAT of 9–11°C for the Bridge Creek flora and Wolfe's (1994) estimate of 13°C for the Willamette flora of western Oregon (a sea level flora considered to be coeval with the Bridge Creek), we infer that the elevation of Bridge Creek assemblages was about 700–1200 m relative to modern sea level, i.e., 500–1000 m above paleo-sea level. The present elevation for the Bridge Creek localities ranges from about 550–800 m in the John Day basin, and about 1100–1200 m in the Crooked River basin.

Fossil floras of similar age from the western Cascades of Oregon, such as the Lyons (Meyer, 1973) and Rujada (Lakhanpal, 1958) floras, contain more conifers and broad-leaved evergreen taxa than the Bridge Creek flora. Wolfe (1981b) considered these more coastal floras to represent Broad-leaved Evergreen and Coniferous forest, suggesting that the climate nearer the coast (at that time in the area of the present Willamette Valley) may have had a slightly warmer MAT and a slightly lower MART than the inland area occupied by the Bridge Creek flora. This may be due to differences in elevation and to the effect of maritime conditions in moderating temperatures nearer the coast. Compared with the present climate of western Oregon, the Lyons and Rujada floras indicate that MAT has apparently not changed significantly, whereas MART has decreased about 5–10°C. (summers have become cooler and winters warmer). The present climate of Oregon also differs in having reduced summer precipitation. Aridity is particularly pronounced today in central and eastern Oregon because of rain-shadow effects resulting from the late Cenozoic development of the high Cascades.

ORIGIN OF THE FLORA

The Bridge Creek flora is dominated by "Arcto-Tertiary" taxa, i.e. temperate deciduous genera that became widely distributed across the Northern Hemisphere by the Miocene and which are important elements of modern Mixed Mesophytic forest (see Wolfe, 1977; Mai, 1991, for historical reviews of the term *Arcto-Tertiary*). Examples include *Torreya, Cercidiphyllum, Liquidambar, Platanus, Ulmus, Fagus, Alnus, Betula, Ostrya, Carya, Juglans, Pterocarya, Craigia, Tilia, Hydrangea, Rosa, Rubus, Cladrastis, Decodon, Acer, Cornus, Hovenia, Fraxinus,* and *Catalpa.*

Although only 46% of the extant genera of the Bridge Creek flora are still native to western North America, many are found today in refugia of eastern Asia (86%) and eastern North America (66%) (Table 6). The Bridge Creek flora provides one of the earliest records of forest that closely approached the generic composition of the modern Mixed Mesophytic forest. It includes, for example, the oldest reliable records of *Fagus, Pterocarya,* and *Ostrya.* This evidently was a time of radiation of many microthermal taxa (Wolfe, 1987). Some products of this radiation, such as *Asterocarpinus* and *Tilia circularis,* apparently never spread to Europe or Asia and succumbed to extinction. The majority of genera found in the Bridge Creek flora were widespread in the Northern Hemisphere by the early Miocene.

The areas of origin of particular taxa and the directions of intercontinental dispersal remain speculative in most instances. Examples of taxa that were shared between Europe and North America, but apparently not Asia, include *Cedrelospermum, Cruciptera, Tetraclinis,* and *Tilia* type B bracts (*sensu* Manchester, 1994a). These and other taxa may have traversed the North Atlantic land bridge during the Eocene (Tiffney, 1985).

A comparison of the Bridge Creek flora with older floras in the region (e.g., Goshen, Clarno, Comstock, and Scio) raises questions concerning the mechanism of floral change through which hardwood deciduous forests replaced subtropical vegetation during the Eocene-Oligocene transition. The Arcto-Tertiary geoflora concept, a theory that developed as early as the 1800s and was later expounded on by Chaney (1938, 1940, 1947, 1948a), sought to explain this change and became widely accepted as fact. Wolfe (1977) presented a detailed historical review of this concept but also provided new evidence discrediting the theory. The Arcto-Tertiary concept basically maintained that a temperate, broad-leaved deciduous forest having a definite floristic composition evolved in high northern latitudes during the Cretaceous and early Tertiary and "migrated" southward to middle latitudes during the Oligocene in response to gradual climatic cooling. Although Chaney

Table 6
Geographic Distribution of Extant Bridge Creek Genera

Genus	Eastern Asia	Eastern North America	Western North America	Europe	Other Regions[1]
Torreya	x	x	x		
Calocedrus	x		x		
Cunninghamia	x				
Metasequoia	x				
Sequoia			x		
Tetraclinis				x	4
Abies	x	x	x	x	1, 2, 4
Keteleeria	x				
Pinus	x	x	x	x	1, 2, 3, 4
Mahonia	x		x		1
cf. *Menispermum*	x	x			
Cercidiphyllum	x				
Fothergilla		x			
Liquidambar	x	x			1, 2
Parrotia					2
Platanus	x	x	x	x	1, 2
Ulmus	x	x		x	1, 2, 3, 4, 5
Fagus	x	x		x	2
Quercus	x	x	x	x	1, 2, 3, 4, 5
Alnus	x	x	x	x	1, 2, 4, 5
Betula	x	x	x	x	2, 6
Ostrya	x	x	x	x	1, 2
Comptonia		x			
Carya	x	x			1
Juglans	x	x	x	x	1, 2, 5
Pterocarya	x				2
Craigia	x				
Tilia	x	x		x	

(*continued*)

Table 6 (*continued*)

Genus	Eastern Asia	Eastern North America	Western North America	Europe	Other Regions[1]
Ribes	x	x	x	x	1, 2, 4, 5
Hydrangea	x	x			1, 5
Amelanchier	x	x	x	x	1, 2, 4
Crataegus	x	x	x	x	2, 4
Rosa	x	x	x	x	2, 4
Rubus	x	x	x	x	1, 2, 7
Cercis	x	x	x	x	1, 2
Cladrastis	x	x			
Decodon		x			
Terminalia	x				3, other tropical
Rhus	x	x	x	x	1, 2, 3, 4, 5
Cedrela	x				1, 5
Acer	x	x	x	x	1, 2, 3, 4
Aesculus	x	x	x	x	
Cornus	x	x	x	x	
Aucuba	x				
Paliurus	x			x	2
Hovenia	x				
Vitis	x	x	x	x	1, 2, 4
Fraxinus	x	x	x	x	1, 2, 4
Catalpa	x	x			
Pinckneya		x			
Total	43	34	24	25	29
Endemics	7	4	1	0	1

[1] Other regions: 1 = Central America and Mexico; 2 = Western Asia including Asia Minor; 3 = Malesia; 4 = Northern Africa; 5 = South America; 6 = Greenland; 7 = Australia.

Sources: Airy Shaw (1973), Krüssman (1978, 1983), Hora (1980), and Mabberley (1987).

(1948a) noted that some species failed to survive while others were added during this so-called migration, he believed that the Arcto-Tertiary geoflora underwent little floristic change and maintained a generally stable community structure over a wide interval of time and space.

Mason (1947) was the first to challenge the theoretical basis for the Arcto-Tertiary geoflora by pointing out that such stability and unity of plant communities through time and space were not possible in view of the dynamic interaction among population genetics, physiologic tolerances of individual species, and fluctuations of the environment. During an event of climatic or environmental change, each individual plant species has its own unique genetic capability of coping with such a change, and all species within a plant community do not have the same response. To assume that the floristic composition of a plant association would remain fundamentally unchanged over a long interval of time is inconsistent with evolutionary theory.

From studies of Alaskan Tertiary floras, Wolfe (1972, 1977) disputed the fossil and stratigraphic evidence for the Arcto-Tertiary concept by showing that the high-latitude Eocene floras of Alaska were subtropical to paratropical, similar to middle-latitude floras of the same age from the Pacific Northwest, and that they lacked the floristic and vegetational character assumed by Chaney. The interpretation of Alaskan floras has been further complicated by the recognition that Eocene floras of southern Alaska are situated on allochthonous accreted terranes. The paleopositions and timing of accretion of some terranes has been disputed, with some evidence suggesting northward displacement of as much as 20° latitude since the middle Eocene (Bruns, 1983; Keller et al., 1984), while other interpretations have inferred middle Eocene positions near present locations (Plafker, 1984; Wolfe and McCoy, 1984). There are few high-latitude Eocene floras situated on cratonic North America for comparison. Preliminary work has been done by Basinger et al. (1988) and LePage and Basinger (1991) on an assemblage that they consider to be of middle to possibly late Eocene age from arctic Canada near present 80° N latitude. This assemblage includes such taxa in common with Bridge Creek as *Metasequoia*, *Pinus*, *Platanus*, *Betula*, and *Carya*, and also contains *Larix*, *Glyptostrobus*, *Picea*, *Pseudolarix*, *Tsuga*?, and *Chamaecyparis*?, as well as other temperate hardwood taxa. On the basis of an overview of Tertiary floras in Greenland and Europe, Mai (1991) considers that the general concept of the Arcto-Tertiary flora remains valid. We concur with Wolfe (1987) that Mixed Mesophytic vegetation was derived from multiple sources.

The Mixed Mesophytic forest of the early Oligocene in western North America developed from the congregation of various lineages having origins in older floras of dissimilar character. Using our concepts and those of Mason (1947) and Wolfe (1972, 1977), we envision plant species as having had at least five possible responses to the climatic cooling of the Eocene-Oligocene transition: (1) local or global extinction, (2) survival through preadaptation, (3) survival through rapid physiological evolution, (4) dispersal from upland regions, and (5) dispersal of particular species (not whole communities) from higher latitudes.

Many species that inhabited the Eocene near-tropical forests of the Pacific Northwest became extinct during the rapid climatic change of the Eocene-Oligocene transition. Some species, however, may have had physiologic tolerances that would have allowed them to live under cooler, less equable climatic conditions, or such tolerances may have evolved rapidly to accommodate climatic change. For example, genera such as *Litseaphyllum, Platanus, Juglans, Palaeocarya, Craigia, Plafkeria*, and *Palaeophytocrene* are known from the older, warmer floras from this region, but they apparently survived the climatic change to become members of the plant community represented by the Bridge Creek flora.

Other taxa in the Bridge Creek flora are closely related to those from older upland floras (Wolfe, 1972), where temperatures were cooler than in the lowlands. Some lineages may have dispersed from these upland areas into lowland areas during the climatic transition. Bridge Creek taxa such as *Abies, Acer, Crataegus, Mahonia*, and *Asterocarpinus* also occur in slightly older upland floras from the Rocky Mountain region, such as the Florissant (MacGinitie, 1953), Ruby (Becker, 1961), and Red Rock Ranch (Meyer, 1986) floras, suggesting probable upland sources for these taxa. Some taxa, such as *Cedrelospermum, Florissantia, Hydrangea*, and *Rhus*, occur in both the temperate upland and near-tropical lowland floras of the late Eocene; their occurrence in the Bridge Creek flora may have resulted from either source.

SYSTEMATIC DESCRIPTIONS

Specific epithets have been selected following examination of type material from the Bridge Creek and other fossil floras and in accordance with the rules of priority in the International Code of Botanical Nomenclature (Greuter, 1988), based on examination of type material from the Bridge Creek and other fossil floras. The synonymies that we provide for each taxon indicate the source of previously proposed combinations that we are accepting, the source of the basionym (including the name of the flora on which it is based if not Bridge Creek), and formerly published names for Bridge Creek specimens that we consider to be synonymous. The term *auct. non* preceding an author's name indicates that the taxonomic name established by that author is not being placed in synonymy; only the specimens attributed to that taxon by the indicated subsequent author(s) are placed in synonymy. Because the scope of our investigation was limited primarily to the Bridge Creek flora, conspecific material from other fossil floras is not included in the synonymies. Material indicated as "additional specimens" (~"hypotypes") includes only those specimens that have been added in this work; specimen numbers from previous publications are not listed.

All original type and illustrated specimens have been examined firsthand, with the exception of some that are missing, as noted in the Appendix. In cases where the original type material is fragmentary or poorly preserved, we have retained the original species name as long as sufficient diagnostic characteristics are present to demarcate the taxon and distinguish it from others in the flora. In instances where an original author described and illustrated specimens of a new species without formally designating a holotype, one specimen has been selected to serve as the lectotype.

Each of the newly described species has a single specimen designated as the holotype on which the species is based. Additional specimens supplementing the basis for the description are designated as paratypes. All newly designated holotypes are illustrated, but spatial limitations in the plates have prevented the illustration of some paratypes. Specimens are available for inspection at the institutions indicated. Some of the original lectotypes and holotypes that were formerly illustrated with line drawings are now re-illustrated with photographs. The photographs have not been retouched.

In addition to describing newly recognized species, we give supplementary descriptions of some formerly described species to characterize them more completely than was done in the original descriptions. Emended descriptions are used to extend the species concept on the basis of additional material that preserves new characters or organs. Previously designated type specimens that lack diagnostic characteristics for valid determination are indicated as indeterminate in the Appendix and are recommended for rejection.

Species are based solely on morphological characteristics and often on only one kind of organ. Where similarities between a fossil and living species are such that they appear indistinguishable, a fossil species name has nevertheless been used because the full suite of characters and organs available for examination in extant material are not obtainable in the fossils for comparison, thus making it impossible to determine with certainty whether the species are the same. When a fossil is indistinguishable from two or more modern genera on the basis of the preserved features, the uncertainty of the paleobotanical determination is indicated by (1) placing quotes around the generic name that has customarily been used in earlier investigations, (2) prefacing the name with cf., or (3) assigning the fossil to a noncommittal organ genus. If the fossil taxon has characteristics distinguishing it from similar extant genera, a new genus is described for the fossil material.

Although the Bridge Creek flora is dominated by leaf fossils, the presence of occasional flowers, fruits, and seeds provides the opportunity to examine multiple organs that may have been produced by the same species. However, in no case have we found leaves and fruits or seeds in physical attachment, and we therefore cannot prove whether different organs of the same family or genus represent the same species. Where there is evidence that only one species of the genus is present (e.g., *Metasequoia, Pinus, Fagus, Ostrya,* and *Cercidiphyllum*), we have provisionally assigned leaves, cones, and seeds to the same species, following the precedent of earlier work on these taxa. In the case of *Acer*, which is represented by multiple species of both leaves and fruits throughout the Bridge Creek flora, the assignment of leaves and fruits to the same species is more speculative. With the exception of *A. osmontii* (which has fruits and leaves of the distinctive section *Macrophylla*), we have considered the fruit and leaf species separately. In other instances (e.g., *Asterocarpinus / Paracarpinus* and *Tetraclinis/Fokieniopsis*), separate formal names are applied to different organs, and we informally indicate our hypotheses of which ones may have been conspecific.

Six of the named fossil genera are of unknown familial affinity. In addition, 37 morphologically distinct taxa remain unidentified and have been given informal number or letter designations (e.g., unknown dicot leaf spp. 1–31 and unknown fruit spp. A–F). These are briefly described and illustrated to call attention to their presence in the Bridge Creek flora. Such specimens are useful for fully documenting the diversity in the flora and for applying their characteristics in physiognomic analyses. It is hoped that the illustration of such specimens will allow other workers to assess their affinities.

Descriptions of leaf architecture follow the terminology of Hickey (1973). Identifications of the leaves are based on detailed comparisons with extant species in the large cleared leaf collection of the U.S. Geological Survey and at the herbaria of the U.S. National Museum, the University of Florida, and the University of California at Berkeley.

Specimens were photographed with low-angle lighting using a 35-mm camera and Kodak Technical Pan 2415 film at ASA 50 and developed and printed for high contrast. All figured illustrations are natural size (×1) unless otherwise noted; all scales are accurate within ±5%.

SPHENOPSIDS

Family EQUISETACEAE

Equisetum sp.
(stem)
(Plate 1, fig. 1)

DISCUSSION: Two specimens of externally ridged, jointed stems are characteristic of *Equisetum*. One specimen with 3.5 cm of the apical portion of a stem is 0.7–1.0 cm wide and shows about eight leaf nodes and ridges in the preserved half of the stem; the other specimen is 0.4–0.5 cm wide with 6.0 cm of the stem preserved.

The rarity of this semiaquatic plant in the Bridge Creek flora and other lacustrine floras may result from a lack of deposition of fine-grained clastics in its shallow-water habitat and from the difficulty with which the plants are disaggregated for transport to deeper depositional sites. *Equisetum*, the single living genus of horsetails, has about 30 extant species distributed chiefly along swamps, lakes, and streams. It is widespread in the fossil record and is nearly cosmopolitan in its extant distribution.

SPECIMENS: UCMP 12626, 12627.

OCCURRENCE: Painted Hills, Iron Mountain (P-4210).

FERNS

Family PTERIDACEAE

"Pteris" silvicola Hall
(leaf)
(Plate 1, figs. 2–4)

Pteris silvicola C. C. Hall *in* Chaney, 1927, pl. 8, figs. 2, 4–7.

DISCUSSION: Specimens from the Crooked River area were described by Chaney (1927) as a new species of *Pteris*. Although the dichotomous venation and lack of a midvein in the pinnule are characteristic of ferns in the family Pteridaceae, the lack of generically diagnostic characters precludes a reliable generic determination. One specimen (UF 10505, pl. 1, fig. 4) is a fragmentary portion of a fertile frond showing globular sori that apparently lack indusia; veins of the pinnule terminate in the sori near the margin.

ADDITIONAL SPECIMENS: UF 10447–10449, 10505–10508.

OCCURRENCE: Fossil, Crooked River.

also applied to Pinus johndayensis
see p. 67 for notes
dmj

Family cf. THELYPTERIDACEAE / DRYOPTERIDACEAE

Gen. et sp. indeterminate
(leaf)
(Plate 1, fig. 5)

DISCUSSION: A single specimen of an infertile frond shows similarities to the families Thelypteridaceae and Dryopteridaceae. It is distinguished from the specimens assigned to the Pteridaceae in having a more rounded and symmetric pinnule with a distinct central midvein and pinnate secondaries.
SPECIMENS: UF 10187.
OCCURRENCE: Crooked River.

Family POLYPODIACEAE

cf. *Polypodium* C. C. Hall
(leaf)
(Plate 1, fig. 6)

"Fern pinnule similar to that of *Polypodium*," *in* Manchester and Meyer, 1987, Oreg. Geol. 49, p. 116, fig. 2A.

DISCUSSION: A single specimen of a fertile entire-margined pinnule has two rows of circular sori and a strong central midvein. Sporangia and spores are not preserved, but the arrangement of the sori is similar to those in some living species of *Polypodium*. More complete material showing the attachment and arrangement of pinnules is necessary for more accurate determination.
SPECIMENS: UCMP 9310.
OCCURRENCE: Fossil.

CONIFERS

Family TAXACEAE

Torreya masonii n. sp.
(leaf)
(Plate 1, figs. 7–9, 13)

Torreya sp., Mason, 1927, Carnegie Inst. Wash. Pub. 346, p. 146, pl. 1, figs. 5, 6.

DIAGNOSIS: Leaves linear to lanceolate, broadest just above the base and often tapering very gradually apically, falcate, longitudinal axis slightly curved; apex sharply acute to attenuate; base asymmetrically rounded, twisted, with attached stout stalk; coriaceous; margin slightly revolute and thickened; length usually 2.4–3.2 cm (one specimen 6.6 cm); width 3–4 mm; midrib very indistinct; two narrow indented stomatal bands typically situated closer to the midrib than the margin, 0.2–0.3 mm wide.

DISCUSSION: *Torreya* is represented by several specimens of isolated leaves from six of the Bridge Creek assemblages. Although the characteristic cuticle is not preserved in these specimens to permit anatomical comparisons, the morphological features preserved support placement in *Torreya*. Characters consistent with *Torreya* include the linear to lanceolate shape, coriaceous texture, sharply attenuated apex, presence of a twisted base, absence of a distinct midvein, and the position of the pair of narrow, indented stomatal bands closer to the leaf midline than the margin. The fossil material is distinct from *Amentotaxus*, which has leaves that are much wider with wide stomatal bands and a distinct midvein. The leaves are distinguished from those of *Taxus* by the sharp, attenuate-pointed needles with narrow stomatal bands, the coriaceous texture, and the tendency for needles to be longer and wider than is typical for *Taxus*.

MacGinitie (1953) synonymized Mason's (1927) *Torreya* sp. with *Torreya geometrora* (Cockerell) MacGinitie from the Florissant flora. However, the Bridge Creek material is distinct in having longer needles that are linear (with parallel margins) to slightly lanceolate rather than strongly lanceolate (tapering markedly between the base and apex) as in *T. geometrora*. The Taxaceae are also present in the middle Eocene Clarno Nut Beds, represented by seeds of *Taxus*, *Torreya*, and an extinct genus similar to *Torreya* (Manchester, 1994b).

The five to seven extant species of *Torreya* are uncommon evergreen trees native to areas of China, Japan, and western and southeastern North America. Three of the Asian species are associates of the Mixed Mesophytic forest with one also present in broad-leaved evergreen forests (Wang, 1961). The Japanese and American species occur in mixed broad-leaved forests having both deciduous and evergreen components.

ETYMOLOGY: This species is named after Herbert L. Mason in recognition of his work on fossil conifers of the western United States.

HOLOTYPE: UF 10351.

PARATYPES: UCMP 125 (Mason, 1927), 12631; UF 10335, 10337, 10340, 10377, 10469, 10580–10583.

OCCURRENCE: Fossil, Cove Creek (Knox Ranch, Pentecost Ranch), Iron Mountain, Lost Creek, Butler Basin.

Family CUPRESSACEAE

The Cupressaceae as used here includes the former Taxodiaceae, as adopted by Eckenwalder (1976) and Hart and Price (1990).

Calocedrus schornii n. sp.
(leaf, ovulate cone)
(Plate 1, figs. 10–12)

DIAGNOSIS: Ovulate cone closed; ovate with laterally extending basal bract-scale elements; apparently imbricate; length 1.8 cm, width 0.6 cm (widest part not including basal bracts); two large fertile bract-scale elements with 10–12 longitudinal striations visible in facial view, shape ovate, area in which bract is free from cone scale apparent in uppermost 1–2 mm of the apex; two basal-external sterile bract-scale elements recurved, extending 4–5 mm from the cone margin in the basal one-third of the cone; apical portions of one facial and two lateral bract-scale elements of the fused central columella extending 1 mm from the apex; 1–2 mm of basal stalk preserved. Branchlet flattened dorsiventrally to form dimorphic lateral and facial leaves; leaves scale-like, appressed, appearing four-ranked; laterally adjacent lateral leaves not touching, facial leaves clearly visible between laterals, sub- and superadjacent leaves overlapping slightly; leaves 4–5 mm length; branchlet width (between outer margins of lateral leaves) 3–4 mm; leaf apices acute to acuminate.

DISCUSSION: *Calocedrus schornii* is known from both halves of one closed cone and portions of two well-preserved branchlets. The cone (pl. 1, fig. 10) is characteristic of *Calocedrus* in having two small basal-external bract-scale elements, two large fertile bract-scale elements (which make up most of the cone specimen, presumably with each counterpart preserving adjacent elements), and protruding apices of the bract-scale elements of the central fused columella. The foliage (pl. 1, figs. 11, 12) is typical of *Calocedrus* in having adjacent lateral leaves that do not touch, apices of lateral and facial leaves in close alignment along the branchlet, acuminate leaf apices, and leaf length greater than branchlet width.

The Bridge Creek species, known only from the Butler Basin locality, represents the earliest known North American record of *Calocedrus*. *Calocedrus* is also known from Miocene localities in western North America, including Clarkia (Smiley and Rember, 1985), Trapper Creek (Axelrod, 1964), Mascall (Mason, 1927; Chaney and Axelrod, 1959), and Pyramid (Axelrod, 1992). The Mascall material was first recognized as the extant *Libocedrus* (= *Calocedrus*) *decurrens* by Mason (1927) and was later transferred to a new fossil species *Libocedrus* (= *Calocedrus*) *masoni* by Chaney and Axelrod (1959). The genus *Libocedrus* is currently circumscribed to include only Southern Hemisphere members of the genus while the Northern Hemisphere species are now assigned to *Calocedrus*. *C.schornii* differs from the Mascall material in having a shorter leaf length relative to branchlet width; the Mascall cone compressions are open rather than closed, making detailed morphological comparison difficult.

The three extant species of *Calocedrus* are trees native to western North America, southeast Asia, and Taiwan. The Asian species are associates of mesothermal notophyllous broad-leaved evergreen forests (Wang, 1961), while the American species is more cool-adapted (microthermal to cool mesothermal) as a member of mixed coniferous to mixed evergreen plant associations (Burns and Honkala, 1990; H. E. Schorn, unpubl. data, 1993).

ETYMOLOGY: This species is named for Howard E. Schorn, who first recognized these specimens as Calocedrus, in appreciation for his contributions to our understanding of fossil conifers.

HOLOTYPE: UCMP 12628 (cone).

PARATYPES: UCMP 12629, 12630 (foliage).

OCCURRENCE: Butler Basin.

Cunninghamia chaneyi Lakhanpal
(leaf, cone scale)
(Plate 2, figs. 1, 2)

Cunninghamia chaneyi Lakhanpal, 1958, Univ. Calif. Pub. Geol. Sci. 35, p. 22, pl. 1, fig. 7; pl. 2, figs. 1–3 (Rujada flora).

SUPPLEMENTARY DESCRIPTION: Cone scale with abfacial surface preserved; shape deltoid with a basal stalk; margins of stalked base strongly concave; apex markedly attenuate; length 2.0 cm; width 1.3 cm; margin finely serrated; raised transverse ridge divides basal area that develops in contact with the subadjacent cone scale from apical area which is freely exposed; longitudinal ridges distinct throughout but especially pronounced in the thickened basal area.

DISCUSSION: *Cunninghamia* is represented by part of a foliar branch and one specimen representing the first known isolated cone scale for this species. The foliage (pl. 2, fig. 1) is typical of *Cunninghamia* in showing the bulbous-shaped adnate basal parts of leaves that remain attached to the stem, spiral arrangement, distinct transverse striations representing fibers in the spongy mesophyll of the needles, and longitudinal striations that are more pronounced than transverse ones (one apparently forming an indistinct midrib). Serrulations are not clearly visible. The broadly convex margins of the elongate-lanceolate needles distinguishes them from *Torreya masonii* in which the margins of needles are more nearly parallel. The cone scale (pl. 2, fig. 2) shows the finely serrated margin, a raised transverse ridge differentiating the apical and thickened basal areas, longitudinal ridges, and the shape typical of extant *Cunninghamia* cone scales.

Cunninghamia chaneyi was described from the Rujada flora (Lakhanpal, 1958) and also occurs in the Lyons flora of the Oregon western Cascades (Meyer, 1973) and in the Gumboot Mountain and Peterson Ridge floras of the southern Washington Cascades. Although the species is virtually identical to extant *Cunninghamia* in observable characters, the internal anatomy remains unknown for these impression specimens. Permineralized cones, stems, and leaves of *Cunninghamiostrobus goedertii* Miller and Crabtree from the lower Oligocene (or upper Eocene?) Jansen Creek Member of the Makah Formation of the Twin Rivers Group, northwestern Washington, have many features in common with *Cunninghamia* (Miller and Crabtree, 1989; Miller, 1990). Based on detailed analyses of *C. goedertii*, Miller and Crabtree (1989) concluded that their specimens are similar to *Cunninghamia* but differ from the extant genus in characters of leaf epidermal structure and vascular supply to the bract-scale complex in the cones. Thus, although the impression material from Bridge Creek cannot be distinguished from the extant genus, it may correspond to a closely related extinct genus. *Cunninghamia* has also been reported on the basis of cone material from the Eocene of Japan (Matsuo, 1967), and similar taxa occur in beds as old as middle Jurassic (Miller and Crabtree, 1989). Cunninghamioid remains persisted into the Miocene in the Pacific Northwest (Wolfe *in* Peck et al., 1964; Smiley and Rember, 1985).

The two or three extant species of *Cunninghamia* are evergreen trees native to Mixed Mesophytic and broad-leaved evergreen forests of China and Taiwan. The modern species are hardy only in the warmer parts of temperate regions.

SPECIMENS: UCMP 12632, 12633.

OCCURRENCE: Painted Hills.

Metasequoia sp.
(foliage, ovulate cone, seed, pollen cone)
(Plate 2, figs. 3–7, 10, 12)

Metasequoia occidentalis (Newberry) Chaney, 1951, pro parte, Trans. Amer. Philos. Soc., new ser. 40, p. 225–229, pl. 2, fig. 2; pl. 4, figs. 1, 2, 9; pl. 5, figs. 1, 2; pl. 7, figs. 3, 6; pl. 12, figs. 1, 2. Brown, 1959, J. Paleont. 33, pl. 24, figs. 10, 11. Manchester and Meyer, 1987, Oreg. Geol. 49, p. 116, fig. 2B–D.

Sequoia langsdorfii auct. non (Brongniart) Heer. Lesquereux, 1883, Rept., U.S. Geol. Surv. Terr. 8, p. 240, pl. 50, figs. 2–4. Knowlton, 1902, U.S. Geol. Surv. Bull. 204, p. 25. Chaney, 1927, Carnegie Inst. Wash. Pub. 346, p. 102. Mason, 1927, Carnegie Inst. Wash. Pub. 346, p. 153, pl. 5, figs. 4, 8.

Sequoia heerii auct. non Lesquereux. Newberry, 1898, U.S. Geol. Surv. Monogr. 35, p. 20, pl. 47, fig. 7. Knowlton, 1902, U.S. Geol. Surv. Bull. 204, p. 23–24.

Taxus sp. Mason, 1927, Carnegie Inst. Wash. Pub. 346, p. 146, pl. 1, fig. 4. Chaney, 1927, Carnegie Inst. Wash. Pub. 346, p. 102.

Abies sp. 2. Mason, 1927, Carnegie Inst. Wash. Pub. 346, p. 151, pl. 4, fig. 3.

DISCUSSION: *Metasequoia* is abundant and ubiquitous in the Bridge Creek flora. It is known from foliage, ovulate cones, pollen cones, and dispersed seeds.

Metasequoia was first described as a genus by Miki (1941) based on Plio-Pleistocene fossils from Japan; later, living trees of *Metasequoia* were discovered in a very restricted range in the Szechuan and Hupeh provinces of China (Hu and Cheng, 1948). The early misidentification of Bridge Creek specimens as *Sequoia* led to erroneous ecological and phytosociological interpretations based on comparisons between the Bridge Creek flora and the modern coast redwood forests of California (Chaney, 1925a, 1927).

Most of the North American fossils that had been identified as *Sequoia* and *Taxodium* were reevaluated by Chaney (1951) following his visit to China where he examined the newly discovered living *Metasequoia* trees. Many of the Paleocene to Miocene fossil species from western North America were reassigned to *Metasequoia occidentalis* (Newberry) Chaney using the epithet from *Taxodium occidentale* Newberry which was based on Paleocene material from Washington. Chaney included most of the North American Tertiary *Metasequoia* in this single species which he considered to have wide variability. However, the material illustrated by Chaney (1951, pl. 10, fig. 2a) from the type locality has needles that are shorter, wider, and more rounded apically than the typical specimens from the Bridge Creek flora. Many of the middle to late Tertiary specimens from North America are very similar to the extant *Metasequoia glyptostroboides* (Chaney, 1951; Wolfe and Tanai, 1980), but the lack of preserved epidermal characters and cone anatomy leaves doubt as to whether the fossils are actually indistinguishable from this living species. The epithet from *Sequoia heeri*, based on material from Montana, might also be applied to the Bridge Creek species, although we hesitate to do so because we have not seen the original type specimens. Hence, we are reluctant to use any of these epithets for the Bridge Creek specimens and have placed them in "*Metasequoia* sp." A broader study of the genus in the Tertiary of North America is required to resolve this nomenclatural problem.

Ovulate cones of *Metasequoia* show size differences between certain localities (compare pl. 3, figs. 5, 6). Cones measured from the assemblage at Fossil (2.4–3.5 cm, based on 18 specimens) are consistently about twice the length of cones from Painted Hills (1.2–1.7 cm, based on 14 specimens), while those from Iron Mountain and Cove Creek are intermediate in size. This may reflect population differences in *Metasequoia*, but we prefer not to distinguish separate species within the flora based on this character alone. Structures composed of aligned needle fragments are interpreted as caddisfly larval cases (pl. 2, fig. 11) and are common at some localities.

Metasequoia was abundant in the middle Eocene of British Columbia, where it is known from silicifications (Basinger, 1981) and compression specimens, but is not known in the Eocene of the John Day basin. The arrival and establishment of the genus in the John Day basin apparently occurred during the late Eocene or early Oligocene. The genus is not common in the European Tertiary, but has a good record in the Neogene of eastern Asia. The single extant species, *M. glyptostroboides*, is a tall, fast-growing deciduous tree. It is endemic to China and occurs within the Mixed Mesophytic forest (Wang, 1961).

NOMENCLATURE: In addition to specimens cited in Chaney's synonymy, he further designated numerous cotypes and paratypes to substantiate the concept of his new combination, *M. occidentalis*. Such type designation violates the rules of the International Code of Botanical Nomenclature, and these specimens should be considered as supplementary to the original species concept based on Newberry's material.

ADDITIONAL SPECIMENS: UCMP 12634; UF 6990, 10387 (foliage). UCMP 12635, 12637; UF 10333, 10353 (ovulate cones). UF 10822 (seed). UCMP 12636; UF 10428 (pollen cones). UF 10479 (needles comprising caddisfly larval case). space

OCCURRENCE: Painted Hills, Fossil, Cove Creek (Knox Ranch), Iron Mountain, Crooked River, Lost Creek, Twickenham.

Sequoia affinis Lesquereux
(foliage)
(Plate 2, figs. 8, 9)

Sequoia affinis Lesquereux 1876, U.S. Geol. Geogr. Surv. Terr. Bull. 5, ser. 2, p. 384 (Florissant).

DESCRIPTION: Branchlets with dimorphic foliage; needles sharp pointed at the apex, thick, apparently with two stomatal bands; some branchlets with outspread, alternately arranged (distichous) needles, 5–18 (typically 8–12) mm long, tapering slightly toward the base; other branchlets with appressed, somewhat scale-like, often falcate, spirally arranged needles, 4–7 mm long; terminal clustered bud scales spheroidal, 2–3 mm diameter.

DISCUSSION: In the Bridge Creek flora, *Sequoia* is known from foliage that has been found only in the Lost Creek assemblage. *Sequoia affinis* is a species established on the basis of material from Florissant. The above description is based only on the Bridge Creek material, which has leaves that are slightly smaller than those from Florissant and does not include any cones. Chaney (1951) pointed out that this fossil species, as known from foliage and cones, is virtually indistinguishable from the living *Sequoia sempervirens*. However, MacGinitie (1953) noted that *S. affinis* has a larger proportion of branchlets with appressed needles. The alternate arrangement of the needles distinguishes *Sequoia* from *Metasequoia*, and the presence of foliage with outspread needles distinguishes it from *Sequoiadendron*.

Sequoia affinis is known from various Oligocene floras in the region, including more coastal floras such as the Willamette and Rujada floras (Lakhanpal, 1958), the Lyons flora (Meyer, 1973), and others of western Oregon (Wolfe and Brown *in* Peck et al., 1964), as well as from the Peterson Ridge and Gumboot Mountain floras of the southern Washington Cascades. *Sequoia* is also present in some middle Eocene assemblages of the Clarno Formation in north-central Oregon.

The single extant species of *Sequoia* is a very tall, long-lived tree endemic to the humid, warm temperate west coast from central and northern California to southern Oregon. It often grows in nearly pure stands, forming a distinct vegetation type, but it also occurs marginally in broad-leaved evergreen and mixed coniferous forests. The vegetation of the Bridge Creek flora indicates lower cold month mean temperatures than those occurring in the modern range of *Sequoia*.

SPECIMENS: UF 10336, 10339, 10349, 10561–10563.

OCCURRENCE: Lost Creek.

Tetraclinis potlachensis (Brown) n. comb.
(ovulate cone, seed)
(Plate 3, figs. 1–9)

~~all specimens missing~~

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Callitris potlatchensis Brown, 1935, J. Paleont. 9, p. 575, pl. 67, fig. 16 (Latah flora). Brown, 1940, J. Wash. Acad. Sci. 30, p. 347, fig. 6.

SUPPLEMENTARY DESCRIPTION: Seed two-winged, shape broadly ovate, symmetrical, base cordate to sometimes nearly straight, apex obtuse to rounded, overall width 7–12 mm, length 4–7.5 mm; wings much wider than seed body, thin, lateral margins rounded; seed body ovate, apex acute, base rounded, length along long axis 3–7 mm, width 2–3.5 mm, longitudinal striae radiating from basal attachment scar and converging toward bi-lobed micropylar tip and demarcating elliptical-shaped resin vesicles. Cone wide-ovate, apparently valvate; cone scales four, opposing pairs dimorphic, one pair about 1.3 times wider than the other, thick and woody, widely ovate, length 7–8 mm, width 9–12 mm, base cordate, apex rounded; abaxial surface of cone scale with fused bract extending about one-third of the length of the cone scale and free at extreme tip, bract with smooth surface and scale with wrinkled surface, bract hemispherical in outline; adaxial surface of scale with fine striations radiating from the base.

DISCUSSION: Co-occurring isolated seeds and cones conform closely to those of extant *Tetraclinis.* Brown (1940) placed a single seed from the Bridge Creek flora in *Callitris potlachensis* Brown (1935), a name based on material from the Miocene of Idaho. Brown (1935) compared the fossil species with extant *Callitris quadrivalvis* Ventenant, a species now placed in synonymy with *Tetraclinis articulata* (Vahl.) Masters. The foregoing description is based on a larger suite of seeds and newly recovered cones that occur together at both UF localities of the Lost Creek assemblage.

The seeds compare favorably with those of *Tetraclinis* in having a cordate base, bisymmetry, large wings, and resin vesicles on the seed body. Although not found *in situ* within the cones, the cordate-based seeds coincide in size and configuration with the area for seed attachment within the fossil cones, supporting our conclusion that they represent a single species. The associated cones, having only four valvate dimorphic cone scales, provide additional support for the assignment to *Tetraclinis*. The fossil cones can be distinguished from those of the single extant species (*Tetraclinis articulata*) by the length of the bract, which in the fossil specimens extends for about one-third of the length of the cone scale, whereas the bract in extant *Tetraclinis* cones extends up to two-thirds of the length. The Bridge Creek seeds and cones are remarkably similar to those of *T. salicornioides* (Unger) Endlicher from the Tertiary of Europe (Kvaček, 1986).

Seeds of *Tetraclinis potlachensis* are also known from the Oligocene Lyons flora of western Oregon and from Miocene floras in Idaho. These occurrences represent the earliest North American record of the genus. The cones, which we have not seen in collections from other Tertiary floras of North America, are known only from the Lost Creek assemblage of the Bridge Creek flora.

The single extant species of *Tetraclinis* is an evergreen tree adapted to warm, dry climates and native to North Africa, Malta, and Spain.

ADDITIONAL SPECIMENS: UF 10162–10165; USNM 42333 (seeds). UF 10151, a,b 10152, 10576; USNM 450636 (cones).

OCCURRENCE: Lost Creek.

Fokieniopsis praedecurrens (Knowlton) n. comb.
(foliage)
(Plate 3, figs. 10–14)

Libocedrus praedecurrens Knowlton 1926, U.S. Geol. Surv. Prof. Paper 140, p. 28, pl. 8, fig. 8 (Latah flora).

DISCUSSION: A distinctive type of cupressaceous foliage with opposite branching occurs at the same two localities as the cones and seeds of *Tetraclinis*. The branchlets are dimorphic with four-ranked leaves. These leaves are flattened dorsi-ventrally to form dimorphic lateral and facial scale-like leaves with rounded apices. The lateral leaves do not overlap between adjacent nodes, and the facial leaves overlap only slightly, if at all. Identical foliage commonly occurs in the Tertiary of Europe and was described as the fossil genera *Hellia* Unger (e.g., Friis, 1977) and *Libocedrites* Endlicher (e.g., Mai and Walther, 1978), which were later placed in synonymy with extant *Tetraclinis* (Kvaček, 1986). On the basis of morphological and cuticular comparisons of *Hellia salicornioides* (=*Tetraclinis salicornioides* [Unger] Kvaček) with extant genera of Cupressaceae, Friis (1977, pp. 111–112) stated that "the fossil species is not identical with any of the examined living species, but there is some agreement in the epidermal structure, as well as in the external and internal structure, of *Tetraclinis articulata*. However, *Tetraclinis articulata* has markedly xeromorphic characters with deeply depressed stomatal bands." Although extant *T. articulata* of the Mediterranean region is xerically adapted, the fossil species was evidently a component of more mesic vegetation. Likewise, the habitat inferred for the *Tetraclinis potlachensis* is more mesic. Cuticle is not preserved in the Bridge Creek specimens.

The same type of foliage is known from other Oligocene localities in the Pacific Northwest, such as the Willamette flora, and from Miocene localities, including Mollala, Eagle Creek, Spokane, and Grand Coulee (Chaney and Axelrod, 1959), and was assigned to *Fokienia praedecurrens* (Knowlton) Chaney and Axelrod (1959). Although similar in construction to branches of the living *Fokienia*, cones and seeds of this genus are lacking at all of these localities.

Fokieniopsis is a fossil genus for foliage superficially similar to that of extant *Fokienia*. McIver and Basinger (1990) established this fossil genus for this type of foliage that is not clearly associated with cones of *Fokienia*. They also described examples of cones and foliage they considered to belong to extant *Fokienia* from the Paleocene of Alberta, Canada. The foliage of *F. praedecurrens*, together with the associated cones and seeds of *T. potlachensis*, are virtually identical in morphology to the corresponding organs of *T. salicornioides* (Unger) Kvaček from the late Eocene to Pliocene of Europe (Kvaček, 1986), but investigations of the North American species have not yet included cuticular analyses. For this reason, we provisionally assign the Bridge Creek foliage to *Fokeniopsis*, although we consider it probably that it corresponds with the associated cones and seeds of *Tetraclinis.*

Although the single extant species of *Tetraclinis* is adapted to warm, dry climates of northern Africa and the Mediterranean region, the wider leaves in the foliage of *F. praedecurrens*, as well as its occurrence with diverse broad-leaved deciduous associates of the Bridge Creek and other middle Tertiary floras of the Pacific Northwest, indicate that the fossil species was adapted to cooler, more mesic conditions.

SPECIMENS: UF 10153–10158, 10161, 10575; USNM 450637.

OCCURRENCE: Lost Creek.

Family PINACEAE

Abies sp.

(ovulate cone scale)

(Plate 4, fig. 1)

Abies, Manchester and Meyer, 1987, Oreg. Geol. 49, p. 116, fig. 2E.

DISCUSSION: A single specimen of a badly decorticated ovulate cone scale is provisionally placed in *Abies*. The specimen is 2 cm wide by 1.3 cm long (scale and stalk) and has a broadly convex distal margin and a broadly decurrent proximal margin. The bract is missing or is not visible.

Fir cone scales are deciduous from the cone axis and are common components in some paleofloras (e.g., Creede and Alvord Creek). The presence of only a single specimen from Fossil suggests that it was a rare component in the local plant association or that it was a member of a plant community more distant from the lacustrine site of deposition. The *Abies* foliage reported by Chaney (1927) and Mason (1927) is actually *Metasequoia*. The 40–50 extant species of *Abies* occur in cool temperate areas of the northern hemisphere.

SPECIMEN: UF 6991.

OCCURRENCE: Fossil.

Keteleeria ptesimosperma n. sp.

(seed)

(Plate 4, fig. 2)

DIAGNOSIS: Winged seed 2.0 cm long (from proximal end of seed body to tip of wing), 0.8 cm wide (at widest portion of wing); admedial edge slightly concave, abmedial edge tapering distally; distal end of wing rounded but joining admedial edge at acute angle; proximal end of wing on abmedial side of seed body developing an auricula; seed body angulate (~triangular), 0.7 cm long, 0.4 cm wide; pterostegium well-developed on adfacial surface of seed body and especially pronounced along proximal end of abmedial edge; wing to seed ratio (along admedial edge) 1.6.

DISCUSSION: The single seed of *Keteleeria* was brought to our attention by H. E. Schorn (pers. comm., 1985). It is distinguished by the well-developed pterostegium (folding of the wing) on the adfacial surface of the seed, a wing that is widest in the proximal half, and a small wing to seed ratio (Wolfe and Schorn, 1990, p. 7).

Keteleeria rujadana Lakhanpal was described from a seed and cone in the Rujada flora (Lakhanpal, 1958) and apparently also occurs in the Willamette flora. Seeds attributed by Lakhanpal to *Pinus knowltoni* (UCMP hypotypes 5156 and 5157) should also be assigned to *K. rujadana* (H. E. Schorn, pers. comm., 1992) and are better preserved than the type material. *Keteleeria ptesimosperma* is distinguished from *K. rujadana* by the smaller size, more triangular seed body, concave admedial edge, better development of the admedial pterostegium, more proximal location of the widest part of the wing, and presence of a distinct auricula. These Oligocene occurrences represent the earliest North American records for *Keteleeria* and indicate diversification within the genus by that time. The earliest reported record of *Keteleeria* is from the Cretaceous of Japan (Miki and Maeda, 1966).

The four to eight extant species of *Keteleeria* are trees native to broad-leaved evergreen forests of China and Taiwan. They are not hardy in temperate climates, and the presence of *K. ptesimosperma* in the predominantly broad-leaved deciduous vegetation of the Bridge Creek flora suggests that the fossil species was adapted to cooler mean annual and mean cold month temperatures than are the modern species.

ETYMOLOGY: The epithet *ptesimosperma* derives from *ptesimos* (Gr = wing) + *sperma* (Gr = seed).

HOLOTYPE: UCMP 12638.

OCCURRENCE: Iron Mountain (P-4210).

Pinus johndayensis n. sp.
(foliage, ovulate cone, seed, pollen cone)
(Plate 4, figs. 3–7; Plate 5, figs. 1–7)

Pinus torreyana auct. non Parry. Mason, 1927, Carnegie Inst. Wash. Pub. 346, p. 147, pl. 1, fig. 3; pl. 2, fig. 3.

Pinus knowltoni auct. non Chaney (1920). Chaney, 1927, Carnegie Inst. Wash. Pub. 346, p. 101. Mason, 1927, pro parte, Carnegie Inst. Wash. Pub. 346, p. 148, pl. 2, fig. 1 only.

Pinus sp. in Manchester and Meyer, 1983, Oreg. Geol. 49, p. 116, fig. 2 F–J.

DIAGNOSIS: Fascicle with five leaves (rarely three or four, but probably due to detachment); length 29 cm (based on one complete specimen), width 0.2 cm; slightly curved; sheath persistent; base bulbous. Ovulate cone elliptical; mature cone 9.5 cm long, 5.0 cm wide; apophysis in dorsal view 1.5–2.0 cm wide, 1.0–1.1 cm high, width to height ratio about 1.7; umbo dorsal, 0.7–0.8 cm wide, 0.4–0.5 cm high; spine centro-erect, protruding above plane of apophysis; immature ovulate cones 3.5–4.0 cm long, 1.4–1.8 cm wide. Winged seed articulate (sometimes found disarticulated or as a seedless wing developed due to an aborted ovule on a sterile scale); 2.1–4.2 cm long (from proximal end of seed body to tip of wing), 0.4–1.1 cm wide (at widest part of wing); admedial edge straight to concave, abmedial edge tapering distally; distal 25%

acute but rounded at extreme tip of wing; seed body elliptical, 0.2–1.0 cm long, 0.1–0.6 cm wide. Pollen cone about 5 cm long, 1.0 cm wide.

DISCUSSION: The placement of unattached organs of pine into a single species seems justified because of the morphological consistency within each organ and because the characters of each organ are typical of the subgenus *Diploxylon*. The foliage has been selected for the holotype because it expresses characters that are diagnostic and more likely to be distinctive when compared to pines from other floras.

We reject the previous assignment to *Pinus torreyana* by Mason (1927), which he based only on foliage from the Butler Basin assemblage, because *P. torreyana* is an extant species and the fossil ovulate cones now available show a dissimilar morphology. The specimens referred by Chaney (1927) and Mason (1927) to *Pinus knowltoni* include an illustrated incomplete fascicle with apparently three needles (probably a variant of *Pinus johndayensis*) and a seed of *Cedrela merrillii*. The type material of *P. knowltoni*, described by Chaney (1920) from the early Miocene Eagle Creek flora, consists of the apical portion of a pollen cone and a very fragmentary specimen with supposedly three needles (this specimen was not relocated); there is no clear basis for placing the Bridge Creek material in this species.

The classification of *P. johndayensis* in the subgenus *Diploxylon* (hard pines) is indicated by the combination of the following characters: (1) the dorsal position of the umbo on the ovulate cone scale, (2) the articulate nature of the winged seed, and (3) the presence of a persistent fascicle bundle sheath. Extant species of *Diploxylon* pines with five needles occur most commonly among several species of the section *Pseudostrobus* (see Krüssman, 1983). Section *Australes* also includes species that have as many as five needles but typically have only three.

Pinus has about 100 species distributed almost exclusively in the Northern Hemisphere in a diverse range of climates. Section *Pseudostrobus* is distributed today primarily in Mexico with some species in western North America, while section *Australes* is distributed in the southeastern United States, Mexico, central America, and the Caribbean Islands.

Pinus johndayensis occurs at several localities with some of the best preserved and most diagnostic material, including the holotype, from Fossil. Although rare or absent in some of the assemblages, it is one of the dominants at Cove Creek and was apparently an important component of the plant association represented by that assemblage. A similar *Diploxylon* pine occurs in the middle Eocene West Branch Creek locality of the Clarno Formation, but it represents a different species having gracile needles and smaller seeds and pollen cones.

ETYMOLOGY: This species is named for the John Day region of north-central Oregon, from which it was collected.

HOLOTYPE: UCMP 9316 (foliage).

PARATYPES: UCMP 126, 132, 12644; UF 10451–10455 (foliage). UCMP 12639, 12707; UF 6996, 10352, 10354, 10447 (ovulate cones). UCMP 12640, 12641; UF 6993, 6994, 10356,10357, 10401, 10435-10446, 10496, 10509, 10764, 10765 (seeds). UCMP 9312, 12642, 12643; UF 10355, 10450, 10510 (pollen cones).

OCCURRENCE: Fossil, Cove Creek (Knox Ranch, Pentecost Ranch), Iron Mountain, Lost Creek, Butler Basin.

duplicate number of "Pteris" silvicola Hall in Chaney. This specimen renumbered -26431
dmi July 2 1998

DICOTYLEDONS

Family LAURACEAE

Cinnamomophyllum bendirei (Knowlton) Wolfe
(leaf)
(Plate 5, figs. 9, 10)

Cinnamomophyllum bendirei (Knowlton) Wolfe, 1977, U.S. Geol. Surv. Prof. Paper 997, p. 89.

Cinnamomum bendirei Knowlton, 1902, U.S. Geol. Surv. Bull. 204, p. 57, pl. 10, fig. 4.

Philadelphus bendirei (Knowlton) Chaney, 1927, *pro parte,* Carnegie Inst. Wash. Pub. 346, p. 118, pl. 17, figs. 1, 2 only.

Sassafras bendirei (Knowlton) Brown, 1940, J. Wash. Acad. Sci. 30, p. 350.

DISCUSSION: Leaves of Lauraceae were placed in the form genus *Cinnamomophyllum* by Wolfe (1977) due to lack of diagnostic morphologic characters for generic determination of lauraceous foliage. Characters distinguishing this form genus from other groups of lauraceous genera include (1) pseudo-palmate venation in the basal pair of secondaries, (2) a basal pair of secondaries are not parallel to other secondaries, (3) the presence of a continuous marginal vein, and (4) areoles having few unbranching or no freely ending veinlets. Although Brown (1940) assigned specimens to *Sassafras*, the lobing commonly present in the leaves of that genus is absent in the small suite of material from Bridge Creek.

LECTOTYPE: USNM 8490 (Knowlton, 1902, pl. 10, fig. 4).

ADDITIONAL SPECIMENS: UCMP 12645–12648; UF 10524.

OCCURRENCE: Painted Hills, Fossil, Iron Mountain, Butler Basin.

Cinnamomophyllum knowltonii n. sp.
(leaf)
(Plate 5, figs. 8, 11)

DIAGNOSIS: Lamina elliptical; apex missing; base acute, decurrent; length to width ratio ~3; petiole 0.8 cm; margin entire, thickened; texture apparently coriaceous; venation pinnate, eucamptodromous; primary vein moderate to stout, slightly curved; secondary veins narrowly acute, lower pair more acute than others, at least four to probably five or six pairs, curved; two nearly parallel veins intermediate between secondary and tertiary order arise on each side at the base of the lamina and follow the margin, one as a marginal vein; veins of similar order arise from the abmedial side of the basal secondaries and are eucamptodromous near the margin; tertiary veins weakly percurrent, slightly sinuous, sometimes forked, usually oriented nearly perpendicular or slightly oblique to the midvein; quaternary veins orthogonal, forming well-developed small quadrangular to sometimes pentagonal areoles, occasionally giving rise to simple veinlets; lamina uniformly dotted with resin bodies 30–40 µm diameter.

DISCUSSION: This species is distinguished from *Cinnamomophyllum bendirei* by its more coriaceous texture (*Cinnamomophyllum knowltonii* may have been evergreen whereas *C. bendirei* may have been deciduous), thickened margin, thicker midrib and petiole, thinner tertiaries and quaternaries, and less sinuous, more organized venation overall.

NOMENCLATURE: This species is named for F. H. Knowlton in recognition of his contributions to the Bridge Creek flora.

HOLOTYPE: UF 10373.

PARATYPE: UF 10370.

OCCURRENCE: Cove Creek (Knox Ranch).

Litseaphyllum presanguinea (Chaney and Sanborn) Wolfe
(leaf)
(Plate 6, figs. 1–3)

Litseaphyllum presanguinea (Chaney and Sanborn) Wolfe, 1977, U.S. Geol. Surv. Prof. Paper 997, p. 68.

Nectandra presanguinea Chaney and Sanborn, 1933, Carnegie Inst. Wash. Pub. 439, p. 73–74, pl. 18, figs. 1, 2, 5, 7 (Goshen flora).

Salix californica auct. non Lesquereux. Chaney, 1927, *pro parte*, Carnegie Inst. Wash. Pub. 346, p. 103, pl. 8, figs. 9, 11 only.

DISCUSSION: The name *Litseaphyllum* was applied by Wolfe (1977) to fossil lauraceous leaves having secondary veins that are approximately parallel and of the same strength and having few unbranched or no freely ending veinlets and a continuous marginal vein. The Bridge Creek specimens conform to these characters, although the marginal vein is indistinct from the apparent marginal thickening. Characters consistent with *Litseaphyllum presanguinea* include secondaries that are strongly curved and convergent with the next higher pair, numerous intersecondary veins, and variable size and length to width ratio (~2.5–4.5).

The specimens frequently have a well-preserved cuticle and appear to have been coriaceous; the species was probably evergreen. *Litseaphyllum presanguinea* also occurs in the latest Eocene-earliest Oligocene Goshen flora of western Oregon; we are uncertain about its occurrence in the Eocene Kushtaka Formation of Alaska (in Wolfe, 1977).

ADDITIONAL SPECIMENS: UF 10184, 10318, 10494, 10534.

OCCURRENCE: Crooked River.

Family NYMPHAEACEAE

Nuphar sp.
(rhizome)
(Plate 6, figs. 4, 5)

DISCUSSION: Rhizome envelopes with scattered circular root scars (each with a central bundle scar) and elliptical leaf scars (each with several bundle scars) are similar to those described as *Nuphar advenoides* Becker (1969) from the latest Eocene-earliest Oligocene Beaverhead Basin of Montana. Specimens from the Iron Mountain assemblage were first recognized by Thompson (1975), who described petiole and root scars. The specimens often occur within dark, organic-rich layers having few leaf impressions and were presumably deposited in shallow water. The 20–25 extant species of *Nuphar* are cold-hardy aquatic plants of northern temperate regions.

SPECIMENS: UF 10426, 10528, 10684.

OCCURRENCE: Fossil, Iron Mountain, Butler Basin.

cf. *Nuphar*
(fruit, seed)
(Plate 75, figs. 8–10)

DESCRIPTION: Seeds smooth, elliptical; length 4–6 mm, width 4–5 mm; surface with a very fine reticulum made up of isodiametric cells about 40 µm in diameter; operculum circular, 0.3 mm diameter. Associated disk-like structure (stigmatic disk of fruit?) 9 mm in diameter with 20 radiating arms, each arm 1–1.2 mm thick and 5 mm long.

DISCUSSION: The seeds of this taxon are similar in size and morphology to those of extant *Nuphar*, although the surface cells are about twice as large as those in the extant *Nuphar lutea*. Both specimens representing this species, although from different localities, show many (10–30) seeds borne in close proximity but apparently detached. This suggests the condition in extant *Nuphar* in which the seeds of each locule are collectively released in a common sac (E. Schneider, pers. comm., 1992). The peculiar disk-like structure with radiating arms (pl. 75, fig. 9) appears to be the remains of the stigmatic disk, ruptured from the apex of the fruit from which the seeds were dispersed. A similar disk, also with 20 stigmatic arms, was figured from the Eocene of Republic, Washington (pl. 1, fig. 2 in Wehr and Manchester, 1996).

SPECIMENS: UF 10584, 10885.

OCCURRENCE: Fossil, Cove Creek.

Nymphaeaceae gen. et. sp. indeterminate
(leaf)
(Plate 6, fig. 6)

DISCUSSION: Small fragments of leaves with venation comparable to that of Nymphaeaceae have been collected from Fossil. These show palmately radiating primary veins each arising from a separate vascular strand of the petiole. Between adjacent primary veins, there is a straight to zig-zag medial vein of secondary order (pl. 6, fig. 6). These veins are confined to the lower part of the lamina and diminish apically (and are replaced by percurrent apically convex tertiaries in the intercostal areas). The leaf is unlike extant *Nuphar* in lacking a distinct midvein, and in this respect, the fossil is more similar to some species of *Nymphaea*. Until more complete specimens are available, we hesitate to make a generic assignment.

SPECIMEN: UF 10859.
OCCURRENCE: Fossil.

Family BERBERIDACEAE

Mahonia simplex (Newberry) Arnold
(leaf)
(Plate 6, figs. 7–10)

Mahonia simplex (Newberry) Arnold, 1936, *pro parte,* Univ. Mich. Contr. Mus. Paleont. 5, p. 58 (synonymy of Bridge Creek specimens of Newberry and Chaney only). Manchester and Meyer, 1987, Oreg. Geol. 49, p. 116, fig. 3G.

Berberis simplex Newberry, 1883, U.S. Nat. Mus. Proc. 5, p. 514; 1898, U.S. Geol. Surv. Monogr. 35, p. 97, pl. 56, fig. 2. Knowlton, 1902, U.S. Geol. Surv. Bull. 204, p. 56.

Odostemon simplex (Newberry) Cockerell, 1908, Bull. Am. Mus. Nat. Hist. 24, p. 91. Chaney, 1927, Carnegie Inst. Wash. Pub. 346, p. 116–117, pl. 14, figs. 7–9, 11.

SUPPLEMENTARY DESCRIPTION: Previous descriptions of this species are supplemented by the following observations: leaflet length 2.5–>6.5 cm, width 1.8–5.5 cm (between apices of spines); petiolule very short or lamina sessile to rachis; teeth typically two or three per side; one or two pairs of secondaries arise palmately at the base of the lamina with an additional two to four pairs arising pinnately from the midrib above, irregularly sinuous in course, sometimes anastomosing, craspedodromous or semicraspedodromous to brochidodromous well within the margin; tertiaries coarsely orthogonal reticulate, brochidodromous tertiaries arise abmedially from secondaries; quaternaries orthogonal reticulate; highest order venation indistinct, apparently with curved, branched veinlets.

DISCUSSION: Newberry (1883, 1898) recognized the first North American fossil *Mahonia*, described as *Berberis simplex*, based on a poorly preserved leaf from the Painted Hills assemblage. Although formerly considered a subgenus of *Berberis*, *Mahonia* is now recognized as a distinct genus characterized by compound rather than simple leaves. Chaney (1927) produced the most complete description based on the Bridge Creek material, which he referred to *Odostemon*, a synonym of *Mahonia*. Schorn (1966) provided a comprehensive review and unpublished revision of North American fossil *Mahonia*.

Mahonia includes about 70 extant species of evergreen shrubs native to eastern Asia as well as North and Central America. Two groups are recognized on the basis of inflorescences (Ahrendt, 1961); differences in leaf venation between these groups support this distinction (Schorn, 1966). The group Orientales, with palmate venation, is native to eastern Asia with the exception of one species (*Mahonia nervosa*) in western North America, whereas the group Occidentales, with pinnate or modified pinnate venation, is native to western North America and Central America (Schorn, 1966). Both groups are recognized in the North American Tertiary. The palmate venation of *Mahonia simplex* indicates affinity with the group Orientales. *M. simplex* has also been reported from various Miocene floras (e.g., Arnold, 1936; Chaney and Axelrod, 1959; Schorn, 1966), and although we have not examined those specimens to validate conspecificity, the illustrations do suggest close similarity. A similar species, *Mahonia bilinica* (Unger) Kvaček and Bůžek, occurs in the lower Miocene of Europe (Kvaček and Bůžek, 1994). *Mahonia marginata* from the Florissant flora is closely similar to *M. simplex*, although there is a tendency for leaflets of the former species to be more elongate and have more teeth (Schorn, 1966).

HOLOTYPE: USNM 7046.

ADDITIONAL SPECIMENS: UCMP 12649–12653; UF 10182, 10183, 10515.

OCCURRENCE: Painted Hills, Fossil, Cove Creek (Knox Ranch, Pentecost Ranch), Iron Mountain, Crooked River, Lost Creek.

Family MENISPERMACEAE

cf. *Menispermum*

(endocarp)

(Plate 7, fig. 1)

DESCRIPTION: Endocarp bisymmetrical, laterally compressed, nearly orbicular in lateral view, but with a pronounced ventral notch; endocarp height 4.5–6.2 mm, width 4.5–7.0 mm, thickness 1.8 mm; dorsal margin of endocarp with a keel in the plane of symmetry; both lateral faces with a broad, shallow, smooth concavity rimmed by a C-shaped ridge separating dorsal and ventral ornamentation; each lateral face with 29–38 radially aligned ridges alternating with rounded grooves that are developed on both ventral and dorsal surfaces. Some examples show a small foramen piercing the endocarp near the base.

DISCUSSION: A single piece of shale with seven endocarp impressions provides the basis for recognizing Menispermaceae in the Bridge Creek flora. The C-shaped outline of the endocarps, dorsal keel, radiating ribs, and lateral foramen are characters diagnostic of the Menispermaceae, tribe Menispermeae (= Cocculeae). The endocarps are especially similar to those of extant *Menispermum*. On the basis of extant and fossil distribution patterns for Menispermaceae, Thanikaimoni (1986, p. 132) concluded that "the Asian genera *Cocculus, Cissampelos,* and *Menispermum* seem to have reached North America during the Miocene." The Bridge Creek occurrence, however, establishes the presence of *Menispermum* (or a genus with identical endocarps) in North

America by the early Oligocene. The Menispermaceae are common and diverse in the Eocene Clarno floras.

Most Menispermaceae are lianas of tropical to subtropical distribution, although some members of the tribe Menispermeae, such as *Menispermum*, may grow in temperate areas. *Menispermum* is a twiny vine with three extant species distributed in eastern North America, Mexico, and eastern Asia.

SPECIMEN: JODA 1085.

OCCURRENCE: Painted Hills.

Family CERCIDIPHYLLACEAE

Cercidiphyllum crenatum (Unger) Brown
(leaf, fruit)
(Plate 7, figs. 2–8; Plate 8, fig. 1)

Cercidiphyllum crenatum (Unger) Brown, 1935, J. Paleont. 9, p. 575–577, pl. 68, figs. 8–10. Brown, 1937, J. Wash. Acad. Sci. 27, p. 509, fig. 9. Brown, 1939, J. Paleont. 13, p. 485–499, pl. 56., fig. 16. Manchester and Meyer, 1987, Oreg. Geol. 49, p. 116, fig. 3C.

Dombeyopsis crenata Unger, 1850, Genera et Species Plantarum Fossilium, Vienna, p. 447 (European Tertiary).

Grewia crenata (Unger) Heer. Newberry, 1898, U.S. Geol. Surv. Monogr. 35, p. 120, pl. 46, fig. 2; pl. 48, figs. 2, 3. Knowlton, 1902, U.S. Geol. Surv. Bull. 204, p. 80. Chaney, 1927, Carnegie Inst. Wash. Pub. 346, p. 133.

Grewia auriculata Lesquereux, 1883, Rept., U.S. Geol. Surv. Terr. 8, p. 252–253, pl. 55, fig. 1. Knowlton, 1902, U.S. Geol. Surv. Bull. 204, p. 81.

Cassia sp.?, Newberry, 1898, U.S. Geol. Surv. Monogr. 35, p. 113, pl. 46, fig. 10.

Cercidiphyllum helveticum auct. non (Heer) Jähnichen, Mai and Walther. Manchester and Meyer, 1987, Oreg. Geol. 49, p. 116, fig. 3G.

SUPPLEMENTARY DESCRIPTION: Lamina broad-ovate to elliptical; apex acute to rounded; base usually cordate, sometimes truncate to acute; length 2.0–8.0 cm, width 1.0–8.0 cm, length to width ratio 0.9 to 2.0; petiole wider than primary veins, width 0.1 cm, length 1.8–2.4 cm; margin crenate; teeth closely and uniformly spaced, convex on both sides, principal vein and higher order lateral veins terminate in apical gland; sinuses angular, acute to obtuse; venation basal actinodromous with five to usually seven primary veins, lateral primaries curved, inner pair extending more than three-fourths of the distance to the apex, second pair extending one-third to more than one-half of the distance to the apex, outermost pair shorter and much weaker; secondaries brochidodromous, up to five pairs originating from midvein, arising abmedially from lateral primaries; tertiaries percurrent, less commonly reticulate, those between adjacent primary veins convex or forming chevrons; quaternaries or quinternaries form areoles; highest order veins freely ending, usually branched two or three times.

DISCUSSION: This species was first recognized in the Bridge Creek flora on the basis of leaves and a fruit by Brown (1935). The Bridge Creek specimens compare well with those assigned to the same species from the Miocene and Pliocene of Europe (Jähnichen et al., 1980) and are nearly indistinguishable in both fruits and foliage from extant *Cercidiphyllum japonicum*. Although the fossil fruits have often been placed in a separate species, *Cercidiphyllum helveticum* (Jähnichen et al., 1980; Manchester and Meyer, 1987), strong evidence favors their assignment to the same species as the foliage. This conclusion is supported by their consistent co-occurrence at different localities and substantiated by a specimen from the Miocene of Clarkia, Idaho, showing fruits of the *C. helveticum* type attached to the same branchlet as leaves of *Cercidiphyllum crenatum* (pl. 4, fig. 8 in Smiley and Rember, 1985).

The Bridge Creek occurrence is apparently the oldest unequivocal record for the genus as confirmed by fruits. The same species extends into Miocene floras of western North America, such as Latah (Chaney and Axelrod, 1959) and Clarkia (Smiley and Rember, 1985). Although the genus has often been reported from the Paleocene and Eocene (e.g., Brown, 1939), these older occurrences have been shown to represent extinct genera of the Cercidiphyllaceae with fruits borne on elongate axes rather than in clusters (Crane, 1989).

Cercidiphyllum is a genus of two species native to Japan and China. The extant *C. japonicum* and *C. magnificum* are large deciduous trees inhabiting temperate, moist valley forests (Numata, 1974; Spongberg, 1979).

ADDITIONAL SPECIMENS: UCMP 12654–12661; UF 10691–10695, 10924, 10925 (leaves). UCMP 9309, 12672; UF 10591, 10696–10698 (fruits).

OCCURRENCE: Painted Hills, Fossil, Cove Creek (Knox Ranch, Pentecost Ranch), Iron Mountain, Lost Creek, Butler Basin.

Family HAMAMELIDACEAE

Fothergilla praeovata (Chaney) n. comb.
(leaf)
(Plate 8, figs. 2–8)

Rhus praeovata Chaney, 1927, Carnegie Inst. Wash. Pub. 346, p. 126, pl. 15, figs. 8, 9.

SUPPLEMENTARY DESCRIPTION: Lamina ovate; apex acute to emarginate; base widely acute to obtuse; length 3.5–5.5 cm, width 2.6–3.6 cm, length to width ratio 1.5–2.1; petiole inflated, 0.6 cm length; margin entire basally, typically toothed in apical half; teeth crenate to serrate, tooth apices formed at right to slightly obtuse angles, apparently glandular; sinuses broadly rounded; venation pinnate, usually craspedodromous, sometimes camptodromous; primary vein moderate, slightly curved; secondaries acute, angle of divergence increases toward the apex with basal pair diverging at 35–40° and uppermost pairs at 70–75°, about five or six pairs, lowermost pair arising at or just above leaf base, course straight to uniformly curved, slightly sinuous, sometimes branched once or twice, rarely forming a brochidodromous loop; intersecondaries occasional, extending one-third to one-half the distance to the margin; tertiaries simple or forked, percurrent to reticulate, course variable, abmedially brochidodromous marginal tertiaries arising from lowermost pair of secondaries; quaternaries and quinternaries orthogonal reticulate; veinlets apparently profusely branched; marginal quaternaries brochidodromous.

DISCUSSION: This species is variable in the degree of development of the teeth and in tertiaries that range from coarsely reticulate to percurrent. Characters frequently observed in leaves of Hamamelidaceae include secondaries that are predominantly craspedodromous but sometimes camptodromous, basal secondaries that arise close to the base and at lower angles than successively higher pairs, and broadly concave sinuses. Characters distinguishing these specimens as *Fothergilla* include the absence of pronounced asymmetry at the base, teeth that are crenate to sharp-serrate with apices forming right to slightly obtuse angles, an acute to obtuse (not cordate) base, brochidodromous marginal tertiary veins arising from the basal secondaries, and distinctly reticulate quaternaries. The freely ending veinlets of the extant species, as in many other leaves of Hamamelidaceae, are branched. The preservation of the fossils is insufficient for resolving the details of the highest order veins, and it is not clear whether the veinlets are as profusely branched as those of the extant species. The teeth conform to the fothergilloid tooth of Wolfe (1989) in the weak development of lateral bracing of the medial vein in the tooth.

Chaney and Axelrod (1959) illustrated two Bridge Creek specimens that they referred to *Hamamelis merriami*, one from Crooked River and one from Cove Creek. The Crooked River specimen is difficult to evaluate because it lacks the base; however, the Cove Creek specimen shows a close similarity to the leaves of *Fothergilla praeovata* and may be conspecific, although we have not seen the specimen. *Fothergilla* has also been described from the middle Eocene of the Puget Group in Washington, where it is restricted to the upper Fultonian stage (Wolfe, 1968). The Fultonian species has more abundant teeth than *F. praeovata*. The two extant species of *Fothergilla* are deciduous shrubs native to eastern North America.

HOLOTYPE: UCMP 91.

PARATYPE: UCMP 90.

ADDITIONAL SPECIMENS: UF 10679; USNM 458389, 458390.

OCCURRENCE: Crooked River.

Liquidambar sp.
(leaf)
(Plate 9, fig. 1)

Liquidambar europaeum auct. non A. Braun. Newberry 1898, p. 100, pl. 47, figs. 1, 2.

DISCUSSION: *Liquidambar* is represented by only two leaf specimens from the Bridge Creek flora. No new specimens have been found since those in the collections made by Condon and described by Newberry (1898). After reexamining the specimens illustrated by Newberry (1898), we concur that they are *Liquidambar*. Although the leaves are not well-preserved, the palmately five-to seven-lobed leaves, attenuate lobe tips, and closely spaced rounded teeth along the margin are typical of extant *Liquidambar*. Details of tertiary and higher order venation are not clear, and marginal glands are not distinguishable. Newberry assigned the fossils to *Liquidambar europeum*, a species previously described from the Tertiary of Europe. However, the preservation of the Bridge Creek specimens is too poor for a definite species assignment. A globose infructescence from the same locality was also attributed to *Liquidambar* (Newberry, 1898), but it does not show the bicarpellate capsules diagnostic of Hamamelidaceae and appears instead to represent Platanaceae.

The four to six extant species of sweetgums are medium to tall deciduous trees native to eastern North America, southeast Asia, and Asia Minor. The genus is also known from the Eocene Chalk Bluffs flora of California (MacGinitie, 1941), and from the Eocene Green River Formation of Utah and Colorado (MacGinitie, 1969), but it has not been observed among the Clarno floras. It is widespread in Miocene floras of the Pacific Northwest (e.g., Chaney and Axelrod, 1959; Wolfe and Brown, *in* Peck et al., 1964; Smiley and Rember, 1985).

SPECIMENS: USNM 7094, 7095 (leaves).

OCCURRENCE: Painted Hills.

Parrotia brevipetiolata n. sp.

(leaf)

(Plate 10, figs. 1–4; Plate 11, figs. 1–4)

DIAGNOSIS: Lamina elliptical to obovate, rarely ovate; apex acute to attenuate; base asymmetrical, usually obtuse, sometimes cordate or acute, basal margin delimited by lowermost secondary veins and marginal tertiary vein; length 4.4–15.3 cm, width 3–8 cm, length to width ratio ~1.9; petiole short, 5–9 mm long, inflated, narrowing toward base of lamina; margin entire basally, typically toothed in apical half; teeth typically low, crenate to sometimes serrate with a mucronate tip; sinuses rounded; venation pinnate, usually craspedodromous, sometimes camptodromous; primary vein moderately thick, straight to slightly curved; secondary veins narrowly acute, about five to seven pairs, basal secondaries sometimes more acute than upper, thickness moderate, course uniformly curved, slightly sinuous, sometimes branching once; intersecondaries short, simple, arising at higher angles than tertiary secondaries; tertiary veins percurrent, course variable, relation to midvein obtuse, marginal tertiary veins arise from secondaries and are abmedially brochidodromous or occasionally craspedodromous into teeth; quaternary veins orthogonal or nearly so and forming areoles, marginal quaternaries looped and forming highest order of venation, areoles well-developed, quadrangular to pentagonal, medium sized, giving rise to simple-curved to twice-branched veinlets.

DISCUSSION: The leaf base, with its margin delimited by the lowermost secondary veins, and the short inflated petiole are striking features of this species. Similar short petioles, though not so inflated, are encountered in some extant genera of the family. Similarities to extant species of *Parrotia* include the (1) asymmetrical base, (2) short and inflated petiole, (3) length to width ratio, (4) basal margin delimited by the lowermost secondary veins, (5) crenate teeth with mucronate tips, (6) margin that is usually entire near the base with the first tooth typically occurring where the basal secondaries first reach the margin, and (7) presence of simple-curved to twice-branched veinlets. The petiole is shorter and more inflated than in extant species of *Parrotia*, and while the other characters suggest a close similarity to extant *Parrotia*, it is possible that the Bridge Creek material may represent an extinct related genus. *Parrotia brevipetiolata* is distinguished from *Fothergilla praeovata* by its larger size, basal veins, and smaller teeth. The single extant species of *Parrotia* is a deciduous shrub or small tree native to northern Iran.

ETYMOLOGY: The specific epithet denotes the characteristically short petiole.

HOLOTYPE: UF 10360.

PARATYPES: UF 10361–10367, 10404–10407.

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OCCURRENCE: Fossil, Cove Creek (Pentecost Ranch).

Hamamelidaceae gen. et sp. indet.

(infructescence)

(Plate 8, fig. 9)

DISCUSSION: Two hamamelidaceous infructescences have been collected. They show a stout axis at least 2.5 cm long with at least four sessile fruits. The fruits are split medially (dehiscence line between the two carpels), rounded-rectangular in shape, 4.5–6 mm long and 4.5–7 mm wide, with two recurved persistent styles protruding from the distal margins. These appear to be the capsular, explosively dehiscent fruits characteristic of the Hamamelidoideae subfamily of the Hamamelidaceae. They may thus correspond to the leaves that have been assigned to *Fothergilla* and/or *Parrotia*.

SPECIMENS: USNM 458380; UCMP 12809.

OCCURRENCE: Fossil, Crooked River.

Family PLATANACEAE

Platanus condonii (Newberry) Knowlton

(leaf)

(Plate 13, fig. 4; Plate 14, fig. 1; Plate 15, figs. 1–3)

Platanus condoni (Newberry) Knowlton in Merriam, 1901, Univ. Calif. Bull. Dept. Geol. 2, p. 289. Knowlton, 1902, U.S. Geological Surv. Bull. 204, p. 64. Chaney, 1927, Carnegie Inst. Wash. Pub. 346, p. 120. Manchester and Meyer, 1987, Oreg. Geol. 49, p. 118, fig. 3H.

Ficus? *condoni* Newberry, 1883, U.S. Nat. Mus. Proc. 5, p. 502; 1898, U.S. Geol. Surv. Monogr. 35, p. 85, pl. 56, fig. 1; pl. 57, fig. 1; pl. 58, fig. 1.

SUPPLEMENTARY DESCRIPTION: Lamina palmately lobate, shallowly three or five lobed; lobe apices acute; base widely obtuse to nearly truncate, often somewhat decurrent at extreme base; length ~12–32 cm (excluding basal laminar appendage), width 15–~45 cm, length to width ratio 0.7–0.8; petiole stout, basally inflated, length at least 4.5 cm; margin undulate; sinuses between the lobes narrowly to broadly rounded; texture chartaceous with raised veins; venation basal to suprabasal palinactinodromous; primary veins straight to slightly curved, angle between adjacent primaries 30–45°; secondaries within lobes arising at narrowly acute (40–45°) angles, six to ten pairs per lobe, eucamptodromous, straight to curved; basal secondaries between adjacent primaries thin, arising at widely acute to right angles from the primaries, five to seven pairs, sinuous to curved, joining to form a series of chevrons pointing toward the sinus; tertiaries percurrent, convex to reticulate, arising from primaries at very widely acute to right angles, marginal tertiaries forming brochidodromous loops; quaternaries thin, percurrent to coarsely reticulate; quinternaries finely orthogonal reticulate; ultimate venation indistinct. Rounded to palmately lobed basal laminar appendage often present, arising at the base of the primary lamina and extending proximally, sometimes fused with the primary lamina, length 2–5 cm, width 2–7 cm, venation actinodromous with five to eight veins.

DISCUSSION: This species is distinguished from the other Bridge Creek *Platanus* (*P. exaspera*) by its large size, five lobes, raised veins, lack of prominent teeth, and by the frequent presence of a palmately lobed, basal laminar appendage. The leaves are the largest known from the Bridge Creek flora and are difficult to portray adequately on a page of this size. Characters distinguishing these leaves as Platanaceae are the palmately lobed lamina, palinactinodromous venation, basally inflated petiole, and presence of distinctive laminar appendages below and often fused with the primary lamina. These appendages differ from the stipules encountered in some extant *Platanus* in that they are consistently situated at the top of the petiole and are attached to and not deciduous from the primary lamina, although this condition is also occasionally observed in *Platanus occidentalis* (Ward, 1888).

In the general form of the lamina and the distinctive chevrons formed by secondary veins, leaves of *Platanus condonii* are similar to those of the extinct platanaceous genus *Macginitiea* Wolfe and Wehr (Manchester, 1986) although there are several important differences: (1) there are fewer lobes in *P. condonii* (three to five versus five to nine), and they are wider, (2) the angle between adjacent primaries is broader (30–45° versus 15–30°), (3) the divergence of primaries is sometimes suprabasal, a feature that is unusual in *Macginitiea*, and (4) the distinctive, large, basal laminar appendage does not occur in *Macginitiea*. Although referred to the genus *Platanus*, the Bridge Creek species is distinct from the leaves of any extant species and could possibly represent a new extinct genus.

P. condonii has a limited stratigraphic range and is known only from the lower Oligocene of the Pacific Northwest. It is also present in the Lyons (Meyer, 1973), Rujada (Lakhanpal, 1958), and Willamette floras in western Oregon.

LECTOTYPE: We designate USNM 7085 (Newberry, 1898, pl. 57, fig. 1; reillustrated here as pl. 15, fig. 1) as the lectotype; other specimens illustrated by Newberry are missing.

ADDITIONAL SPECIMENS: UCMP 12662; UF 10593–10596; USNM 458413.

OCCURRENCE: Painted Hills, Fossil, Butler Basin.

Platanus exaspera n. sp.
(leaf)
(Plate 12, figs. 1, 2; Plate 13, figs. 1, 3)

Platanus aspera Newberry 1883, U.S. Nat. Mus. Proc. 5, p. 509; 1898, *pro parte,* U.S. Geol. Surv. Monogr. 35, p. 102, pl. 42, figs. 1–3, pl. 59, fig. 3 (not pl. 44, fig. 5); Manchester and Meyer 1987, Oreg. Geol. 49, p. 118, fig. 3B.

Tilia aspera (Newberry) LaMotte 1935, *pro parte,* Carnegie Inst. Wash. Pub. 455, pt. 3, p. 45, pl. 2, figs. 1, 2 only.

Tilia oregona LaMotte 1935, *pro parte,* p. 47, pl. 3, fig. 6 only.

DIAGNOSIS: Leaves ovate to obovate, frequently trilobed, apex attenuate; base cordate; length 8–17.2 cm, width 7–15+ cm, length to width ratio ~1.0; petiole 1–3.6 cm, markedly inflated (bulbous) at base; margin serrate; teeth falcate, sometimes glandular, concave on apical side, convex to concave on basal side, rarely compound with one or two small secondary teeth on lower flanks of a primary tooth; sinuses broadly rounded (scalloped); venation with basally actinodromous primaries; craspedodromous secondaries arising from the midvein; midvein straight to slightly curved, lateral primaries somewhat weaker, typically curved, angle between adjacent primary veins 35–55°; secondaries arising at 25–30°, five to eight pairs, straight to curved; lateral primaries producing seven to nine abmedial secondaries at angles of 30–60°; tertiaries percurrent, usually sinuous, rarely forked; quaternary and quinternary veins thick, reticulate, usually orthogonal, giving rise to simple to branched freely ending veinlets.

DISCUSSION: The trilobate form, scalloped sinuses, cordate base, and basally flared petiole of this species are consistent with assignment to *Platanus*. The lack of palinactinodromy, a feature diagnostic of *Platanus,* has resulted in confusion of some of these leaves with *Tilia*. However, palinactinodromy, the condition whereby primaries arise at one or more subsidiary points of radiation above the base of the lamina, is expressed only in leaves with five or more primary veins. Unlobed and trilobed leaves encountered among fossil and extant *Platanus* species are actinodromous.

The six to ten extant species of *Platanus* include one from southeastern Asian, one from southeastern Europe to Iran, one from eastern North America, and the remainder distributed from the southwestern United States to southern Mexico. They are tall trees that grow primarily in riparian habitats. *Platanus exaspera* is most similar to the eastern North American species, *Platanus occidentalis.*

NOMENCLATURE: The name *Platanus aspera* proposed by Newberry (1883, 1898) for this species is no longer applicable to the Bridge Creek sycamore. Although Newberry (1898) illustrated several specimens, he did not designate a holotype. One of the specimens included by Newberry is actually *Tilia*. LaMotte (1935) designated this *Tilia* specimen as the lectotype for a new combination, *Tilia aspera* (Newberry) LaMotte. We have examined all of the original specimens illustrated by Newberry. Aside from the lectotype for *T. aspera,* which has teeth with angular sinuses, we consider that the other specimens illustrated by Newberry (1898) represent *Platanus.* We designate the epithet *exaspera* for this new species.

HOLOTYPE: UF 6997.
PARATYPES: UF 10176, 10177, 10342, 10549–10555.
OCCURRENCE: Painted Hills, Fossil, Crooked River, Lost Creek.

Platanus sp.
(infructescence and fruits)
(Plate 13, fig. 2; Plate 15, figs. 4–7)

Liquidambar europaeum auct. non Al. Braun Newberry 1898, pro parte, U.S. Geol. Surv. Monogr. 35, p. 100, pl. 47, fig. 3 only.
Platanus fruiting head Manchester and Meyer, 1987, Oreg. Geol. 49, p. 118, fig. 3E.
Platanus fruitlet Manchester and Meyer, 1987, Oreg. Geol. 49, p. 118, fig. 3F.

DISCUSSION: *Platanus* is also represented in the flora by infructescences and isolated fruits. The infructescences are globose heads, 18–21 mm in diameter, composed of numerous achenes each with a persistent protruding style. The styles from the numerous achenes are evenly distributed around the periphery of the head, not grouped in fives as they are in compressions and petrifactions of *Macginicarpa* (Manchester, 1986). The isolated achenes are elongate-obovate, with the narrowly conical lateral sides indicating close packing within the fruit. Fruits of extant *Platanus* have the same shape, whereas those of *Macginitiea* are ovate. Dispersal hairs are not visible and perhaps not preserved.
SPECIMENS: UCMP 12710; UF 6998, 10601–10603, 10720–10723.
OCCURRENCE: Painted Hills, Fossil, Crooked River, Lost Creek.

Family ULMACEAE

Cedrelospermum lineatum (Lesquereux) Manchester
(leaf and fruit)
(Plate 16, figs. 1–12)

Cedrelospermum lineatum (Lesquereux) Manchester, 1989, Am. J. Bot. 73, p. 124.
Banksites lineatus Lesquereux. Brown 1940, J. Wash. Acad. Sci. 30, p. 352, fig. 11.
Ulmus brownellii auct. non Lesquereux. Chaney, 1927, *pro parte,* Carnegie Inst. Wash. Pub. 346, p. 113. pl. 12. figs. 3, 6, 7, 8, pl. 13, figs. 1, 3, 6 only (not fig. 4).
Tremophyllum hesperium (Brown) Manchester and Meyer, 1987, Oreg. Geol. 49, p. 118, fig. 4C.

DISCUSSION: This species, represented by both leaves and winged fruits, belongs to an extinct genus, *Cedrelospermum* Saporta, found in Eocene and Oligocene floras of western North America, in the Neogene of southern Mexico (Magallón-Puebla and Cevallos-Feriz, 1994), and in Eocene to Miocene floras of Europe (Manchester, 1987a). Twigs with attached fruits and leaves from the Florissant flora were used to confirm that these fruits and leaves were produced by the same fossil species (Manchester, 1989b). The fruit of *Cedrelospermum* is a small samara a with a well-developed lateral wing (pl. 16, figs. 9–11). The leaves are similar to those of extant *Zelkova* but are typically more slender and elongate. *Cedrelospermum* leaves resemble those of *Ulmus* in the short petiole, strongly asymmetrical base, evenly spaced craspedodromous secondary veins, and tendency for a tertiary vein to branch abmedially from the secondary vein near the margin and enter the sinus; however, the leaves of *Ulmus* are broader and generally have compound teeth.

Although leaves occur in five assemblages of the Bridge Creek flora, fruits are relatively rare (only three specimens) and have been found only in the Crooked River assemblage. Although none of the fruits are complete, they are estimated as 9–11 mm in length, 3.5–4 mm in primary wing width, and 3–4 mm in nutlet length. In fruit size, they fall on the borderline between two previously recognized species, *Cedrelospermum lineatum* (typically > 1 cm long) of the Florissant flora, and *Cedrelospermum nervosum* (typically < 1 cm long) of the Green River flora (Manchester, 1989b). The associated leaves, with consistently well-developed teeth, correspond to those of *C. lineatum*.

ADDITIONAL SPECIMENS: UF 7004,① 10169, 10170, 10172, 10174, 10175, 10178–10180, 10299, 10608, 10633 (leaves). UF 10185, 10186; USNM 42336 (fruits).

OCCURRENCE: Fossil, Cove Creek (Knox Ranch), Iron Mountain, Crooked River, Butler Basin.

①: Ulmus chaneyi Pl 17, fig 1

Genus *Ulmus*

Ulmus is present in about half of the Bridge Creek assemblages. The Bridge Creek elms were included in a taxonomic revision of ulmaceous leaves from western North American Tertiary floras by Tanai and Wolfe (1977), who provided a useful synonymy and critical review of previously published species. Morphologic overlap among some of the species they recognized, however, makes it difficult to identify certain specimens. While fruits would help in resolving species problems, they are very rare in the Bridge Creek flora.

Burnham (1986) recognized problems of overlap in foliar characters among elms and attributed fossil ulmaceous leaves to informal morphotypes that she indicated could correspond to one or more actual species. Although we are using previously established binomials for two of the Bridge Creek elms, two others are treated here simply as unnamed leaf morphotypes.

There are problems in delimiting not only fossil but also extant elm species, as evidenced by the disparity in treatments of extant elms by different authors who recognize between 18 and 45 species worldwide. In the following section, we treat four types of foliage and two types of fruits. The elms are deciduous trees native to eastern North America, Mexico, eastern Asia, and Europe.

Key to the leaves of *Ulmus*

1a. Subsidiary teeth occasionally present on both the apical and basal flanks of the primary teeth.. *Ulmus chaneyi*
1b. Subsidiary teeth present only on the basal flanks of the primary teeth 2
  2a. Leaves with more subsidiary teeth (typically two or three), and 16–18 secondary veins.. *Ulmus speciosa*
  2b. Leaves with fewer subsidiary teeth (typically one or two), and 10–14 secondary veins.. 3
    3a. Leaves small, narrower (length to width ratio 2.1–3.0), base usually cuneate.. *Ulmus* sp. 1
    3b. Leaves small to large, broader (length to width ratio 1.3–2.0), base often cordate.. *Ulmus* sp. 2

Ulmus chaneyi Tanai and Wolfe
(leaf)
(Plate 17, figs. 1–4)

Ulmus chaneyi Tanai and Wolfe, 1977, U.S. Geol. Surv. Prof. Paper 1026, p. 5, pl. 4B.

Ulmus pseudo-americana auct. non Lesquereux. Manchester and Meyer, 1987, Oreg. Geol. 49, p. 118, fig. 4B.

DISCUSSION: *Ulmus chaneyi* is readily distinguished from other North American Tertiary *Ulmus* leaves in the nature of its marginal serration. The principal teeth have subsidiary teeth on both the upper and lower flanks, and in this respect, the leaves closely resemble leaves of the extant eastern Asian species *Ulmus laciniata* Mayer (Tanai and Wolfe, 1977). Leaf length ranges from 4.7 to 16 cm. *Ulmus chaneyi* was originally described on the basis of three incomplete leaves from the Twickenham assemblage. Three leaves from Fossil are placed with *U. chaneyi* but differ from the type material in having principal teeth that are more acute and often having fewer than four basal subsidiary teeth.

SPECIMENS: UF 7004, 10520, 10523.

OCCURRENCE: Fossil, Twickenham.

Ulmus speciosa Newberry
(leaf)
(Plate 18, figs. 1–6)

Ulmus speciosa Newberry, 1883, U.S. Nat. Mus. Proc. 5, p. 507; 1898, pro parte, U.S. Geol. Surv. Monogr. 35, p. 80, pl. 45, figs. 2–4 only. Knowlton, 1902, U.S. Geol. Surv. Bull. 204, p. 53.

Ulmus pseudo-americana Lesquereux, 1883, Rept., U.S. Geol. Surv. Terr. 8, p. 249, pl. 54, fig. 10. Tanai and Wolfe, 1977, U.S. Geol. Surv. Prof. Paper 1026, p. 7, plate 1, figs. A–E, H.

Ulmus newberryi Knowlton, 1902, U.S. Geol. Surv. Bull. 204, p. 54, pl. 9, fig. 4.

DISCUSSION: *Ulmus speciosa* is distinguished from the other Bridge Creek elms by the tendency for a higher number of secondary veins and the presence of two or three subsidiary teeth that occur only on the lower flanks of primary teeth.

Within the range of leaves that we include in *U. speciosa*, Tanai and Wolfe (1977) retained a second species, *Ulmus pseudo-americana* Lesquereux. While rejecting the criteria used by earlier authors to distinguish these species, Tanai and Wolfe treated *U. pseudo-americana* and *U. speciosa* as distinct species on the basis of characters of tooth shape and the behavior of tertiary veins at the tooth sinus. *U. pseudo-americana sensu* Tanai and Wolfe (1977) has acutely trigonal primary teeth, usually with two large subsidiary teeth and sometimes accompanied by a minute third subsidiary tooth, and has a prominent tertiary vein that forks near the base of the sinus and extends along each margin of the sinus. *U. speciosa* Newberry *sensu* Tanai and Wolfe has somewhat shorter primary teeth that are more apiculate, two (rarely three) small subsidiary teeth of nearly equal size, and tertiary veins that terminate directly at each principal sinus. However, the preservation of the type specimens on which these names are based is insufficient to verify this distinction, and in our observations of a similar extant species, *Ulmus americana*, we found that in a single leaf, tertiary veins may either terminate or fork at the sinus. We concur with Knowlton (1902) and LaMotte (1952) in considering that the characters of this leaf type are within the range of variability of a single species.

Although *U. speciosa* is best represented at its type assemblage at Painted Hills, it is now also known from a few specimens at Fossil, Iron Mountain, and Crooked River.

ADDITIONAL SPECIMENS: UCMP 12721, 12722, 12728; UF 10758, 10761; USNM 9367, 458391.

OCCURRENCE: Painted Hills, Fossil, Iron Mountain, Crooked River.

Ulmus sp. 1
(leaf)
(Plate 19, figs. 1–5)

Ulmus speciosa auct. non Newberry, 1883, U.S. Nat. Mus. Proc. 5, p. 507; 1898, *pro parte*, U.S. Geol. Surv. Monogr. 35, p. 80, pl. 45, fig. 8 only.

Ulmus paucidentata auct. non H. V. Smith. Tanai and Wolfe, 1977, *pro parte*, U.S. Geol. Surv. Prof. Paper 1026, p. 6–7, pl. 2, fig. G (illustrated Twickenham specimen only).

DISCUSSION: Some leaves from the Painted Hills assemblage differ from those of *Ulmus speciosa* in being smaller and narrower (length to width ratio 2.1–3.0) and in having a cuneate base and fewer subsidiary teeth. Tanai and Wolfe (1977) assigned such leaves, including specimens from Painted Hills and Twickenham, to *Ulmus paucidentata*, a species based on material from the Miocene Thorn Creek flora of Idaho (Smith, 1939). It is likely that the

Bridge Creek material may represent a taxon distinct from the Miocene species. We have not closely reexamined the Twickenham or Thorn Creek material. It is justifiable to recognize species of *Ulmus* based in part on leaf size because certain extant species of elms (e.g., *U. pumila*, *U. parvifolia*, and *U. alata*) have only small leaves.

SPECIMENS: UCMP 12723–12726; UF 10173; UO 2734.

OCCURRENCE: Painted Hills, Crooked River.

Ulmus sp. 2
(leaf)
(Plate 20, figs. 1–4)

DISCUSSION: Among the ulmaceous foliage from the assemblage at Fossil, leaves are frequently encountered that overlap with *Ulmus speciosa* in lamina shape and size, but which are distinguished by primary teeth that are broader and have few (none to two) subsidiary teeth and by a tendency for fewer pairs of secondaries (10–14 versus 16–18). The marginal serration of these leaves is similar to that of *Ulmus* sp. 1, but the leaves differ in their wider shape (length to width ratio 1.3–2.0), generally larger size, and less cuneate base. The leaves at Fossil range to a very large size (11 cm wide and at least 20 cm long in UF 10760).

SPECIMENS: UCMP 10727; UF 10521, 10522, 10634, 10760.

OCCURRENCE: Fossil, Cove Creek (Pentecost Ranch).

Ulmus sp. A
(fruit)
(Plate 21, figs. 3, 5)

DESCRIPTION: Fruit stipitate with an elliptical, flattened seed body (4.8–6.3 mm long, 3–4.5 mm wide) and a pair of free, elongate stigmatic arms 2–3 mm long at the fruit apex and a persistent synsepalous calyx 4 mm long and 4 mm wide; stipe 5 mm long; wing not developed.

DISCUSSION: This type of fruit, with protruding styles and lacking a well-defined wing, closely resembles that of *Ulmus* section *Chaetoptelea* and is also known from the Clarno Formation and other Eocene localities in western North America (Manchester, 1989a).

Fruits of *Ulmus* are rare in the Bridge Creek flora and previous reports of *Ulmus* fruits from the flora have been found to be incorrect. Those formerly called *Ulmus speciosa* (Newberry, 1898; Chaney, 1927) are now known to represent fruit valves of the tiliaceous genus *Craigia* (Kvaček et al., 1991). Reexamination of the fruit illustrated as *Ulmus brownellii* by Chaney (1927, pl. 13, fig. 4) indicates that it is not ulmaceous but rather an example of *Potanospira fryi*. Considering the abundance of *Ulmus* foliage at the Painted Hills assemblage, it is noteworthy that no fruits have been found in co-occurrence. Conversely, most of the fruits have been recovered from the Crooked River assemblage, where foliage is relatively rare.

7037

✓ dmj SPECIMENS: UF 7307, 10757.
OCCURRENCE: Crooked River.

Ulmus sp. B
(fruit)
(Plate 21, figs. 1, 2, 4)

DESCRIPTION: Fruits stipitate with a well-developed wing surrounding the elliptical seed body; stigmatic notch present at apex of wing, but without free stigmatic arms. The fruit body (minus the stipe) 8.4–9.5 mm long, 5.5–6.3 mm wide, the elliptical central body 5–6 mm long, 2.6–3.3 mm wide; stipe 2.3–4.5 mm long, persistent calyx 3.5 mm high and 3.5 mm wide.

DISCUSSION: The fruit type is distinguished from *Ulmus* sp. A by the prominent wing surrounding the fruit body. This is one of the earliest examples of *Ulmus* fruits with substantial wings, like those of most extant species. These specimens are similar to the fruits associated with foliage of *Ulmus pseudo-fulva* from the Eocene of Chalk Bluffs, California (MacGinitie, 1941; Manchester, 1989a) and with *Ulmus tenuinervis* from Florissant (MacGinitie, 1953; Manchester, 1989a).

SPECIMENS: UF 10171, 10569, 10830.

OCCURRENCE: Crooked River, Fossil.

"Zelkova" hesperia Brown 1946
(leaf)
(Plate 16, figs. 13, 14)

Zelkova hesperia Brown 1946, J. Wash. Acad. Sci. 36, p. 346, fig. 3.

DISCUSSION: The single specimen on which the above assignment is based resembles leaves of extant *Zelkova* in the absence of subsidiary teeth and in tooth shape and venation. The teeth are broad, with rounded basal flanks, and the secondary veins tend to fork as often seen in extant species of *Zelkova*. Although the similarity of the single fragmentary leaf to those of *Zelkova* would seem to substantiate Brown's assignment, the specimen may instead represent a variant of *Ulmus* or *Cedrelospermum*. Seedling leaves of *Ulmus americana* are simply serrate. The lamina is broader than those typical of *Cedrelospermum*.

The fossil record of *Zelkova* foliage in western North America was reviewed by Burnham (1986), who considered that the genus is present in western North American Tertiary floras. However, many of the specimens illustrated in the literature are actually *Cedrelospermum* (Manchester, 1989b). As yet, no fruits have been found to prove the determination, although they are common in the Tertiary of Europe and Asia (Manchester, 1989a).

Zelkova is a genus of five to seven extant species of deciduous trees or shrubs distributed in southeastern Europe and in western and eastern Asia.

SPECIMEN: USNM 42365.

OCCURRENCE: Crooked River.

Family FAGACEAE

Fagus pacifica Chaney

(leaf, fruit)
(Plate 21, figs. 6–10, Plate 22, figs. 1–6)

Fagus pacifica Chaney, 1927, Carnegie Inst. Wash. Pub. 346, p. 108–109, pl. 10, figs. 6–9. Brown, 1937, J. Wash. Acad. Sci. 27, p. 508, fig. 11. Manchester and Meyer, 1987, Oreg. Geol. 49, p. 118 and 121, figs. 4G–I.

DISCUSSION: The presence of beech trees in the Bridge Creek flora is documented by leaves, cupules, and nuts. The leaves can be distinguished by their usually ovate shape, acute apex, serrate margin, sharply acute teeth fed by relatively straight craspedodromous secondary veins, and broadly rounded sinuses (pronounced on the concave upper flanks of teeth). The leaves lack the marginal vein seen in the Bridge Creek species of *Quercus*. Typically, the margin has just one tooth per secondary vein, but subordinate teeth occasionally occur, each fed by a tertiary vein arising abmedially from the secondary vein close to the margin (pl. 22, fig. 5). The woody cupules are elliptical to ovate, 13–20 mm long, 12–13 mm wide, four-valved (pl. 21, fig. 9), borne on a peduncle, and covered with recurved prickly appendages up to 4 mm long (pl. 21, figs. 7, 8, 10). The nut is elongate, acute at the apex, rounded at the base, and evidently triangular in cross section, with a narrow wing along each of the longitudinal margins (pl. 21, fig. 6). Complete specimens from Fossil show that the peduncle was up to 20 mm in length (pl. 21, fig. 7), longer than the cupule itself.

The foliar architecture, cuticular anatomy, and aspects of fruit morphology of modern and fossil species of *Fagus* were recently reviewed in considerable detail with illustrations of leaf clearings and epidermal preparations as a basis for interpreting the fossil record and evolution of this genus (Kvaček and Walther, 1991, 1992). Kvaček and Walther divided extant species of *Fagus* into four groups based on foliage and fruit characters. Because its leaves have distinct teeth and the fruits have relatively short peduncles (one to two times the length of the cupule), *Fagus pacifica* is most similar to groups 2 and 3. (Group 2 includes the extant Asian species *Fagus hayatae*, *F. pashanica*, *F. lucida*, and *F. chienii*, and group 3 includes the extant North American species *F. grandifolia* and *F. mexicana*.) Among extant species, true craspedodromy, as encountered in *F. pacifica*, prevails in the American *Fagus grandifolia–F. mexicana* complex and in the Chinese species *F. hayatae*. The fossil differs from other extant species in a variety of characters. Some have much longer peduncles (e.g., *F. engleriana*, *F. longipetiolata*, *F. multinervis*, and *F. japonica*), and some have more flattened scale-like appendages on the cupule. The leaves of most species have less pronounced teeth and semicraspedodromous to camptodromous venation. The occasional presence of intercalated teeth is a feature shared with leaves of extant *F. pashanica*.

The Bridge Creek occurrence represents the earliest known unequivocal record of *Fagus* substantiated by fruits. The genus extends into the Miocene in the western United States and is first documented in the upper Oligocene of

Europe and Asia. The 10–15 extant species of beech are moderate to tall deciduous trees native to eastern North America, Europe, and southeast Asia.

NOMENCLATURE: *Fagus pacifica* Chaney was originally described from Bridge Creek material, but was later synonymized by LaMotte (1952) with *Fagus bonnevillensis*. We have examined the fragmentary type specimen of *Fagus(?)bonnevillensis* Chaney from the Eagle Creek flora and consider that the curvature of the secondary veins dismisses it from *Fagus*; it may belong to *Toxicodendron* (J. A. Wolfe, pers. comm., 1995). Hence, we retain the original name of *F. pacifica* for the Bridge Creek material. LaMotte (1952) listed various Miocene occurrences of *F. pacifica* along with other species of *Fagus* that he synonymized with *F. bonnevillensis*. A reevaluation of many Tertiary records is needed to determine the validity of the reported occurrences of *F. pacifica* in floras other than Bridge Creek.

UF 7010

ADDITIONAL SPECIMENS: UF 10214, a 10222, 10597, 10598, 10923 (leaves). UF 25197, USNM 9213 (nuts). UF 7035, 10215, 10636, 10637, 10776 (cupules).

a

OCCURRENCE: Painted Hills (nut), Fossil (leaves and cupules), Crooked River (leaves and fruits), Butler Basin (leaves).

Genus *Quercus*

The oaks are represented by both leaves and acorns at several Bridge Creek localities. Two species are recognized, although their probable co-occurrence at Painted Hills indicates that morphologic overlap may occur between them. This may be complicated by hybridization, which is common among extant species of *Quercus*. An earlier report of *Castanea* (Chaney, 1927) was based on leaves that are similar to both *Quercus* and *Castanea*; however, the absence of chestnut fruits and the presence of a marginal vein in the leaves supports their placement in *Quercus*. Although lobed oaks are known from the Oligocene of Texas (Daghlian and Crepet, 1983), they are not present in the pre-Miocene of western North America.

Oak leaves and acorns are common at the classic Bridge Creek locality at Painted Hills. Two of the critical type specimens designated by Lesquereux (1883, pl. 54, fig. 9; illustrated here in pl. 23 fig. 1) and Newberry (1898, pl. 49, fig. 5; illustrated here in pl. 24, fig. 1) are too poorly preserved to show critical diagnostic characters for evaluation. The difficulty in evaluating these early type specimens leaves some doubt in our resolution of nomenclatural problems. Some of the other *Quercus* leaf specimens illustrated by Lesquereux (1883) and Newberry (1898) are provisionally assigned as cf. *Quercus consimilis* in the Appendix, although they are not formally placed into synonymy below.

The oaks include 450–600 species of both deciduous and evergreen trees and shrubs. They are widely distributed in the middle to low latitudes of North America, Europe, Asia, and Malesia as well as in northern Africa and western South America.

Quercus berryi Trelease
(leaf)
(Plate 23, figs. 1–17)

Quercus breweri auct. non Engelmann. Lesquereux, 1883, *pro parte*, Rept., U.S. Geol. Surv. Terr. 8, p. 246, pl. 54, fig. 9 only.

Quercus berryi Trelease, 1918, pro parte, Brooklyn Botanic Garden Mem. 1, p. 499 (new name assigned by Trelease to *Q. breweri* Lesquereux, same specimens as above).

Quercus clarnensis auct. non Trelease. Chaney, 1927, *pro parte*, Carnegie Inst. Wash. Pub. 346, p. 111–112; pl. 10, figs. 10–13; pl. 11, figs. 1–6, 9, 1 (not including the synonymies).

SUPPLEMENTARY DESCRIPTION: Lamina usually elliptical to obovate, sometimes slightly ovate; apex acute; base acute to occasionally rounded; length 1.8–8.5 cm, width 0.5–3.2 cm, length to width ratio 1.7–5.1; petiole normal to inflated (especially near its base), length 0.1–0.6 cm; margin usually serrate to occasionally entire, often serrate in upper two-thirds of lamina and entire below; teeth usually distinctly concave to sometimes nearly straight on apical side, convex to straight on basal side, tooth apex acute and often asymmetrical, secondary vein enters tooth along upper side or medially; sinuses rounded to angular; venation pinnate, craspedodromous (where serrate) to brochidodromous or eucamptodromous (where entire); primary vein stout, straight to curved; secondary veins moderately acute, occasional abnormal veins widely acute to obtuse, 8–14 (usually 12) pairs, course sinuous to curved, rarely branched; intersecondaries rare; tertiaries weakly percurrent to reticulate, typically arising at nearly right angles from both upper and lower sides of secondaries; quaternaries reticulate, often orthogonal, apparently forming areoles; quinternaries giving rise to straight or rarely curved veinlets; fimbrial vein forms the margin.

DISCUSSION: *Quercus berryi* is most common in the Crooked River and Lost Creek assemblages, although a few apparently conspecific specimens are known from the Painted Hills assemblage. *Q. berryi* is highly variable in size, shape, length to width ratio, and margin. It is distinguished from the other Bridge Creek oak, *Quercus consimilis*, by having the following characters: (1) the shape and size are more variable, especially toward being more obovate and smaller (although the shape and size of some specimens fall within the range of *Q. consimilis*); (2) the petiole is typically shorter; (3) the margin is sometimes more irregular; (4) the secondary veins typically diverge from the midrib at more variable angles, each following an irregular (usually sinuous) course that sometimes differs from that of adjacent secondaries; (5) the tertiary veins are not strongly percurrent, straight, and evenly spaced as in *Q. consimilis*, but tend to be weakly percurrent to reticulate and more sinuous and variably spaced; and (6) the higher vein orders are distinct to the fifth order and form a fine reticulum. Both *Q. berryi* and *Q. consimilis* are variable morphologically, and in some instances their characters appear to intergrade. It is possible that hybridization, common in extant oaks, may account for this morphologic intergradation at localities where both species occur.

NOMENCLATURE: The name *Quercus breweri* was assigned by Lesquereux to five specimens from the Painted Hills assemblage. Later, Trelease recognized that the name was preoccupied and assigned the new name *Q. berryi*, but no lectotype was designated. We consider that three of these specimens are *Q. consimilis*, one is missing, and the remaining one is hereby designated as the lectotype (see below), which is apparently conspecific with the species common at Crooked River and treated by Chaney (1927) as *Quercus clarnensis*. This Crooked River species is distinct from *Q. consimilis* based on examinations of large suites of newly collected material, and although tertiary and higher order venation is not preserved in the lectotype of *Q. berryi*, this specimen appears to conform to this group and provides the oldest available epithet. The name *Q. clarnensis* Trelease was given as a new name for *Quercus affinis* (Newberry) Knowlton because the latter was a preoccupied name. We consider that the type of this species (originally *Fraxinus affinis* Newberry, USNM 7125), although poorly preserved and lacking diagnostic characters, is a specimen of *Q. consimilis* Newberry.

LECTOTYPE: We designate the lectotype as UCMP 1774 (Lesquereux, 1883, pl. 54, fig. 9; reillustrated here as pl. 23, fig. 1).

ADDITIONAL SPECIMENS: UCMP 12668–12669; UF 10188–10208, 10210, 10211, 10537–10544; USNM 458392.

OCCURRENCE: Painted Hills, Crooked River, Lost Creek.

Quercus consimilis Newberry
(leaf)
(Plate 24, figs. 1–8)

Quercus consimilis Newberry, 1883, U.S. Nat. Mus. Proc. 5, p. 505; 1898, *pro parte*, U.S. Geol. Surv. Monogr. 35, p. 71, pl. 43, figs. 2–5 only. Manchester and Meyer, 1987, Oreg. Geol. 49, p. 121, figs. 4J,K.

Quercus simplex Newberry, 1883, U.S. Nat. Mus. Proc. 5, p. 505; 1898, U.S. Geol. Surv. Monogr. 35, p. 78, pl. 43, fig. 6.

Fraxinus affinis Newberry, 1883, U.S. Nat. Mus. Proc. 5, p. 510; 1898, U.S. Geol. Surv. Monogr. 35, p. 127, pl. 49, fig. 5.

Quercus breweri auct. non Engelmann. Lesquereux, 1883, *pro parte*, Rept., U.S. Geol. Surv. Terr. 8, p. 246, pl. 54, figs. 6–7 only.

Quercus berryi Trelease *pro parte*, 1918, Brooklyn Botanic Garden Mem. 1, p. 499 (new name assigned by Trelease to *Q. breweri* Lesquereux, same specimens as above).

Quercus affinis (Newberry) Knowlton, 1902, U.S. Geol. Surv. Bull. 204, p. 45.

Quercus clarnensis Trelease, 1918, Brooklyn Botanic Garden, Mem. 1, p. 499.

Castanea orientalis Chaney, 1927, Carnegie Inst. Wash. Pub. 346, p. 110, pl. 12, figs. 1, 4.

SUPPLEMENTARY DESCRIPTION: Lamina elliptical to slightly ovate; apex acute to attenuate; base normal to cuneate acute, sometimes asymmetrical; length 3.8–14+ cm, width 1.2–4.0 cm, length to width ratio 3.0–6.8; petiole 0.9–1.6 cm, normal to inflated (especially near its base); margin serrate to entire, sometimes with only occasional teeth, teeth typically more numerous in upper two thirds of lamina; teeth concave to rarely straight on apical side, straight to slightly convex on basal side; sinuses rounded; venation pinnate, craspedodromous (where serrate) to eucamptodromous or weakly brochidodromous (where entire); primary vein stout, curved; secondaries acute (35–65°), 10–24 pairs, straight to slightly curved, rarely branched; tertiaries percurrent, straight to slightly sinuous, sometimes forked, arising at widely acute to nearly right angles from lower sides of secondaries and at obtuse to nearly right angles from upper sides of secondaries; quaternaries reticulate; quinternaries indistinct, apparently forming areoles.

DISCUSSION: This species is a dominant element in the Painted Hills assemblage and is also present in less abundance at all other Bridge Creek assemblages. These leaves are similar to those of extant *Quercus* subgenus *Lepidobalanus* in their elongate-elliptical nonlobed shape, many parallel secondary veins, and occasional presence of spinose teeth.

The specimens that Chaney (1927) attributed to *Castanea orientalis* from the Crooked River and Butler Basin assemblages are included in our description of *Quercus consimilis*. The well-developed fimbrial vein seen in the better preserved material is typical of most extant sections of *Quercus* and occurs only rarely in *Castanea* (e.g., *C. henryi*). Acorns are common at the localities where these leaves are abundant, whereas the distinctive cupules of *Castanea* have not been recovered from any of the Bridge Creek localities.

NOMENCLATURE: The name *Quercus consimilis* Newberry has page priority over other synonymous species of *Quercus* described by Newberry. He also included acorns and cupules that we refer to *Quercus* spp. (fruit; see below). The leaf specimen of Newberry's pl. 43. fig. 2 is here selected as the lectotype.

The specimens illustrated by Lesquereux (1883; pl. 53, figs. 9–12; pl. 54, fig. 4; pl. 54, figs. 5, 8) as *Quercus furcinervis* Rossm., *Q. drymeja* Unger, and *Q. breweri* Lesquereux, respectively, might be *Q. consimilis*, but they have been excluded from the above synonymy because the specimens are missing from the UCMP collections and Lesquereux's illustrations are insufficient for adequate diagnosis.

LECTOTYPE: We designate the lectotype as USNM 7058 (Newberry, 1898, pl. 43, fig. 2; reillustrated here as pl. 24, fig. 1); not USNM specimens 7058A or 7058B, which are Newberry's *Quercus simplex* and *Betula heterodonta*, respectively.

ADDITIONAL SPECIMENS: UCMP 12664–12667; UF 7011, 10516.

OCCURRENCE: Painted Hills, Fossil, Cove Creek (Knox Ranch), Iron Mountain, Crooked River, Lost Creek, Butler Basin.

Quercus spp.
(fruit)
(Plate 21, figs. 11–16)

Quercus consimilis Newberry, 1883, U.S. Nat. Mus. Proc. 5, p. 505; 1898, *pro parte*, U.S. Geol. Surv. Monogr. 35, p. 71, pl. 43, figs. 7–10 only.

Quercus furcinervis auct. non (Rossm.) Unger. Lesquereux, 1883, Rept., U.S. Geol. Surv. Terr. 8, p. 244, pl. 53, fig. 8.

Quercus cupule Manchester and Meyer, 1987, Oreg. Geol. 49, p. 121, fig. 4L.

DISCUSSION: Acorns are present in five of the Bridge Creek assemblages and are preserved as complete nuts as well as isolated caps that substantiate the presence of *Quercus* in the flora. Scales of the cupule are helically arranged (pl. 21, fig. 14), indicating affinities with subgenus *Erythrobalanus* or *Lepidobalanus*, but are not fused into concentric circles (a feature of *Lithocarpus* and *Quercus* subgenus *Cyclobalanopsis*). Specimens range in size and in the extent to which the nut is covered by the cupule; however, we have not attempted a full systematic treatment of these fruits. The correspondence of acorn morphotypes with the two Bridge Creek leaf species has not been documented. It is noteworthy that the three specimens of acorns known from Fossil (e.g., pl. 21, fig. 16) are about twice as large as the largest specimens from other assemblages, yet the foliage from Fossil is virtually identical to that of *Quercus consimilis*.

Although the type material on which Newberry based his description of *Q. consimilis* included as many specimens of acorns as leaves, we have chosen a leaf as the lectotype for the species because the epithet has been applied widely to foliage rather than nuts from other middle Tertiary floras (LaMotte, 1952).

SPECIMENS: UCMP 12670, 12671; UF 10213, 10216. acorns

OCCURRENCE: Painted Hills, Fossil, Iron Mountain (P-4210), Crooked River, Lost Creek.

Family BETULACEAE

Genus *Alnus*

Leaves and infructescences of *Alnus* are among the most common dicotyledonous remains in the Bridge Creek flora. Suites of alder leaf specimens from individual localities have a range of variability within which separate species might be described, yet the nearly continuous range of leaf forms suggests intergrading morphologies within highly variable species. Previously, the Bridge Creek alders have been treated both by taxonomic splitting (e.g., Knowlton, 1902; Klucking, 1959) and by lumping into a single species (Chaney, 1925a, 1927). Klucking's revision of western North American fossil Betulaceae recognized four alder species from the Bridge Creek flora. We conservatively recognize two distinct species of *Alnus*. In addition, several variant leaf forms that have not been assigned to either species are also illustrated.

Alnus is a genus of deciduous trees and shrubs that is widespread in North America, Europe, Asia, western South America, and northernmost Africa. Alders typically grow in wet habitats, and their abundance in the Bridge Creek flora is probably due to their dominance around the margins of the lake basins. Most species are pioneers in early successional stages following burning or cutting (Furlow, 1979). This may be another factor accounting for their abundance in the flora if sites around the depositional basins had been disturbed by volcanic activity or fire.

Alnus heterodonta (Newberry) n. comb.

(leaf)

(Plate 25, figs. 1–9; Plate 26, figs. 1–4)

Betula heterodonta Newberry, 1883, U.S. Nat. Mus. Proc. 5, p. 508–509; 1898, *pro parte,* U.S. Geol. Surv. Monogr. 35, p. 64, pl. 44, figs. 1–4, pl. 45, fig. 1 only. Knowlton, 1902, U.S. Geol. Surv. Bull. 204, p. 41.

Populus polymorpha Newberry, 1883, U.S. Nat. Mus. Proc. 5, p. 506; 1898, U.S. Geol. Surv. Monogr. 35, p. 50–51, pl. 46, figs. 3, 4, pl. 47, fig. 4, pl. 49, figs. 4, 7–9.

Betula heteromorpha Knowlton, 1902, U.S. Geol. Surv. Bull. 204, p. 39–40, pl. 3, figs. 6, 7, pl. 5, fig. 1.

Betula bendirei Knowlton, 1902, U.S. Geol. Surv. Bull. 204, p. 40, pl. 4, fig. 2.

Alnus macrodonta Knowlton, 1902, U.S. Geol. Surv. Bull. 204, p. 42, pl. 4, fig. 1.

Quercus oregoniana Knowlton, 1902, U.S. Geol. Surv. Bull. 204, p. 47, pl. 6, figs. 2, 3, pl. 7, fig. 1.

Alnus holandiana auct. non Jennings. Manchester and Meyer, 1987, *pro parte,* Oreg. Geol. 49, p. 121, fig. 5A only.

SUPPLEMENTARY DESCRIPTION: Lamina ovate to elliptical; apex acute, rarely slightly acuminate; base rounded, obtuse, cordate, or rarely acute, often asymmetrical; length 1.9–10.5+ cm, width 1.7–7.6 cm; length to width ratio 1.1–2.3; petiole 0.3–2.8 cm; margin serrate, apparently sometimes revolute; primary teeth typically convex or acuminate (sometimes straight) on both apical and basal sides, angle between the trend of the apical and basal sides typically obtuse to right angled but sometimes acute, secondary vein enters tooth medially and often bends down or sometimes up; secondary teeth of variable size (no distinct tertiary teeth), usually serrate but rarely crenate, straight to convex or acuminate on both apical and basal sides, sometimes situated along the lower flanks of large primary teeth; sinuses angular, typically acute or sometimes right angled; venation pinnate, craspedodromous; primary vein moderate, straight to slightly curved; secondaries narrowly to moderately acute (30–55°), angle often increasing slightly toward apex, six to nine pairs, straight to curved; tertiaries percurrent, usually convex to sometimes straight, sometimes slightly sinuous, occasionally forked, one to three tertiaries often arise from distal one-quarter of secondaries and feed directly into teeth or sinuses, the lower of these marginal tertiaries often joins at obtuse to right angles with a tertiary vein approximately parallel to the margin and arising from the upper side of the next lowest pair of secondaries; quaternaries percurrent between the tertiaries to reticulate; quinternaries reticulate and form areoles; 6° veinlets freely ending, once or twice branched.

DISCUSSION: *Alnus heterodonta* is one of the most common and ubiquitous species in the Bridge Creek flora. It has a variable morphology, particularly in the range of diversity seen in the base and the teeth. The lectotype has a widely ovate form with an elongated, acute apex, while more typical specimens are more nearly elliptical with a broad acute apex. The marginal serration varies from large primary teeth that are divided along their lower flanks by subsidiary teeth, to secondary teeth that occur below the flanks of the primary teeth.

The variability of this species may be even greater if certain of the other alder leaf forms (e.g., pl. 29, figs. 1–3) are considered to represent the same species.

LECTOTYPE: From the syntypes originally designated, we select USNM 7072 (Newberry, 1989, pl. 44, fig. 2; reillustrated here as pl. 25, fig. 1) as the lectotype.

ADDITIONAL SPECIMENS: UCMP 12676–12682, 12826. UF 10167, 10218, 10221, 10226, 10227, 10235, 10244, 10254, 10556–10558, 10565–10568.

OCCURRENCE: Painted Hills, Fossil, Cove Creek (Knox Ranch, Pentecost Ranch), Iron Mountain, Crooked River, Lost Creek, Butler Basin.

Alnus newberryi n. sp.
(leaf)
(Plate 27, figs. 1–4; Plate 28, figs. 1–3)

Alnus holandiana auct. non Jennings. Manchester and Meyer, 1987, *pro parte,* Oreg. Geol. 49, p. 121, fig. 5B only.

DIAGNOSIS: Lamina elliptical to sometimes slightly ovate; apex acuminate; base obtuse, slightly curved and asymmetrical; length 5.2–12 cm, width 2.8–6.6 cm; length to width ratio 1.8–2.4; petiole length 1.5–3.0 cm; margin serrate; teeth usually convex (sometimes straight or acuminate) on apical side, convex to concave on basal side, acute to rounded at apex, darkened and apparently glandular at the tip, indistinctly compound with zero to four usually smaller teeth between those fed by secondaries;secondary or tertiary veins usually enter teeth medially or apically (sometimes basally); sinuses angular (nearly right-angled) to acuminate, occasionally entered by a tertiary or rarely secondary vein; venation pinnate, craspedodromous; primary vein moderate, straight to curved; secondaries usually acute (~40–55°), seven to nine pairs, straight to curved; tertiaries percurrent, straight to slightly convex, often slightly sinuous, occasionally forked, often the outermost percurrent tertiary has a distinct angular bend where another tertiary arises and extends to the margin, one to three normal to strong tertiaries often arise on basal side of the distal one-half of secondaries and feed directly into teeth; quaternaries and quinternaries reticulate, often orthogonal; 6° forms veinlets, indistinct.

DISCUSSION: This species is distinguished from other Bridge Creek alders by its smaller, often more rounded teeth, acuminate apex, and sometimes longer petiole. It is known from the assemblages at Painted Hills and Fossil.

ETYMOLOGY: This species is named for John S. Newberry in recognition of his early contributions to the study of the Bridge Creek flora and the geologic reconnaissance of the western United States.

HOLOTYPE: UF 7015. The holotype is with Manchester & Meyer (1987)

PARATYPES: UCMP 12683–12686, 12729; UF 10559, 10560.

OCCURRENCE: Painted Hills, Fossil.

Alnus spp.

(variable leaf morphotypes)
(Plate 29, figs. 1–3)

The above descriptions of *Alnus heterodonta* and *Alnus newberryi* are conservative in the characters used to circumscribe these species. Some specimens do not conform to the these two species as described. These may represent variants of the *A. heterodonta* type, although we are hesitant to include them in that species.

SPECIMENS: UF 10168, 10224, 10232.

OCCURRENCE: Iron Mountain, Crooked River.

Alnus spp.

(infructescence, fruit, staminate catkin)
(Plate 29, figs. 4–12)

Alnus sp.? Newberry, 1898, U.S. Geol. Surv. Monogr. 35, p. 67, pl. 46, fig. 7.
Alnus carpinoides Lesquereux, 1883, U.S. Geol. Surv. Terr., 8, p. 243, pl. 51, fig. 4a.
Alnus seed catkin Manchester and Meyer, 1987, Oreg. Geol. 49, p. 121, fig. 5C.
Alnus holandiana auct. non Jennings Manchester and Meyer, 1987, *pro parte*, Oreg. Geol. 49, p. 121, fig. 5D.

DISCUSSION: The cone-like infructescences of *Alnus* (pl. 29, figs. 4, 11, 12) are common at most localities. Isolated fruits showing the pair of lateral wings and two styles (pl. 29, fig. 6) are also present but probably are often overlooked because of their small size. Pollen catkins are also abundant (pl. 29, figs. 5, 7–10), and some of the specimens from Crooked River have the pollen sacs preserved with intact *Alnus* pollen. We have not attempted to distinguish species, but it is likely that these include representatives of both *Alnus heterodonta* and *Alnus newberryi*.

SPECIMENS: UCMP 12687; UF 10236, 10245, 10699–10706 (infructescences). UF 10230a, 10392, 10843, 10850b, 10853 (pollen catkins). UF 10811 (fruit).

OCCURRENCE: Painted Hills, Fossil, Cove Creek (Knox Ranch), Iron Mountain, Crooked River, Lost Creek.

Betula angustifolia Newberry

(leaf, bract, fruit)
(Plate 30, figs. 1–9)

Betula angustifolia Newberry, 1883, U.S. Nat. Mus. Proc. 5, p. 508; 1898, U.S. Geol. Surv. Monogr. 35, p. 63–64; pl. 46, fig. 5; pl. 47, fig. 5. Knowlton, 1902, U.S. Geol. Surv. Bull. 204, p. 41.
Alnus serrulata fossilis Newberry, 1898, U.S. Geol. Surv. Monogr. 35, p. 66–67, pl. 46, fig. 6. Knowlton, 1902, U.S. Geol. Surv. Bull. 204, p. 42.
Alnus carpinoides Lesquereux, 1883, pro parte, U.S. Geol. Surv. Terr., 8, p. 243; pl. 51, fig. 5 only.

Betula heterodonta Newberry, 1898, *pro parte*, U.S. Geol. Surv. Monogr. 35, p. 64–65, pl. 45, fig. 6 only.

SUPPLEMENTARY DESCRIPTION: Lamina ovate; apex acute; base obtuse, often decurrent and acute just above the petiole, typically asymmetrical; length 6.5–10.7 cm, width 2.7–4.8 cm, length to width ratio 1.5–2.5; petiole length 1.5 cm; margin serrate; teeth usually acuminate (sometimes straight, concave, or convex) on both apical and basal sides, indistinctly compound, four to six teeth between those fed by secondaries generally smaller but of variable size, secondary or tertiary veins enter teeth medially or basally; sinuses angular, acute; venation pinnate, craspedodromous; primary vein moderate, straight to slightly curved; secondaries narrowly to moderately acute (25–60°), apical pairs more acute than basal, often decurrent at divergence from midvein (especially in basal half of lamina), 8–12 pairs, typically straight, sometimes slightly curved; tertiaries percurrent, slightly convex and sinuous, occasionally forked, typically three tertiaries arise nearly perpendicular to the midvein from the distal one-quarter of secondaries and feed directly into teeth; quaternaries and quinternaries reticulate, usually orthogonal. Fruiting bracts 5–6 mm long, 2.5–3 mm wide, trilobed, length from base to apex of central lobe 5–6.5 mm, from base to apex of lateral lobes, 3–5 mm. Fruits winged, roughly circular in outline, 4.5 mm long and wide; nutlet narrow obovate, 3.5 mm long, 1.5 mm wide, adjoined by a pair of lateral wings, apex of nutlet with a pair of divergent 0.8-mm stigmatic arms.

DISCUSSION: Newberry (1898) was the first to recognize *Betula* in the Bridge Creek flora, although the leaves of his material have also been referred to *Alnus* (e.g., Klucking, 1959). The leaves (pl. 30, figs. 1–6), trilobed bracts (pl. 30, fig. 7), and bi-winged fruits (pl. 30, figs. 8, 9) of *Betula angustifolia* Newberry are known only from the Painted Hills assemblage. The diagnostic trilobed bracts, found in association with the leaves and fruits, confirm the determination as *Betula*.

B. angustifolia leaves can be distinguished from other Betulaceae of the Bridge Creek flora by the following characters: (1) Secondaries follow a straighter, less arcuate course than those of the Bridge Creek species of *Alnus* and *Ostrya*. (2) They possess more pairs of secondaries than alders, but fewer than *Paracarpinus*. (3) The teeth are not distinctly compound. (4) Tertiaries arising from distal secondaries consistently tend to feed directly into teeth; tertiaries close to and paralleling the margin are not present. This is one of the most important characters for distinguishing these leaves from those of the alders, although this tendency also occurs in *Paracarpinus* and *Ostrya*. (5) There are more teeth between secondaries, especially as compared to the Bridge Creek species of *Alnus*. (6) Tooth apices are not as long and extended as those of *Ostrya*. (7) The tooth apices are darkened and apparently glandular.

These characters establish that the leaves of *B. angustifolia* are recognizably distinct from those of other Bridge Creek Betulaceae. Although many of these leaf characters are found among extant species of both genera, we support Newberry's original assignment to *Betula* because these leaves, together with the diagnostic *Betula* fruiting bracts, are known only from the Painted Hills assemblage.

The birches are a genus of about 60 species of deciduous trees and shrubs distributed widely throughout the middle and high latitudes of the Northern Hemisphere. The genus is not known from older floras of the John Day Basin, but it is well-documented on the basis of leaves, inflorescences, pollen, bracts, and fruits from the Eocene of Princeton, British Columbia (Crane and Stockey, 1987). *Betula angustifolia* differs from the Princeton species, *B. leopoldae*, by having leaves with thinner secondary veins, fruits with wider wings, and smaller bracts (5–6 mm versus 7–11 mm long).

LECTOTYPE: From the original syntypes, we select USNM 7075 (Newberry, 1898, pl. 46, fig. 5; reillustrated here as pl. 30, fig. 1) as the lectotype.

ADDITIONAL SPECIMENS: UCMP 12673–12675 (leaves). USNM 458384–458386 (fruits). USNM 458386–458388 (bracts).

OCCURRENCE: Painted Hills.

Ostrya oregoniana Chaney
(leaf, fruit)
(Plate 31, figs. 1–7)

Ostrya oregoniana Chaney, 1927, Carnegie Inst. Wash. Pub. 346, p. 106, pl. 9, fig. 12, pl. 10, figs 1–4.

Carpinus grandis auct. non Unger. Chaney, 1927, *pro parte*, Carnegie Inst. Wash. Pub. 346, p. 105, pl. 9, fig. 11 only.

DISCUSSION: *Ostrya oregoniana* was first described by Chaney (1927) and is represented by well-preserved leaves and diagnostic fruits. It occurs only in the Crooked River assemblage. Although leaves of some species of *Ostrya* appear similar to *Carpinus* and *Paracarpinus*, the determination is confirmed by the presence of associated fruits with their characteristic bladder-like involucre enclosing the nutlet. Leaves of this species can be distinguished from *Paracarpinus chaneyi* by the secondaries that are gently curved and sometimes sinuous and which give rise to conspicuous abmedial branches (Meyerhoff, 1952; Manchester and Crane, 1987).

The presence of both leaves and fruits of *Ostrya* in the Bridge Creek flora provides the earliest unequivocal record for this genus in North America. The range of *Ostrya* prior to the Oligocene is not documented by fruits and remains questionable.

Ostrya is represented by seven to ten extant species of small- to medium-sized deciduous trees that are widely adapted and native to eastern and western North America, Central America, southern Europe, eastern Asia, and Japan.

ADDITIONAL SPECIMENS: UF 6099, 10258, 10260–10262 (leaves). UF 6100, 10257, 10270, 10281; USNM 458393, 458394 (fruits).

OCCURRENCE: Crooked River.

Genera *Asterocarpinus* and *Paracarpinus*

Foliage virtually identical to that of extant *Carpinus* occurs at all assemblages of the Bridge Creek flora except Painted Hills and has been placed in the organ genus *Paracarpinus* (Manchester and Crane, 1987). This genus was established to accommodate fossil leaves having a suite of characters typical of extant *Carpinus* but also encountered among other genera of the Betulaceae, such as extant *Ostrya carpinifolia*.

Carpinus fruits, with their distinctive enlarged, persistent bracts, are often preserved in fossil leaf deposits of Europe and Asia, but are absent from all of the Bridge Creek assemblages where the leaves of *Paracarpinus* occur. However, Manchester and Crane (1987) recognized a new genus of extinct betulaceous fruit, *Asterocarpinus*, that consistently co-occurs with *Paracarpinus* leaves in the Bridge Creek assemblages and in the late Eocene floras of Florissant, Colorado, and Grant, Montana. Although Manchester and Crane (1987) proposed that *Asterocarpinus* fruits were probably borne by plants that produced *Paracarpinus* foliage, they refrained from a formal assignment of these remains to the same genus and species for three reasons. First, none of the specimens shows the physical attachment required to prove unequivocally that the fruits and leaves are conspecific. Second, foliage conforming to *Paracarpinus* occurs on trees of some extant species of *Carpinus* and *Ostrya*; hence, the leaves alone do not provide the level of generic resolution available from fruits in the Betulaceae. Third, although *Paracarpinus* leaves of the Bridge Creek flora (*Paracarpinus chaneyi*) are readily distinguished from those of Florissant (*Paracarpinus fraterna*), the fruits from Bridge Creek belong to the same species as those at Florissant (*Asterocarpinus perplexans*).

Our investigation also supports the hypothesis that the Bridge Creek representatives of *A. perplexans* and *P. chaneyi* were produced by a single biological species, although they are treated individually below.

Asterocarpinus perplexans (Cockerell) Manchester and Crane
(fruit)
(Plate 32, figs. 2–5)

Asterocarpinus perplexans (Cockerell) Manchester and Crane, 1987, Bot. Gaz. 148, p. 267, figs. 1–17; Manchester and Meyer, 1987, Oreg. Geol. 49, p. 121, fig. 5F.

DISCUSSION: *Asterocarpinus* fruits are samaras with four or five (rarely six or seven) wings situated in the same plane and radiating from a central nutlet. The nutlet itself resembles that of *Carpinus*, in size and morphology. It is 2.5–3.5 mm long, ovate in face view, lensoid in cross section, and has 9–12 longitudinal surface ribs, a persistent epigynous perianth and a persistent style with two stigmatic arms. The wings are long-elliptical to oblanceolate and entire-margined with pointed apices, and have leaf-like venation consisting of a midvein and pinnately arranged secondary veins. Despite the similarity of *Asterocarpinus* nutlets and associated *Paracarpinus* foliage to those of extant *Carpinus* species, the peculiar radially arranged bract complex of *Astero-*

carpinus perplexans is markedly different from the single trilobed bract of *Carpinus* fruits.

The range of this genus extends from the upper Eocene to lower Oligocene in western North America. In addition, it is known from the latest Eocene or earliest Oligocene Bembridge flora of southern England (nutlet illustrated as "*Carpinus* sp." and involucre "*Abelia* sp. 4," *in* Reid and Chandler, 1926, pl. 6, fig. 10, and pl. 9, fig. 6). The genus is not known from Tertiary deposits of Asia.

ADDITIONAL SPECIMENS: UF 10585–10589.

OCCURRENCE: Fossil, Cove Creek (Pentecost Ranch), Iron Mountain, Crooked River, Lost Creek.

Paracarpinus chaneyi Manchester and Crane
(leaf)
(Plate 31, figs. 8–10; Plate 32, fig. 1)

Paracarpinus chaneyi Manchester and Crane, 1987, Bot. Gaz. 148, p. 267, figs. 26–31; Manchester and Meyer, 1987, Oreg. Geol. 49, p. 121, fig. 5E.

Carpinus grandis auct. non Unger. Chaney, 1927, *pro parte*, Carnegie Inst. Wash. Pub. 346, p. 105, pl. 9. figs. 6, 10 only.

DISCUSSION: Leaves of *Paracarpinus* have closely spaced craspedodromous secondary veins that are consistently straight and parallel to one another, with the basal two pairs of secondaries closer together at the midvein than any of the succeeding pairs. As they approach the margin, some of the secondaries give off one or two weak abmedial branches that enter teeth. Although the leaves of *Ostrya oregoniana* are common in the Crooked River assemblage, they can usually be distinguished with ease by the curved secondaries that frequently give off a series of strong abmedial branches to the margin (pl. 31, fig. 2).

This is one of the most abundant leaf types at Fossil, Cove Creek, Iron Mountain, and Lost Creek, falling behind only *Metasequoia* and *Alnus* in relative abundance. Its absence from the Painted Hills assemblage is striking. *Paracarpinus chaneyi* leaves and *Asterocarpinus perplexans* fruits co-occur at all assemblages of the Bridge Creek flora except Painted Hills.

ADDITIONAL SPECIMENS: UF 10512, 10259, 10590.

OCCURRENCE: Fossil, Cove Creek (Knox Ranch, Pentecost Ranch), Iron Mountain, Crooked River, Lost Creek.

Family MYRICACEAE

Comptonia columbiana Dawson
(leaf)
(Plate 32, figs. 8–11)

Comptonia columbiana Dawson, 1890, Trans. Royal. Soc. Can. 8, p. 81, text fig. 10, Wolfe and Wehr, 1987, U.S. Geol. Surv. Bull. 1597, p. 16, pl. 9, figs. 1–3 (Republic flora).

Myrica difforme (Sternberg) Chaney, 1927, Carnegie Inst. Wash. Pub. 346, p. 103, pl. 9, figs. 1, 3, 5.

DISCUSSION: *Comptonia* is readily identified by its distinctive pinnately lobed leaves. The fossil leaves are elongate-elliptical with cuneate bases and acute apices and range from 2.1 cm to at least 8.4 cm in length and from 0.8 to 1.7 cm in width. The lobes are broadly rounded, often with one to three small acuminate to obtuse teeth. Lobe length is variable according to the depth of sinus incision, which typically ranges from one-half to one-third of the distance to the midrib or rarely completely to the midrib. Typically, two nearly parallel secondary veins lead into each lobe and a secondary vein leads into each lobal sinus.

Normal leaves of the extant species, and of other fossil species of *Comptonia,* show only one serration per lobe. The presence of doubly serrate lobes distinguishes *Comptonia columbiana* from the extant species and from other fossil species of the genus (Wolfe and Wehr, 1987). Most, but not all, of the leaves from Lost Creek show as many as three teeth on at least a few of the lateral lobes. Thus, the leaves from the Bridge Creek flora are similar to those recognized from the middle Eocene Republic flora of Washington (Wolfe and Wehr, 1987), and we have provisionally placed them in *C. columbiana.* However, our material, and that illustrated by Chaney (1927), is distinguished by having lobal sinuses that are relatively weakly incised (K. Uemura, pers. comm., 1997). The sinus incision of the Bridge Creek specimens is rarely more than half of the distance to the midrib, yet leaves of *C. columbiana* from other floras are usually incised almost or completely to the midrib. A more detailed investigation, examining foliar variation in the extant species and other fossil species, is needed to determine whether the Bridge Creek material may represent a new species.

Comptonia is closely related to *Myrica* and is still treated within the latter genus by some authors, but it differs in its "fern-like" incised leaves and stipules (Krüsmann, 1978). The single extant species, *Comptonia peregrina,* is a deciduous shrub native to eastern North America. Although restricted in its present distribution, the genus was common in the Tertiary of Europe (Knobloch, 1961; Vassilev and Zhilin, 1968; Bůžek, 1971) and Asia (Huzioka and Uemura, 1979; Zhilin, 1980).

ADDITIONAL SPECIMENS: UF 10493, 10766–10771.

OCCURRENCE: Lost Creek.

Family JUGLANDACEAE

The walnut family is well-represented in the Bridge Creek flora, although the leaves and fruits are relatively rare at most localities. Fruits provide the most reliable characters for segregating extant and fossil genera of Juglandaceae (Manchester, 1987b). In the Bridge Creek flora, five genera are known from fruits: *Carya*, *Pterocarya*, *Cruciptera*, *Palaeocarya*, and *Juglans*. Of these, *Cruciptera* and possibly *Palaeocarya* (combining characters of extant *Engelhardia* and *Oreomunnea*) are extinct.

Carya sp. 1
(leaflet)
(Plate 33, figs. 1, 2)

DISCUSSION: One leaflet from Fossil shows characters that distinguish it from other juglandaceous leaflets of the Bridge Creek flora and support placement within the genus *Carya*. The secondary veins are dominantly craspedodromous and, as they approach the margin, give off two or more successive abmedial branches that enter teeth. The tertiary veins are percurrent, relatively thick, straight, closely spaced, and parallel to one another. Areolation, as in the other Bridge Creek juglandaceous taxa, is very fine.

Among extant genera of Juglandaceae, similar leaflets are encountered in *Carya*, *Platycarya*, and *Cyclocarya*. If *Platycarya* or *Cyclocarya* were present anywhere in the Bridge Creek flora, it is likely that the distinctive samaras would have been recovered. We hypothesize that the leaflets represent *Carya*, although it must be noted that the foliage of *Cruciptera* is unknown and might have resembled that of *Carya*. Fruits of *Carya* (described below) and triporate, heteropolar juglandaceous pollen indistinguishable from that of extant *Carya* occur at Fossil.

SPECIMEN: UF 10481.

OCCURRENCE: Fossil.

Carya sp. A
(fruit)
(Plate 34, figs. 2, 3)

Juglans. Manchester and Meyer, 1987, Oreg. Geol. 49, p. 118, fig. 4E.

DISCUSSION: Two nut impressions representing *Carya* are known from the Bridge Creek flora. One of these was previously considered to be *Juglans* based on outline of the nut compression (Manchester and Meyer, 1987). However, the specimen shows a persistent, stout stylar prominence (pl. 34, fig. 2) characteristic of *Carya* and not *Juglans*. In addition, the specimen is consistent with *Carya* in the smooth external surface of the nut, and creases in the mold indicate that the specimen was originally four-angled in cross section. An impression from Cove Creek shows the angles more distinctly (pl. 34, fig. 3). *Carya* is also represented by a leaflet and pollen from Fossil. A large collection of similar *Carya* fruit impressions is known from a late Eocene or early Oligocene locality (Nichols Spring assemblage; Ashwill, 1983) near Gray Butte, west of the John Day Basin.

The hickories are represented by 17–25 extant species that are tall deciduous trees native to eastern North America and eastern Asia.

SPECIMENS: UCMP 12810; UF 7007. previously figured Machester & Meyer, 1987

OCCURRENCE: Fossil, Cove Creek (Pentecost Ranch).

Cruciptera sp.
(fruit)
(Plate 32, figs. 6, 7)

Cruciptera sp. Manchester, 1991, Syst. Bot. 16, p. 720, fig. 16.

DISCUSSION: *Cruciptera* is an extinct juglandaceous genus from the Paleogene of western North America (Manchester, 1991) and Europe (Manchester et al., 1994) with samaras composed of four spatulate wings situated in the same plane and arising orthogonally from a small globose nutlet. The juglandaceous affinity of this genus was confirmed on the basis of nutlet morphology revealed in permineralized specimens from the Clarno Formation (Manchester, 1991). In the Bridge Creek flora, *Cruciptera* is known from only three specimens. These samaras are convergent in form with the four- to six-winged samaras of *Asterocarpinus* which are much more common in the Bridge Creek flora but are readily distinguished in characters of the nutlet and wing venation (Manchester and Crane, 1987; Manchester, 1991). The venation of *Cruciptera* consists of thin, subparallel, closely spaced veins of equivalent thickness that dichotomize a few times between the base and apex of the wing (pl. 32, figs. 6, 7), whereas that of *Asterocarpinus* is pinnate, with a midvein giving off secondary veins that typically loop at the margin (pl. 32, figs. 2–5).

Although rare in the Bridge Creek assemblages, *Cruciptera* is abundant in the Eocene Clarno floras and is also known from a few specimens in the Oligocene Lyons and Willamette floras of western Oregon (Manchester, 1991). The genus is common at the late Eocene(?) Sumner Spring locality at Gray Butte (Manchester, 1991). The foliage of *Cruciptera* has not been determined.

ADDITIONAL SPECIMENS: UF 10646, 10772. 9327

OCCURRENCE: Fossil, Crooked River. Stet

ok

Juglandiphyllites cryptatus (Knowlton) n. comb.
(leaflet)
(Plate 33, figs. 3–6; Plate 34, figs. 1, 4)

Juglans cryptata Knowlton, 1902, U.S. Geol. Surv. Bull. 204, p. 35, pl. 6, fig. 4, 5.
Pterocarya sp. Manchester and Meyer, 1987, Oreg. Geol. 49, p. 118, fig. 4D.

DISCUSSION: *Juglandiphyllites* Boulter and Kvaček (1989) is a genus accommodating fossil leaflets with affinity to Juglandaceae. Because of the overlapping leaf architectural characters observed in leaves of extant *Carya, Cyclocarya,* *Juglans*, and *Pterocarya*, it is sometimes difficult to determine precise modern generic affinities of some species of fossil juglandaceous foliage. *Juglandiphyllites cryptatus* was first described on the basis of two specimens of leaflets from the Painted Hills assemblage. The asymmetry and semi-craspedodromous venation of the leaflets and the type and distribution of teeth indicate juglandaceous affinity. Additional specimens are now available, permitting a more complete understanding of the species. Salient features of this leaf type include the asymmetrical base, short petiolule (except terminal leaflets), and secondary veins of irregular course (not parallel to one another) that vary in behavior at the margin, with some secondaries forming a strong intramarginal arch and others directed into the teeth. The teeth are often rounded and are fed medially or submedially by secondary or tertiary veins. Secondary veins occasionally bifurcate once or twice before reaching the margin, but usually lack the two or three successive admedial branches to the teeth encountered in *Carya* sp. 1.

The leaflets show characters found both in extant *Juglans* (sec. *Rhysocaryon*) and in *Carya*, and although originally attributed to *Juglans* (Knowlton, 1902), Chaney and Axelrod (1959) formed the new combination *Carya cryptata* (Knowlton). It is possible that the species does in fact represent one of these genera, although both genera are now known from other species of leaflets in the Bridge Creek flora (*Carya* sp. 1 and *Juglans wheelerensis*). It is also probable that *Juglandiphyllites cryptatus* foliage was produced by one of the extinct juglandaceous genera known from fruits.

We have collected this species of leaflet in close association with engelhardoid fruits (*Palaeocarya* cf. *olsonii*) at both the Painted Hills and Fossil assemblages. We observed only three specimens, including two of Knowlton's originals, from Painted Hills, but it is relatively common at Fossil. The same kind of leaflet occurs at the Sumner Spring locality (late Eocene?), where both *Palaeocarya* and *Cruciptera* fruits occur. It is likely that *Juglandiphyllites cryptatus* was produced by the same species as *Palaeocarya* cf. *olsonii*. Foliage of the related modern genus *Engelhardia* varies from entire-margined to serrate and can be nearly identical to that of *Juglandiphyllites cryptatus* (e.g., *E. serrata*; see Dilcher and Manchester, 1986, figs. 3–6).

LECTOTYPE: We designate UCMP 2503 (Knowlton, 1902, pl. 6, fig. 4; reillustrated here as pl. 33, fig. 4) as the lectotype.

✓ * ok

ADDITIONAL SPECIMENS: UF 7006, 10482–10486, 10490.

OCCURRENCE: Painted Hills, Fossil.

Juglans wheelerensis n. sp.
(leaflet)
(Plate 35, figs. 1–3)

DIAGNOSIS: Lamina apparently elliptical to obovate, asymmetrical; apex missing, base acute, length estimated at 10 cm, width 4.4 cm, length to width ratio ~2.3; margin serrate; teeth convex on basal flank, straight to concave on apical flank, apex acute; sinuses narrowly acute; venation brochidodromous with some craspedodromous tertiaries; primary vein moderately thick, distinct ly curved; secondary veins originating at moderate to wide-acute angles

(50–70°), ~10–12 pairs, thickness moderate, course straight to sinuous, abruptly curved near the margin, courses of adjacent secondaries sometimes variable; intersecondaries simple, occasional, extending up to one-half the distance to the margin, sometimes arising at wider angles than secondaries; tertiary veins sinuously percurrent to coarsely reticulate, widely spaced; marginal tertiaries sometimes camptodromous and forming a single series of brochidodromous loops, sometimes craspedodromous and entering the apical sides of teeth and either ending in a sinus (with a quaternary vein continuing to the tooth apex) or touching the sinus and deflecting slightly before arching to the tooth apex; quaternaries and quinternaries orthogonal reticulate, irregular in shape; veinlets sometimes present, simple, unbranched; marginal quaternaries forming loops but also sometimes craspedodrome to the tooth apices.

DISCUSSION: This species is represented by two leaflets that are fragmentary but have excellently preserved venation. The species is distinguished by the brochidodromous venation with some craspedodromous tertiaries that enter the apical sides of teeth or end in the sinuses, a feature characteristic of *Juglans* section *Rhysocaryon* (Wolfe, 1959) and of *Oreomunnea* and *Alfaroa* (Dilcher and Manchester, 1986). The latter genera are readily distinguished from this fossil and from extant *Juglans* in various characters, including well-developed intersecondary veins and auriculate leaflet bases.

The assemblage at Fossil also includes a compressed nut that might belong to *Juglans*. The specimen (pl. 34, fig. 5) is elliptical in longitudinal outline, 2.0 cm high and 1.6 cm wide, with about ten meridional grooves. More and better specimens are needed to determine whether the fruit is correctly assigned to the genus.

The walnuts include 15–21 extant species of deciduous trees that are native to North and Central America, southern Europe to eastern Asia, and western South America. The black walnut group (section *Rhysocaryon*) is endemic to North and South America.

ETYMOLOGY: The epithet *wheelerensis* refers to Wheeler High School, in the town of Fossil, Oregon, on the grounds of which the specimens were collected.

HOLOTYPE: UF 10600.

PARATYPE: UF 10860.

OCCURRENCE: Fossil.

Palaeocarya cf. *olsonii* (Brown) Manchester
(fruit)
(Plate 34, figs. 6–8)

cf. *Palaeocarya olsoni* (Brown) Manchester, 1987, Missouri Bot. Gard. Monogr. Syst. Bot. 21, p. 55, fig. 26H.

Carpinus grandis auct. non Unger. Chaney 1927, *pro parte*, Carnegie Inst. Wash. Pub. 346, p. 105, pl. 9, figs. 7–9 only.

cf. *Engelhardia olsoni* Brown. Manchester and Meyer, 1987, Oreg. Geol. 49, p. 118, fig. 4F.

DESCRIPTION: Fruit with trilobed wing; wing lobes lanceolate-obovate; central lobe length 17–42 mm, width 6–9 mm; lateral lobe length 9–21 mm; venation of each lobe consisting of a midvein paralleled on either side by an ascending lateral vein; ascending lateral veins particularly well-developed in the lower half of each lobe, merging in the upper portion into a system of marginal loops of the secondary veins. Prophyllum circular, diameter 9 mm. Nutlet globose, diameter 3.5–7.5 mm, covered with circular peltate trichomes 80–140 µm in diameter, pedicel nonadherent, sepals four.

DISCUSSION: *Palaeocarya* Saporta is a fossil genus for trilobed winged fruits similar to those of extant *Engelhardia* of eastern Asia and *Oreomunnea* of tropical America. Although fruits of these extant genera are readily distinguished from each other on the basis of differences in wing venation, septation of the nutlet, and development of the stigmatic area, many of the fossil species incorporate characters of both extant genera.

Brown (1940) and Manchester (1987b) noted the resemblance between the Bridge Creek specimens and *Palaeocarya olsonii*, a species based on specimens from the Miocene of Idaho. The fruits have wing venation resembling that of *Oreomunnea* (each lobe has three or more major veins rather than a single primary vein with simple pinnate venation).

The species is clearly different from that common in the Clarno Formation, *Palaeocarya clarnensis*, the fruits of which are shed with a segment of persistent pedicel and have wing lobes with only weak marginal veins. *Palaeocarya willamettensis* of comparable age from the Willamette flora (Manchester, 1987b) is also distinct from the Bridge Creek species, having only a small prophyllum.

Both *Engelhardia* and *Oreomunnea* are large trees of tropical regions. *Engelhardia*, distributed from India to Sumatra, has five extant species. *Oreomunnea*, which ranges from Mexico to Costa Rica, has two extant species. *Oreomunnea*, and its sister genus with large wingless fruits, *Alfaroa*, have distinctive foliage that is readily distinguished from that of other extant Juglandaceae. Fossil foliage of that type, known as *Oreoroa*, is abundant in the Eocene of Tennessee and Kentucky and in the middle Eocene to middle Miocene of Europe (Dilcher and Manchester, 1986), but has not been found in the Bridge Creek flora nor in any other Tertiary flora of western North America.

ADDITIONAL SPECIMENS: JODA 4467; UCMP 12703; UF 7013, 10269, 10717–10719, 10780.

OCCURRENCE: Painted Hills, Fossil, Iron Mountain, Crooked River, Lost Creek.

Pterocarya sp.
(leaflet)
(Plate 36, figs. 1–5)

Prunus coveus Chaney, 1927, pro parte, Carnegie Inst. Wash. Pub. 346, p. 123, pl. 15, fig. 1 only.

Prunus chaneyi auct. non Condit. Chaney and Axelrod, 1959, *pro parte*, p. 185 (synonymy of Chaney [1927, pl. 15, fig. 1] only).

DISCUSSION: These leaflets have closely and evenly spaced, small, simple teeth. The secondary veins are consistently camptodromous except near the leaflet apex; each secondary loops apically near the margin to join the superadjacent secondary without prominent forking. The tertiaries are percurrent and straight, and the higher order veins form a fine orthogonal mesh. The teeth are sharp-tipped and are enervated medially by tertiary veins, all of equal thickness, that arise abmedially from the marginal loop of the secondary vein. The leaflets are similar to those of extant species of *Pterocarya*, such as *P. stenoptera* and *P. rhoifolia*. *Pterocarya* leaflets have not been confirmed at any other Bridge Creek assemblages besides Butler Basin.

This species is similar to, and possibly conspecific with, *Pterocarya mixta* from various Miocene localities in the western United States (Brown, 1937a; Chaney and Axelrod, 1959). Similar leaflets also occur in the Oligocene Lyons flora (Meyer, 1973). Fruits have not been described from Mascall, the type locality for *P. mixta*, but would be useful in considering the question of whether the Bridge Creek species belongs to the same species.

Pterocarya is a genus of deciduous trees of six to ten extant species distributed mainly in eastern Asia with a single species in the Caucasus region.

SPECIMENS: UCMP 12695, 12696; UF 10488.

OCCURRENCE: Butler Basin.

Pterocarya occidentalis Manchester
(fruit)
(Plate 36, fig. 6)

Pterocarya occidentalis Manchester 1987, Missouri Bot. Gard. Monogr. Syst. Bot. 21, p. 103, fig. 44C–F.

DISCUSSION: A single fruit of *Pterocarya* is known from the Butler Basin assemblage. It is a biwinged samara with a pair of rounded ovoid wings 6 mm long and 6.8 mm wide, diverging obliquely from a central nutlet. The nutlet is 3.5 mm in diameter and is longitudinally ridged. Full fruit width is 15.5 mm and length 7.5 mm. A thin bract at least 1.8 mm long protrudes from the base of the fruit. All of these features are consistent with extant *Pterocarya* (cf. *P. hupehensis*, pl. 36, fig. 7).

This is a species based on fruits from the Miocene Weaverville flora of northern California (Manchester, 1987b; locality age from Barnett, 1989); it is also known on the basis of fruits from the Oligocene Lyons and Gumboot Mountain floras (Manchester, 1987b). The leaflets described above as *Pterocarya* sp. are abundant at the same locality and are presumed to represent the same species. *Pterocarya* appears to have become more diverse in the Miocene, with two additional species of fruits known from the Clarkia flora of Idaho (Manchester, 1987b).

ADDITIONAL SPECIMEN: UF 10489.

OCCURRENCE: Butler Basin.

ok

Family STYRACACEAE

Flectorivus microdontos n. gen. et sp.
(leaf)
(Plate 37, figs. 1–5, 7)

Nyssa crenata auct. non Chaney (1920). Chaney, 1927, pro parte, Carnegie Inst. Wash. Pub. 346, p. 130, pl. 15, fig. 11 only (not his synonymy of Eagle Creek flora specimens).

GENERIC DIAGNOSIS: Lamina elliptical to obovate, apex obtuse to acute, base cuneate to obtuse; teeth small, glandular, apically oriented; venation pinnate, camptodromous; secondaries acute, curved, occasionally branched, giving rise to tertiary loops near the margin; intersecondaries occasional; tertiaries percurrent to orthogonal reticulate, often convex or sinuous; marginal tertiaries forming a uniseriate series of abmedial brochidodromous loops giving rise to branches that feed the teeth; quaternary veins orthogonal and forming areoles; veinlets simple to branched one to three times.

SPECIES DIAGNOSIS: Lamina elliptical to obovate; apex obtuse to acute; base cuneate to obtuse, lamina sometimes extending along upper part of petiole; length 5.0–7.5 cm, width 2.7–5.0 cm, length to width ratio 1.5 to 2.4; petiole ~0.5 cm; margin finely serrate along its entire outline; teeth usually only slight glandular extensions of tertiary veins protruding < 0.2 mm beyond the margin, 0.7–3.5 mm apart, apically oriented; venation pinnate, camptodromous; primary vein straight to slightly curved; secondaries acute, curved, occasionally branched, about eight to ten pairs, giving rise to tertiary loops near the margin; intersecondaries occasional, usually extending about one-third the distance to the margin, generally arising at higher angles than the secondaries, most often simple but sometimes composite; tertiaries percurrent to orthogonal reticulate, often convex or sinuous, usually arising at right angles from the upper side of secondaries and at right to acute angles from lower sides; marginal tertiaries forming a uniseriate series of abmedial brochidodromous loops giving rise to branches that feed the teeth; quaternary veins orthogonal and forming areoles; veinlets simple to branched one to three times, straight to curved; marginal ultimate venation usually incomplete to sometimes looped.

DISCUSSION: This species has the following characters typical of Styracaceae: (1) a series of abmedial brochidodromous loops formed by tertiary veins along the margin, (2) very small apically oriented teeth that are glandular extensions of tertiary veins originating as branches from the abmedial loops, and (3) freely ending veinlets that are simple to at least twice branched. Extant genera with closely similar foliage include *Styrax*, *Melliodendron*, and *Pterostyrax*; of these genera, only *Pterostyrax* was noted to have marginal ultimate venation that is sometimes incomplete like that of the fossil (pl. 37, fig. 6). All of these genera occur in eastern Asia, and *Styrax* also occurs in Europe and the Americas. Some species of *Styrax* are evergreen. The fossil species is not clearly identical to any one modern genus and is therefore described as the new genus *Flectorivus*.

NOMENCLATURE: The epithet *crenata* applied by Chaney (1920, 1927) is based on type material from the Eagle Creek flora; although these leaves were described as *Nyssa*, they actually appear to belong in the Hamamelidaceae. The Bridge Creek specimens differ greatly in venation and serration, and require a different epithet as well as generic assignment.

ETYMOLOGY: The generic name, flecto (L = crooked) + rivus (L = stream) refers to the Crooked River, denoting the assemblage where it occurs. The epithet *microdontos* refers to the very small teeth typical of these leaves.

HOLOTYPE: UF 10317.

PARATYPES: UCMP 92; UF 10219, 10495, 10529–10533, 10607; USNM 458395.

OCCURRENCE: Crooked River.

Family TILIACEAE

Craigia oregonensis (Arnold) Kvaček, Bůžek and Manchester

(fruit)

(Plate 40, figs. 7–9)

Craigia oregonensis (Arnold) Kvaček, Bůžek, and Manchester, 1991 (issued 1992), Bot. Gaz. 152, p. 522.

Koelreuteria oregonensis Arnold, 1952, The Paleobotanist 1, p. 77, figs. 1–3; Brown, 1959, J. Paleont., 53, p. 127, pl. 24, figs. 6, 7.

Ulmus speciosa Newberry, 1898, *pro parte*, U.S. Geol. Surv. Monogr. 35, p. 80, pl. 45, fig. 7 only. Chaney, 1927, Carnegie Inst. Wash. Pub. 346, p. 114, pl. 12, fig. 5.

Ptelea miocenica auct. non Berry. Brown, 1937, U.S. Geol. Surv. Prof. Paper 186-J, pl. 51, fig. 4.

Pteleaecarpum oregonense (Arnold) Manchester in Bůžek, Kvaček, and Manchester, 1989, Bot. Gaz. 150, p. 485, figs. 36–44.

Pteleaecarpum oregonensis (Arnold) Manchester and Meyer, 1987, Oreg. Geol. 49, 118, fig. 6L, M.

DISCUSSION: This species is represented by dehisced fruit-capsule valves common at most localities of the Bridge Creek flora. Bůžek et al. (1989) illustrated a variety of specimens from the Bridge Creek flora and showed that this species is congeneric with European and Asian fossil fruits of the fossil genus *Pteleaecarpum*. They concluded that *Pteleaecarpum* is extinct and that it probably belonged to the Sapindaceae. More recently, however, it was discovered that *Pteleaecarpum* fruits are identical in morphology and cuticular features to those of the extant tiliaceous genus *Craigia* (Kvaček et al., 1991).

Craigia is a genus of two species of trees native to southwestern China (Kvaček et al., 1991). The leaves corresponding to *Craigia oregonensis* are not yet known. Those of the extant species tend to be pinnately rather than palmately veined. 7033

ADDITIONAL SPECIMENS: UCMP 12689, 12690; UF 8011, 8014, 10707–10716; USNM 458396.

OCCURRENCE: Painted Hills, Fossil, Cove Creek (Knox Ranch, Pentecost Ranch), Iron Mountain, Crooked River, Butler Basin, Gray Butte Canal.

Plafkeria obliquifolia (Chaney) Wolfe
(leaf)
(Plate 38, figs. 1–4, Plate 39, figs. 1–4)

Plafkeria obliquifolia (Chaney) Wolfe, 1977, U.S. Geol. Surv. Prof. Paper 997, p. 91; Manchester and Meyer, 1987, Oreg. Geol. 49, p. 121, fig. 6A.

Celtis obliquifolia Chaney, 1925, Carnegie Inst. Wash. Pub. 349, p. 52, pl. 1, figs. 1, 3, 5. Chaney, 1927, Carnegie Inst. Wash. Pub. 346, p. 115, pl. 13, fig. 12; Brown 1937, U.S. Geol. Surv. Prof. Paper 186-J, p. 173, pl. 48, fig. 6.

Ficus planicostata auct. non Lesquereux. Newberry, 1898, U.S. Geol. Surv. Monogr. 35, p. 88; pl. 46, fig. 1. Knowlton, 1902, U.S. Geol. Surv. Bull. 204, p. 56.

Cornus ovalis auct. non Lesquereux. Chaney, 1927, Carnegie Inst. Wash. Pub. 346, p. 131, pl. 19, figs. 1–3.

Alangium oregonensis Wolfe, 1977, U.S. Geol. Surv. Prof. Paper 997, p. 93.

SUPPLEMENTARY DESCRIPTION: The following characters modify the description of Chaney (1925b). Base usually strongly asymmetrical, acute to obtuse, broadly rounded, or slightly cordate; petiole often slightly inflated at its base and at attachment to lamina, length 0.9–2.2 cm; margin entire to sometimes broadly undulate, rarely developing a large tooth or small lobe with an acute apex; secondaries six to ten pairs; intercostal tertiaries strongly percurrent, straight to slightly curved or sinuous, occasionally forked, predominantly at right angles to midvein; quaternaries percurrent to orthogonal reticulate; fifth- and sixth-order veins orthogonal reticulate.

DISCUSSION: These leaves are distinguished by an asymmetrical and variable base, entire to sometimes undulate margin, palmate venation with five to usually six primary veins radiating from the base (normally with one more lateral primary on the larger side of the lamina), brochidodromous secondaries, transverse percurrent tertiaries, percurrent to orthogonal reticulate quaternaries, a fine reticulum formed by fifth- and sixth-order venation (pl. 38, fig. 2), and the petiole that is inflated both at the base and at the attachment to the lamina (pl. 39, fig. 2). Although most of the leaves are entire-margined, some have undulations (e.g., pl. 39, fig. 2) and a few of the specimens from Fossil and Crooked River show actual lobes, with acute apices and rounded sinuses (e.g., pl. 38, fig. 4). These variable forms intergrade and appear to represent a single species.

Leaves of the *Plafkeria* type occur in more than one modern genus of the malvalean families Sterculiaceae and Tiliaceae. They also show similarities to leaves of *Alangium* (see below). Leaves of this type (although without lobes) occur in many European floras ranging from Miocene to Pliocene and have been placed in *Byttneriophyllum* Knobloch and Kvaček (1965). Knobloch and Kvaček (1965) provided a comprehensive review of the literature on the widespread European species *Byttneriophyllum tiliaefolium*, along with new anatomical information, comparative studies, and an assessment of systematic affinities. Following Berger (1955), they noted the similarity between *B. tiliaefolium* and the Bridge Creek species (cited as *Celtis obliquifolia* Chaney). The higher orders of venation are not described for *B. tiliaefolium*, but Knobloch and Kvaček illustrate and describe important details of cuticular anatomy including characteristic "hair bundles" for specimens from Dubňany and Postorna, Czech Republic. The Bridge Creek specimens lack cuticular preservation, yet in many instances clearly show the higher orders of venation. If it can be demonstrated that the Bridge Creek species is congeneric with *B. tiliaefolium*, then the name *Byttneriophyllum* would have priority over *Plafkeria* and a new combination would be necessary. At the present time, however, the lack of cuticular details for the Bridge Creek species and the lack of details of higher order venation for the European material preclude the merger.

In the asymmetry of the lamina and the architecture of primary, secondary, and tertiary veins, the leaves of *Plafkeria* and *Byttneriophyllum* are similar to those of extant *Alangium* section *Marlea*. Indeed, it is possible that leaves of *Alangium* and Sterculiaceae could easily be confused if the higher order venation or cuticular anatomy is not preserved. Leaves of *Alangium* section *Marlea*, like those of *Pterospermum*, may range from entire to asymmetrically lobed. *Alangium* section *Marlea* is known from the Tertiary of North America and Europe on the basis of fruits (Eyde et al., 1969); hence, it would not be unexpected to find fossil leaves of the genus. Wolfe (1977) described some material as *Alangium oregonensis*, and Knobloch and Kvaček (1965) cite many instances in the European literature of *Byttneriophyllum* being placed in *Alangium*. When higher order venation (quaternary and higher) is preserved, the leaves of *Alangium* are readily identified by irregular areolation and numerous freely ending veinlets, in contrast to the leaves of Tiliaceae and Sterculiaceae which have a well-organized orthogonal mesh with few freely ending veins. In all of the Bridge Creek specimens well enough preserved to observe higher order venation, the leaves of *Plafkeria* correspond to Malvales and not to *Alangium*.

Although affinities with the Malvales are apparent, the generic affinities remain uncertain. Leaves of extant *Tilia* species from China are sometimes entire-margined and bear close resemblance to *Plafkeria*, but similar leaves are also produced by other genera such as *Pterospermum* and *Burretiodendron*. Among the malvalean fruits known from Bridge Creek, *Florissantia speirii*, *Craigia oregonensis*, and *Tilia circularis* are all possible candidates for correlation with this foliage type.

Plafkeria obliquifolia is present in the latest Eocene–earliest Oligocene Goshen (*Viburnum thomae* of Chaney and Sanborn, 1933), Bilyeu Creek–lower Thomas Creek (*Alangium thomae* of Wolfe in Peck et al., 1964), and Scio (*Tilia williamsi* of Sanborn, 1947) floras of western Oregon. Its presence in the early Oligocene Bridge Creek, Willamette, Rujada (*Alangium thomae* of Lakhanpal, 1958), and Lyons (*Alangium thomae* of Meyer, 1973) floras apparently represents the last stratigraphic occurrence for the genus.

NOMENCLATURE: In North America, this leaf type was formerly described by Wolfe (1968) as *Willisia* (not *Willisia* Warm.) and later renamed *Plafkeria* (Wolfe, 1977).

* not in TYPE/FIG. DRAWER

ADDITIONAL SPECIMENS: UCMP 12714, 12715; UF 10264, 10267, 10268, 10316, 10344, 10456*, 10470*; USNM 458397.

OCCURRENCE: Painted Hills, Fossil, Cove Creek (Knox Ranch, Pentecost Ranch), Iron Mountain, Crooked River, Twickenham.

Genus *Tilia*

Tilia is represented in the Bridge Creek flora by both leaves and bracts with attached fruits. Two species are readily distinguished by infructescence bracts, one of which is elongate and has pinnate venation and a prominent midvein, and the other of which is generally orbicular and has palmate venation. The associated leaves are more difficult to differentiate, and some may represent other tiliaceous genera. We distinguish three leaf types: (1) *Tilia aspera*, which has less distinctly palmate venation and more teeth at the base; (2) *Tilia fossilensis*, which has more rounded teeth (sometimes very small) and a generally larger lamina; and (3) *Tilia lamottei*, which has fewer secondaries than the other two.

The classification of extant species of *Tilia* is problematic, and different workers have widely varying opinions concerning the number of extant species. Extant species often show high morphologic variability (Hardin, 1990). The 30–50 extant species of basswoods (lindens) are moderate to large deciduous trees distributed in eastern North America, Europe, and eastern Asia.

Tilia circularis (Chaney) n. comb.
(bract, fruit)
(Plate 40, figs. 1, 2)

Tilia circularis Manchester, 1994, Am. J. Bot. 81, p. 1180, figs. 1A, 2–12.

Asarum circularis Chaney, 1927, Carnegie Inst. Wash. Pub. 346, p. 115, pl. 13, fig. 11

Limnanthemum circularis (Chaney) Brown, 1940, J. Wash. Acad. Sci. 30, p. 352.

Nymphoides circularis (Chaney) Brown, 1946, J. Wash. Acad. Sci. 36, p. 352.

"*Tilia*" *circularis* (Chaney) Manchester and Meyer, 1987, Oreg. Geol. 49, p. 121, fig. 5I.

DISCUSSION: Bracts of *Tilia circularis* have a rounded outline, cordate base, and actinodromous venation with nine or more primary veins that dichotomize and anastamose, giving rise to higher orders of venation and forming a fine reticulum. A detailed description of the bracts and attached fruits was presented by Manchester (1994a). As indicated in the above synonymy, these bracts were formerly thought to be vegetative leaves unrelated to *Tilia*. Although the ovate shape and large width distinguishes these bracts from those of all extant species of *Tilia*, the venation of the bracts, combined with the morphology of the attached infructescences (e.g., pl. 40, fig. 2), shows the unquestionable affinity to *Tilia* (Manchester, 1994a). The species is also known from the Haynes Creek flora of Idaho (D. E. Axelrod, pers. comm., 1996) and the Lyons flora of western Oregon (Meyer, 1973), where it co-occurs with the fossil leaf genus *Plafkeria* and with *Tilia* leaves similar to those treated here as *T. fossilensis*. At the Iron Mountain, Fossil, and Crooked River assemblages, these bracts outnumber the vegetative *Tilia* leaves, indicating a taphonomic bias.

Cited specimen not in TYPE CABINET

HOLOTYPE: UCMP 72.

ADDITIONAL SPECIMENS: UCMP 12693; UF 10398, UF 10616, 10737–10754.

OCCURRENCE: Fossil, Cove Creek (Knox Ranch), Iron Mountain, Crooked River, Butler Basin.

Tilia pedunculata Chaney
(bract, fruit)
(Plate 40, figs. 3–6)

Tilia pedunculata Chaney, 1920, Contr. Walker Mus. 2, p. 179, pl. 19, figs. 3, 4 (Eagle Creek flora). Manchester, 1994, Am. J. Bot. 81, p. 1181, figs. 14–19.

DISCUSSION: The elongate bracts of *T. pedunculata* are similar in shape and venation to those of most extant species of *Tilia*. However, as in *T. circularis*, the bract and peduncle are free from one another above the base of the bract lamina. In most extant species, the peduncle is adnate to the lower 1/3 to 1/2 of the bract lamina. The lack of adnation between the peduncle and bract and the palmate basal secondary veins occur in a single living species, *Tilia endochrysea* of China, and in the widespread European Miocene species *Tilia longebracteata* Andrae (Spitzlberger, 1984; Manchester, 1994a). The type locality for *Tilia pedunculata* is in the Miocene Eagle Creek Formation of Oregon. Specimens are also known from the Miocene of Succor Creek, Idaho (Brown, 1937c), and the late Eocene Haynes Creek flora of eastern Idaho (Hall and Swain, 1971). The geographic and stratigraphic distribution of *T. pedunculata* and other species of *Tilia* bracts was reviewed by Manchester (1994a). In the Bridge Creek flora, there is more than one type of *Tilia* foliage and more than one type of bract, so it is difficult to be certain which type of foliage corresponds to *T. pedunculata*. However, in the early Miocene of northern Bohemia, Czech Republic, Bůžek and Kvaček (1992) recognized similar bracts and fruits together with associated sharply toothed leaves of *Tilia brabenecii*, that are most similar to the Bridge Creek leaves described here as *Tilia lamottei*.

ADDITIONAL SPECIMENS: UCMP 12694, 12712, 12713, 12808; UF 10615, 10729–10736.

OCCURRENCE: Cove Creek (Pentecost Ranch), Iron Mountain, Crooked River.

Tilia aspera (Newberry) LaMotte
(leaf)
(Plate 41, figs. 1–3)

Tilia aspera (Newberry) LaMotte, 1935, *pro parte*, Carnegie Inst. Wash. Pub. 455, pt. 3, p. 45, pl. 1, fig. 1 only.

Platanus aspera Newberry, 1883, U.S. Nat. Mus. Proc. 5, p. 509; 1898, *pro parte,* U.S. Geol. Surv. Monogr. 35, p. 102, pl. 44, fig. 5 only.

Tilia oregona LaMotte, 1935, Carnegie Inst. Wash. Pub. 455, pt. 3, p. 47, pl. 3, figs. 1–5.

DISCUSSION: LaMotte (1935) recognized two species of *Tilia* foliage from the Painted Hills assemblage and distinguished *Tilia oregona* as more symmetrical, smaller, and less variable than *Tilia aspera*. The leaves of *T. oregona* are probably small leaves of *T. aspera*. Although this species was previously assigned to *Platanus*, leaves of *Tilia* can be distinguished by the angular, rather than curved, sinuses. *T. aspera* leaves are readily distinguished from those of *Tilia fossilensis* and *T. lamottei* by the positioning of the lowest pair of secondary veins. The distance between the leaf base and the first pair of secondaries on the midrib is shorter in *T. aspera* than in the other two species. Because of inadequate preservation of details of higher order venation in this species and the absence of *Tilia* fruiting bracts in the assemblage where these leaves occur, the generic assignment remains to be confirmed.

NOMENCLATURE: Although Newberry (1883, 1898) included several leaves of *Platanus* among the specimens that he described as *Platanus aspera,* he did not designate a holotype. LaMotte (1935) reassigned the species to *Tilia* and designated as the lectotype a specimen that is indeed *Tilia*. Hence, the epithet *aspera* must be applied to the leaves of *Tilia*. The true *Platanus* leaves figured by Newberry are now assigned to *Platanus exaspera* sp. nov.

LECTOTYPE: USNM 7083, designated by LaMotte (1935).

ADDITIONAL SPECIMENS: USNM 458398, 458399.

OCCURRENCE: Painted Hills.

Tilia fossilensis n. sp.

(leaf)

(Plate 41, fig. 4; Plate 42, fig. 1; Plate 43, figs. 1–3)

DIAGNOSIS: Lamina ovate to rarely obovate or circular, asymmetrical to sometimes symmetrical; apex attenuate (one specimen); base cordate; length 8–20 cm, width 6.6–20.2 cm, length to width ratio 1–1.6; petiole 2.7–5 cm, commonly inflated, especially at its base and near attachment with lamina; margin serrate to crenate; unlobed; some teeth small, rounded glandular protrusions along broadly and shallowly crenate margin; other teeth larger and broadly rounded, right angled, or obtuse, both apical and basal flanks convex; sinuses between large teeth angular, acute to sometimes obtuse; venation palmate, with seven to nine veins radiating from base of lamina, midvein most prominent, lateral primaries successively weaker; primary veins straight to curved, usually with the midvein straighter; secondaries usually craspedodromous to rarely semicraspedodromous, arising from both sides of the midvein but typically only from the abmedial side of lateral primaries; four (?) to eight pairs of secondaries arising from the midvein below the apical attenuation, curved, acute, arising at 40–55°; tertiary veins percurrent, straight to convex, sometimes sinuous, sometimes branched in intercostal area; quaternaries percurrent to orthogonal reticulate; quinternaries orthogonal reticulate; sixth-order veins forming small areoles (~0.2 mm); freely ending veinlets occasional, straight.

DISCUSSION: *Tilia fossilensis* is distinguished from *Tilia lamottei* by its rounder, less pronounced teeth and by the presence of an additional order of venation (areoles formed by 6° rather than by 5° veins). Leaves of *Tilia* from the Lyons flora of western Oregon (Meyer, 1973) are similar in the rounded teeth and cordate base and may be conspecific. *T. fossilensis* leaves are not abundant in the Bridge Creek flora, but a concentration was found in one stratum at Fossil. Bracts of *Tilia circularis* co-occur with this species at the Fossil and Knox Ranch assemblages and also occur in the Lyons flora. The morphology of the leaves is most similar to some of the eastern Asian species (e.g., *Tilia tuan*, *Tilia kwangtungensis*, and *Tilia oblongifolia*) in characters of the margin, teeth, and apex. Leaves of other extant tiliaceous genera (e.g., *Burretiodendron*, *Craigia*, and *Excentrodendron*) are also similar and can be difficult to distinguish without fruits. Although fruits of *Craigia* occur in the Bridge Creek flora, the leaves of the two extant species differ from those of *T. fossilensis* in having fewer basal primaries, sometimes more pinnate venation, and tertiaries that are more sinuous and widely spaced.

ETYMOLOGY: This species is named for the assemblage at Fossil, from which the best preserved specimens have been recovered.

HOLOTYPE: UF 10376.

PARATYPES: UF 10432, 10492, 10547, 10548, 10605, 10612.

OCCURRENCE: Fossil, Cove Creek (Knox Ranch).

Tilia lamottei n. sp.
(leaf)
(Plate 44, figs. 1–5)

DIAGNOSIS: Lamina ovate, asymmetrical; apex unknown; base cordate; length 8.5–~12 cm, estimated width 8.2–~11.5, length to width ratio ~1; petiole 3 cm, often swollen at junction with lamina; margin serrate; teeth acute to right angled, sometimes acuminate-tipped, apical flank concave to straight, rarely convex, basal flank convex to straight, rarely concave, sinuses angular, acute to right angle, glands apparently absent; venation palmate, with five to seven veins radiating from base of lamina, midvein most prominent, lateral primaries successively weaker; primary veins straight to curved, usually with the midvein straighter; secondaries craspedodromous, arising from both sides of midvein but typically arising only from abmedial side of lateral primaries; at least five pairs of secondaries arising from midvein; secondaries curved, narrowly acute, arising at 35–45°; tertiary veins percurrent, straight to convex, sometimes sinuous, sometimes branched in intercostal area, rejoining oppositely or alternately; quaternaries and quinternaries orthogonal, quinternaries predominantly quadrangular forming a reticulum of small square areoles (~0.2 mm); freely ending veinlets occasional, straight, unbranched.

DISCUSSION: *Tilia lamottei* is distinguished from *Tilia aspera* in having more distinctly palmate venation with secondaries that are more curved and fewer in number. It is differentiated from *Tilia fossilensis* in having fewer secondaries and teeth that are generally larger and more distinct with sharp apices. At the type locality (Pentecost, PA-2), this leaf co-occurs with the lanceolate-bracted fruits of *Tilia pedunculata*, and there is a possibility that they actually represent the same species. Although cuticle and trichomes are not preserved in the Bridge Creek material, this species resembles the foliage of *Tilia brabenecii* from the early Miocene of northern Bohemia, which is associated with nondecurrent bracts similar to those of *T. pedunculata* (Bůžek and Kvaček, 1992).

HOLOTYPE: UCMP 12711.

PARATYPES: UF 10263, 10491, 10604.

OCCURRENCE: Cove Creek (Knox Ranch, Pentecost Ranch), Iron Mountain, Crooked River.

Family STERCULIACEAE

Florissantia speirii (Lesquereux) Manchester
(flower, fruit)
(Plate 45, figs. 1–4)

Florissantia speirii (Lesquereux) Manchester 1992, Am. J. Bot. 79, pp. 996–1008, figs. 1–7, 11–22, 43–47, 51–53.

Porana speirii Lesquereux, 1883, Rept., U.S. Geol. Surv. Terr. 8, p. 172, pl. 28, fig. 15 (Florissant flora). Chaney 1927, Carnegie Inst. Wash. Pub. 346, p. 134. Brown, 1940, J. Wash. Acad. Sci. 30, p. 353, fig. 12.

Florissantia physalis Knowlton, 1916, Proc. U.S. Nat. Mus. 51, p. 270 (Florissant flora). Manchester and Meyer, 1987, Oreg. Geol. 49, p. 121, fig. 6N, O.

Holmskioldia speirii (Lesquereux) MacGinitie 1953, *pro parte*, Carnegie Inst. Wash. Pub. 599, p. 156 (his synonymy of Bridge Creek occurrences).

DISCUSSION: *Florissantia* is a genus of fruits and flowers common in Eocene and Oligocene floras of the Pacific Northwest. The specimens are readily recognized by their large subcampanulate calyces, which persisted into the fruiting stage and evidently functioned in wind dispersal. The Bridge Creek specimens correspond closely to the type material from Florissant, Colorado, and have proven important in providing excellent details of fruits, styles, stamens, pollen, and calyx morphology useful in distinguishing *Florissantia* as an extinct genus of Sterculiaceae (Manchester, 1992).

Although *Florissantia* is common in middle and late Eocene floras, the youngest known occurrence of the genus is in early Oligocene floras of the Pacific Northwest, including Bridge Creek, Lyons (Meyer, 1973), Shale City (Wolfe, *in* Peck et al., 1964), and Gumboot Mountain.

ADDITIONAL SPECIMENS: UCMP 12691, 12692; UF 7031, 7036, 8381, 8382, 10408, 10410, 10417–10419, 11745.*

OCCURRENCE: Painted Hills, Fossil, Cove Creek (Knox Ranch, Pentecost Ranch), Iron Mountain, Crooked River, Lost Creek.

* cited specimens not stored in "TYPE" cabinet

ok

Family GROSSULARIACEAE

Ribes sp.
(leaf)
(Plate 45, figs. 5, 6, 9, 10)

DESCRIPTION: Lamina deltoid or trilobed; apex apparently acute; base cordate; length ~3.8–~7.5 cm, width ~3.8–~6.0 cm; petiole at least 2 cm long; margin dentate, teeth blunt, with convex apical and basal flanks; venation actinodromous, with middle primary dominating, giving off about five pinnate secondary veins; tertiary veins percurrent, convex; higher order venation forming an irregular mesh; lamina dotted with evenly spaced glands.

DISCUSSION: The gland-dotted lamina, palmate venation, and blunt glandular teeth in this leaf are characters diagnostic of *Ribes*. The two specimens have a torn margin and were apparently delicate; however, details of the teeth are evident and the venation is well-preserved. Similar glands are observed in *Ribes japonicum* and other extant species.

There are about 150 extant species of currants that are deciduous (occasionally evergreen) shrubs widely distributed throughout the northern temperate regions as well as western South America.

SPECIMENS: UF 10476, 10631. OK

OCCURRENCE: Fossil, Iron Mountain.

Family HYDRANGEACEAE

Hydrangea sp.
(infructescence, calyx)
(Plate 45, figs. 7, 8)

Hydrangea flower Manchester and Meyer 1987, Oreg. Geol. 49, p. 121, fig. 5J.
Cornus ovalis auct. non Lesquereux. Chaney, 1927, Carnegie Inst. Wash. Pub. 346, p. 131, pl. 19, fig. 4.

DISCUSSION: The distinctive, four- (rarely three-) parted calyces of *Hydrangea* are known only from one or two specimens from each of the assemblages listed below. A fruiting panicle from the Painted Hills assemblage that also belongs to *Hydrangea* was erroneously illustrated as that of *Tilia* (LaMotte 1936, pl. 3, fig. 6). *Hydrangea* calyces have been recognized at many localities in the Tertiary of North America (LaMotte, 1952). Specimens from the Eocene Florissant flora assigned to *Hydrangea florissantia* (Cockerell, 1908) are similar to those of *Hydrangea bendirei* from the Miocene Mascall flora (Knowlton, 1902; Chaney and Axelrod, 1959). Because it is difficult to discern species in the extant genus based only on calyx morphology, we hesitate to provide a specific assignment for the Bridge Creek taxon. Leaves of *Hydrangea* have not been recognized in the Bridge Creek flora.

Hydrangea is a genus of 23–80 evergreen or deciduous plants that includes trees, shrubs, climbers, and epiphytes found in eastern North America, southeastern Asia, Malesia, and western South America.

ADDITIONAL SPECIMENS: UCMP 12697, 12708; UF 7021, 10266.

ok

OCCURRENCE: Painted Hills, Fossil, Iron Mountain, Crooked River.

Family ROSACEAE

Genus *Amelanchier*

Two species of *Amelanchier* are recognized on the basis of foliage in the Bridge Creek flora. They are rare in the assemblages we have studied, but another apparently distinct species is common in the Twickenham assemblage. Species distinctions within this genus are not always straightforward, and intermediate forms may be the result of hybridization and/or ecological variation.

The 6–25 extant species of serviceberries are deciduous and range in size from shrubs to small trees. They are distributed mostly in north temperate areas chiefly in North America, but with a few representatives in Europe and eastern Asia.

Amelanchier covea (Chaney) Chaney and Axelrod
(leaf)
(Plate 46, figs. 1–3)

Amelanchier coveus (Chaney) Chaney and Axelrod, 1959, *pro parte,* Carnegie Inst. Wash. Pub. 617, p. 183–184 (their synonymy of Bridge Creek material only).

Prunus coveus Chaney, 1927 *pro parte,* Carnegie Inst. Wash. Pub. 346, p. 123–125, pl. 15, fig. 6 only.

DISCUSSION: Although Chaney referred the Bridge Creek material to *Prunus*, Chaney and Axelrod's (1959) subsequent reassignment to *Amelanchier* is supported by examination of cleared leaves indicating that *Prunus* is rarely craspedodromous, usually has glands at the base of the lamina or on the petiole, and does not typically have transverse tertiaries. *Amelanchier covea* is distinguished from *A. grayi* by its tendency for semicraspedodromous venation (some secondaries may be craspedodromous) and, at least in the holotype, the tendency for smaller teeth. Only two determinable specimens are known, both from the Cove Creek assemblage. One specimen illustrated by Chaney (1927, pl. 15, fig. 4) may be *Amelanchier*, but it does not preserve tertiaries and is indeterminate. The limited material of both *A. covea* and *A. grayi* makes it difficult to fully assess the range of variability within each species or to determine whether the variability can be accommodated within the range of a single species.

ADDITIONAL SPECIMEN: UCMP 12698.

OCCURRENCE: Cove Creek (Pentecost Ranch).

Amelanchier grayi Chaney
(leaf)
(Plate 46, figs. 4–8)

Amelanchier grayi Chaney, 1927 *pro parte*, Carnegie Inst. Wash. Pub. 346, p. 120–121, pl. 14, figs. 3, 4 (fig. 5 is indeterminate).

Amelanchier scudderi Cockerell, *in* MacGinitie, 1953, *pro parte*, Carnegie Inst. Wash. Pub. 599, p. 115 (synonymy of material from Chaney 1927, pl. 14, figs. 3, 4 only).

SUPPLEMENTARY DESCRIPTION: Additional material indicates a wider range of variability for *Amelanchier grayi* than described by Chaney, including the following: lamina ovate to obovate; apex broadly rounded to acute; base cuneate to obtuse; length ~3–6+ cm, width ~2–4+ cm; petiole normal, distinctly curved, 1.5 cm long; margin serrate, usually without teeth in basal one-quarter to one-third of lamina; teeth convex to concave on upper side, usually convex to sometimes straight on lower side and occasionally with a small subsidiary tooth, secondary vein enters the tooth medially, tooth apex usually acute to sometimes obtuse; sinuses angular to rounded; venation pinnate, craspedodromous; secondaries curved, often more so near the margin, sometimes once or twice branched, feeding one or two (rarely three) teeth, 8–11 pairs; intersecondaries sometimes present and extending as much as two-thirds the distance to the margin; tertiary veins percurrent, simple to forked, often sinuous, usually perpendicular to midvein, but ranging to perpendicular to secondaries; quaternaries and higher order veins orthogonal, veinlets simple to once or rarely twice branched, straight to curved; areoles formed by quaternary or quinternary veins, 0.25–0.5 mm.

DISCUSSION: Although this species was synonymized by MacGinitie (1953) with *Amelanchier scudderi* from the Florissant flora, we prefer to recognize it as a separate species because the Florissant material has a thicker petiole, fewer pairs of secondaries, and secondaries that are less curved (e.g., MacGinitie, 1953, pl. 50, fig. 2). *Amelanchier grayi* is distinguished from the other Bridge Creek species, *A. covea*, by a much stronger tendency for craspedodromy. *Amelanchier grayi* is very similar to *A. alvordensis* from the Oligo-Miocene Alvord Creek flora of southeastern Oregon (Axelrod, 1944), but differs in having tertiaries that are more frequent and show a more regular course.

ADDITIONAL SPECIMENS: UF 10285,10325, 10330, 10391. acc

OCCURRENCE: Iron Mountain, Crooked River.

Crataegus merriamii (Knowlton) n. comb.
(leaf)
(Plate 47, figs. 1–4, 7–9)

Sapindus merriami Knowlton, 1902, U.S. Geol. Surv. Bull. 204, p. 78–79, pl. 9, fig. 5.

Crataegus flavescens Newberry (not Bosc), 1883, U.S. Nat. Mus. Proc. 5, p. 507; 1898, U.S. Geol. Surv. Monogr. 35, p. 112, pl. 48, fig. 1; Knowlton, 1902, U.S. Geol. Surv. Bull. 204, p. 66, pl. 10, fig. 1.

Myrica diversifolia Lesquereux, 1883, Rept., U.S. Geol. Surv. Terr., 8, p. 241, pl. 50, fig. 10.

Crataegus newberryi Cockerell, 1908, Bull. Am. Mus. Nat. Hist., 24, p. 95. Chaney, 1927, Carnegie Inst. Wash. Pub. 346, p. 121, pl. 14, figs. 6, 10; Manchester and Meyer 1987, Oreg. Geol. 49, p. 121, fig. 5G.

SUPPLEMENTARY DESCRIPTION: The following characters supplement the description provided by Chaney (1927): length to >8 cm; lobes three to eleven (usually five to nine); base usually obtuse to rounded; width to 4.0 cm; quinternaries random reticulate, areoles 0.2–0.4 mm; 6° veinlets present but indistinct.

DISCUSSION: Pinnately lobed leaves occur in several genera of the rosaceous subfamily Maloideae (Robertson et al., 1992). Based on the full suite of material, this species corresponds to *Crataegus* in the presence of three or more (typically five to nine) moderately to deeply pinnate lobes. The Bridge Creek specimens can be distinguished from *Malus* which, although similarly lobed in some species (e.g., *Malus hupehensis* and *M. transitoria*), typically possesses five or fewer lobes.

In a study of the leaf morphology of modern *Crataegus*, El-Gazzar (1980) observed that the degree of leaf incision in the basal sinuses and the presence or absence of intersecondary veins that run toward the sinuses are correlated with geographic distribution. Deeply incised leaves with intersecondaries running toward sinuses occur mainly in species of *Crataegus* section *Crataegus* (*sensu* Phipps et al., 1990), which occurs today mainly in Europe and Asia, with one species in the southeastern United States (Robertson et al., 1992). The Bridge Creek hawthorns clearly show the pronounced leaf incision and presence of the intersecondary veins characteristic of section *Crataegus*.

Although usually not abundant, *Crataegus* is present in all of the Bridge Creek assemblages considered here. There are 200–280 recognized extant species of *Crataegus*, although many are not clearly differentiated due to extensive hybridization. They are deciduous shrubs or trees native to North America, Asia, and Europe.

NOMENCLATURE: The earliest epithets for Bridge Creek material recognizable as *Crataegus* are *flavescens* and *diversifolia*; both epithets were preoccupied by extant species, and this material was renamed *Crataegus newberryi* by Cockerell (1908). However, a fragmentary, poorly preserved specimen (pl. 47, fig. 1) showing the characteristic lobing of *Crataegus*, described by Knowlton (1902) as *Sapindus merriami*, predates the name *C. newberryi* and has priority for the specific epithet.

HOLOTYPE: UCMP 2506.

OK ✓

ADDITIONAL SPECIMENS: UCMP 12699, 12700, 12709; UF 10272, 10273, 10397, 10498–10504.

OCCURRENCE: Painted Hills, Fossil, Cove Creek (Knox Ranch, Pentecost Ranch), Iron Mountain, Crooked River, Lost Creek, Butler Basin.

cf. *Malus* or *Pyrus*
(leaf)
(Plate 47, figs. 5, 6, 10, 11)

DESCRIPTION: Lamina elliptical; apex acute to rounded; base acute, decurrent; length 1.8–4.4 cm, width 1.2–1.8 cm, length to width ratio 1.5–3; petiole curved, 4–8 mm; margin serrate; teeth small, simple, concave to convex on upper side, usually convex to sometimes straight on lower side, tooth apex with a circular gland; sinuses angular to rounded; venation pinnate, camptodromous; secondaries sinuous, curved, seven to ten pairs; intersecondaries extending as much as one-half the distance to the margin; tertiary veins percurrent to reticulate, simple to forked, usually perpendicular to midvein; marginal tertiaries looped to coarsely reticulate with branches extending into the teeth; quaternaries forming random reticulate areoles; quinternaries forming once or twice branched, straight to curved veinlets.

DISCUSSION: This species is based on several well-preserved specimens. The transverse tertiaries, minutely toothed margin, and teeth with conspicuous glands are distinctive features of the lamina consistent with those in some extant species of *Malus* and *Pyrus*, although the fossil leaves tend to be smaller. Because the leaves of these two genera overlap considerably in architectural characters, we hesitate to place the fossil species in either.

ok

SPECIMENS: UCMP 12730; UF 10343, 10395, 10399, 10774, 10775.

OCCURRENCE: Fossil, Butler Basin.

cf. *Pyracantha*
(leaf)
(Plate 47, figs. 12, 13)

DESCRIPTION: Lamina slightly obovate; apex rounded; base apparently acute; length 1.6 cm, width 0.6 cm, length to width ratio 2.7; petiole not preserved; margin serrate; teeth broadly rounded; sinuses rounded; texture coriaceous; venation pinnate, craspedodromous; primary vein stout, straight; secondaries narrowly acute (30–45°), straight to sinuous, branching dichotomously once or twice, sometimes with branches joining those of adjacent secondaries, terminating at the margin; tertiaries and quaternaries random reticulate; veinlets simple to once branched.

DISCUSSION: A single specimen appears similar to *Pyracantha* and shows the branched secondaries and very fine areolation typical of that genus. Extant *Pyracantha* shows considerable leaf size variation within the same plant and includes very small leaves similar to the specimen from Fossil. Although some of the venation characteristics are also common to *Vauquelinia*, species of that genus have a tendency to be much more elongate, have more distinct teeth, and are not typically as small as the Bridge Creek specimen. *Schinopsis*, in the Anacardiaceae, is similar in all orders of venation and has distinct craspedodromous venation, although the cleared leaves that we examined have entire margins.

Pyracantha is represented by six to ten extant species of evergreen shrubs that are distributed from southeast Europe to central China.

SPECIMEN: UF 10396.
OCCURRENCE: Fossil.

Rosa hilliae Lesquereux
(leaf)
(Plate 48, figs. 1–8)

Rosa hilliae Lesquereux, 1883, Rept., U.S. Geol. Surv. Terr. 8, p. 199 (Florissant flora). Chaney, 1927, *pro parte*, Carnegie Inst. Wash. Pub. 346, p. 123, pl. 13, figs. 8, 9, pl. 14, fig. 1 only.

Prunus coveus Chaney, 1927, *pro parte,* Carnegie Inst. Wash. Pub. 346, p. 123, pl. 15, fig. 3 only.

DISCUSSION: *Rosa hilliae* was originally described by Lesquereux (1883) on the basis of leaflets from the Florissant flora and was later recognized by Chaney (1927) in the Bridge Creek flora. As noted by MacGinitie (1953) and Becker (1961), however, there is much variation within living species of *Rosa,* and *R. hilliae* is best considered as an organ species.

New collections have provided additional data on the leaves of this species. One specimen shows the basal portion of the compound leaf with the stipule adhering to the petiole base, as is characteristic of the genus (pl. 48, fig. 2). Another leaf lacks the base but shows that there were at least five leaflets including a terminal (pl. 48, fig. 1).

An examination of cleared leaves of various species of *Rosa* indicates the following characters in common with the fossil material: (1) leaflet length is <4 cm and averages ~2 cm; (2) teeth are simple and closely spaced; 3) venation varies from craspedodromous to camptodromous, often in the same leaflet; and (4) length to width ratio is ~1.5 to 2. These characters, along with the co-occurrence of *Rosa* fruits at four assemblages, support the placement of the leaflets in *Rosa*.

The roses are deciduous or occasionally evergreen shrubs widely distributed in temperate and subtropical areas of the Northern Hemisphere. Various authors recognize between 100 and 250 species.

ok ADDITIONAL SPECIMENS: UCMP 12701; UF 10271, 10284, 10461, 10462, 10878, 10879; USNM 458400–458402.

OCCURRENCE: Painted Hills, Cove Creek (Pentecost Ranch), Iron Mountain, Crooked River, Lost Creek.

Rosa sp.
(fruit)
(Plate 48, figs. 9–12)

Umbellularia oregonensis Chaney(?). Chaney, 1927, Carnegie Inst. Wash. Pub. 346, p. 117, pl. 14, fig. 2.

DESCRIPTION: Fruit pedicellate, urn-shaped, lateral walls rounded; length 10–16 mm, width 7.5–10 mm; apex truncate, flared into a disk-like structure; base acute; pedicel 1.0–1.8 mm thick, 8–16 mm long, with slender prickles or hairs. Fruit containing about ten rounded seeds 1.5–2 mm in diameter.

DISCUSSION: Rose hips are not abundant, but they occur at several different localities of the John Day Formation. The affinity of these fruits to *Rosa* is indicated by the pedicel with thin prickles, the mass of small rounded seeds, and the apical disk. The apical disk, which is preserved in all of the specimens, corresponds to the expansion where the perianth was borne.

These fruits probably correspond to the leaflets of *Rosa hilliae* discussed above. Prickly stems showing elliptical attachment scars typical of Rosaceae are present at several localities (pl. 48, figs. 13, 14). While some of these twigs may represent *Rosa*, they cannot be distinguished with certainty from those of *Rubus*. A similar fruit was illustrated from the Beaverhead basins of southwestern Montana ("acorn" of Becker, 1969, pl. 19, fig. 13.).

SPECIMENS: UCMP 75, 12716; UF 10457–10459. OK ✓

OCCURRENCE: Painted Hills, Iron Mountain, Crooked River, Lost Creek.

Genus *Rubus*

Rubus, although not previously known from the Bridge Creek flora, is represented by two leaf species, one from Iron Mountain and the other from Crooked River. These show characters that are sufficiently different to justify their placement into separate species. Fruits of *Rubus* have also been recovered from the Crooked River assemblage (pl. 49, fig. 5).

There are at least 250 species of extant *Rubus*. The blackberries, raspberries, loganberries, and others are deciduous or evergreen shrubs distributed primarily in the Northern Hemisphere, but also in Africa, Australia, and New Zealand.

Rubus ameyeri n. sp.
(leaf)
(Plate 49, figs. 1, 3)

DIAGNOSIS: Lamina ovate; apex acute; base asymmetrical, rounded to cordate; length 4.8 cm, width 3.3 cm, length to width ratio ~1.5; petiol(ul)e short (2.5 mm), thin, armed with prickles; margin serrate; teeth acute to right angled, irregular in size, with the principal vein entering medially or submedially, sinuses sharp, glands apparently absent; venation pinnate, craspedodromous; primary vein straight; secondaries arising from midvein at 45–25°, about eight pairs, uniformly curved, sometimes branching once near the margin with both branches ending in teeth; intersecondaries absent or rare; tertiaries percurrent, course variable, typically curved or sinuous, sometimes branched; marginal tertiaries arise from secondaries and are craspedodromous into teeth; higher order venation not preserved.

DISCUSSION: *Rubus ameyeri* is based on a single specimen from Iron Mountain with two leaves attached along a prickly twig. The position of buds is not preserved, and we are uncertain whether this foliage was simple or pinnately compound. The lateral attachment of two laminae to the axis excludes the possibility of a trifoliate or palmately compound leaf. The ovate rather than trilobed outline of the lamina distinguishes this species from the extant subgenus *Anoplobatus* Focke. Several similar species occur in the raspberry subgenus *Idaeobatus*.

ETYMOLOGY: This species is named for the first author's father, Arnold W. Meyer, whose trade for more than 50 years has included the cultivation of blackberries, loganberries, and boysenberries in the Willamette Valley of Oregon.

ok ✓ HOLOTYPE: UF 10475.

OCCURRENCE: Iron Mountain.

Rubus fremdii n. sp.
(leaf)
(Plate 49, figs. 2, 4)

DIAGNOSIS: Lamina elliptical; apex acute; base asymmetrical, rounded; length 5.5–6.0 cm, width 2.0–3.0 cm, length to width ratio ~2–2.75; petiol(ul)e 3–13 mm long, armed with prickles; margin serrate; teeth acute, of irregular size, with the principal vein entering medially, sinuses rounded, glands absent; venation pinnate, craspedodromous; primary vein moderately thick, straight, bearing occasional prickles; secondary veins arising from midvein at 60–40° angles, about nine pairs, thickness moderate, course uniformly curved; intersecondaries absent or rare; tertiaries oppositely percurrent, course variable, oriented approximately perpendicular to the midvein, marginal tertiary veins arise from secondaries and form loops, occasionally craspedodromous into teeth; quaternary and higher order veins commonly orthogonal, highest order with excurrent branches fifth or sixth; freely ending veinlets branched once to twice, curved; basal portion of lamina with a marginal vein.

DISCUSSION: This species is based on a single specimen from Crooked River showing two leaves or leaflets arising from a single node along a prickly stem. It is possible that these represent two oppositely arranged leaflets of a pinnately compound leaf or two simple leaves. This species differs from *Rubus ameyeri* in the shape of the laminae, the sharper and more acute teeth, the rounded sinuses, and the orientation of tertiaries perpendicular to the midvein.

ETYMOLOGY: This species is named for Ted Fremd, paleontologist for John Day Fossil Beds National Monument.

✓ ok HOLOTYPE: UF 10460.

OCCURRENCE: Crooked River.

Rubus sp.
(fruit)
(Plate 49, fig. 5)

DISCUSSION: A single fruit of *Rubus* has been recovered from the Crooked River assemblage. The fruit body is about 4.5 mm long and wide, with persisting ovate sepals 2 mm wide and 5 mm long that taper to a sharp apex. The pedicel is 0.8 mm diameter and bears slender prickles that are 0.3-0.5 mm long.

SPECIMEN: UF 10861.

OCCURRENCE: Crooked River.

Rosaceous prickly stems
(Plate 48, figs. 13, 14)

Rosa hilliae auct. non Lesquereux. Chaney, 1927, *pro parte*, Carnegie Inst. Wash. Pub. 346, p. 123, pl. 13, fig. 10 only.

DISCUSSION: Portions of prickly rosaceous stems are common in some assemblages of the Bridge Creek flora. The evidence from those with attached leaves of both species of *Rubus* described above indicates that at least some of these represented blackberries. Others may correspond to *Rosa hilliae*.

SPECIMENS: UF 10277, 10278. ok

OCCURRENCE: Fossil, Cove Creek (Knox Ranch), Iron Mountain, Crooked River, Lost Creek.

Family LEGUMINOSAE

Cercis maurerae n. sp.
(fruit)
(Plate 49, figs. 8–10)

Cercis sp. Chaney, 1927, Carnegie Inst. Wash. Pub. 346, p. 125, pl. 15, fig. 5.

Pod similar to that of *Cercis* Manchester and Meyer, 1987, Oreg. Geol. 49, p. 121, fig. 6B.

DIAGNOSIS: Fruit an elongate-elliptical pod, straight; length 8.0–10.8 cm; width 1.0–1.6 cm; apex and base acute, stipitate, stipe up to 4 mm long, valve margins straight to convex, occasionally concave in places due to a slight constriction between some of the seeds, placental suture with a wing 1–2 mm wide; valves dehiscent with fine, reticulate transverse veins, placental wing without venation. Seeds 11 or more, elliptical, length 3.2–6.5 mm, width 1.8–6.0 mm, borne on funicles 0.2 mm thick, 1–2 mm long, oriented perpendicular to the length of the pod.

DISCUSSION: This legume pod conforms closely to those of extant *Cercis*. Shared features include shape, size, presence of a stipe, presence of a placental wing (a flange of tissue along the placental suture), and the number, shape, and orientation of the seeds. Although various extant genera produce pods that are stipitate and have a placental wing, *Cercis* is unusual because of the absence of venation within the placental wing (Herendeen and Dilcher, 1991). The fossil species, like extant *Cercis*, lacks venation within the wing, but has a distinct transverse venation pattern over the main body of the valve. LaMotte (1952) placed Chaney's "*Cercis* sp." in synonymy with *Cercis spokanensis* Knowlton, a Miocene species that has subsequently been assigned to *Caesalpinia spokanensis* (Knowlton) Herendeen and Dilcher (1991). However, the Bridge Creek species differs from *C. spokanensis* in its narrower placental suture, lack of venation in the wing, and greater fruit length.

Leaves corresponding to *Cercis* have not been observed in the Bridge Creek flora. Extant species of *Cercis* have distinctive cordate simple leaves that may be interpreted as unifoliolate-compound because of the pulvinus at the junction between the lamina and petiole. Such leaves are present in the Florissant flora of Colorado (Knowlton, 1916; MacGinitie, 1953).

The redbuds are deciduous trees and shrubs with six to seven extant species distributed throughout North America, southern Europe, and eastern Asia.

ETYMOLOGY:This species is named in honor of Catherine Maurer (1898–1987) and her family, who kindly provided access to the localities at Iron Mountain.

HOLOTYPE: UF 10477.

PARATYPES: UCMP 88, 12811; UF 7023, 10297, 10298, 10685; USNM 458405.

OCCURRENCE: Painted Hills, Fossil, Iron Mountain, Cove Creek (Knox Ranch, Pentecost Ranch), Crooked River.

Cladrastis oregonensis Brown
(leaflet)
(Plate 49, fig. 6)

Cladrastis oregonensis Brown, 1937, J. Wash. Acad. Sci., 27, p. 415, fig. 1.

Cladrastis oregonensis (Knowlton and Cockerell) Brown, 1946, *pro parte* (fruit only), J. Wash. Acad. Sci. 36, p. 349 (synonymy for *Cladrastis oregonensis* Brown only).

Pod similar to that of *Cladrastis* Manchester and Meyer, 1987, Oreg. Geol. 49, p. 121, fig. 6C.

DESCRIPTION: Fruit an elongate-elliptical pod, straight; length 2.5–6.2 cm; width 1.1–1.8 cm; apex and base acute; stipe ~2 mm long, with remains of the campanulate calyx at base; valve margins convex, rarely concave in places due to a slight constriction between some of the seeds; placental and nonplacental sutures each with a 1.6–2.2 mm wide wing; valves dehiscent; venation fine, reticulate; veins of the nonplacental wing oriented slightly oblique to the margin of the pod. Seeds one (or two?), positioned near the center of the pod, elliptical; length 10.0–10.5 mm, width 4.0–4.5 mm; oriented parallel to the length of the pod; borne on thick funicles; up to five abortive seeds having same shape as the large seed occasionally present.

DISCUSSION: As noted by Brown (1937b), this species conforms to *Cladrastis* in the stipe and in the orientation of the seed parallel to the fruit axis. The holotype, reproduced photographically in pl. 49, fig. 7 to supplement Brown's original diagrammatic illustration, is the most complete and well-preserved specimen, showing the persistent calyx, details of venation, and remains of five small, obliquely oriented abortive seeds. The species is represented both by complete pods and by isolated dehisced valves. Some of the specimens are similar to the pod from Florissant that Knowlton (1916, p. 278, pl. 19, fig. 4) described as *Dalbergia? coloradensis*. The Florissant specimen shows winged placental and nonplacental sutures, has a single developed seed, and shows at least five obliquely oriented abortive seeds. Similar pods of extant *Cladrastis* are illustrated by Herendeen (1992, p. 120, figs. 142–144).

Cladrastis includes four to six extant species of deciduous trees disjunct between eastern North America and eastern Asia.

HOLOTYPE: USNM 40008.

ADDITIONAL SPECIMENS: UF 10286, 10295, 10296, 10686–10690. OK

OCCURRENCE: Painted Hills, Fossil, Iron Mountain, Crooked River, Lost Creek.

Cladrastis sp.
(fruit)
(Plate 49, fig. 7)

DISCUSSION: Manchester and Meyer (1987) illustrated a multiseeded stipitate pod from Fossil and indicated its similarity to *Cladrastis*. Like the specimens attributed to *Cladrastis oregonensis*, it is stipitate and has its seeds oriented parallel to the length of the pod. The pod measures 7.5 cm long by 0.7 cm wide. It differs from the specimens included in *C. oregonensis* by the constrictions between seeds, the number of seeds (three rather than one or two), and the lack of wings on both margins. Despite these differences, which give this specimen an appearance distinct from the specimens on which *C. oregonensis* is based, it is possible that this is a variant pod of the same species. The number of seeds developed, presence of constrictions, and development of wings on the placental and nonplacental sutures are variable in extant species of *Cladrastis*. ✓ ok

SPECIMEN: UF 7024. ✓

OCCURRENCE: Fossil.

cf. *Cladrastis*
(leaflet)
(Plate 50, figs. 6, 7)

DISCUSSION: A few leaflets from Fossil correspond closely in form and venation to those of extant *Cladrastis*. Although such leaflet architecture occurs in other genera of Leguminosae, the association with pods assignable to *Cladrastis* suggests that the leaflets may represent the same genus.

SPECIMENS: UF 10468, 10683. ✓

OCCURRENCE: Fossil.

Micropodium ovatum (Lesquereux) Brown
(fruit)
(Plate 50, figs. 1, 2)

Micropodium ovatum (Lesquereux) Brown, 1937, J. Wash. Acad. Sci. 27, p. 417, fig. 2.

Ailanthus ovata Lesquereux, 1883, U.S. Geol. Surv. Terr. Rept. 8, p. 254, pl. 51, fig. 8 only.

DESCRIPTION: Fruit an oblong-ovate pod; rounded at the apex; base acute, evidently without stipe, length 1.5 cm, width 0.8 cm wide; placental suture line with a broad wing. Seeds one or two (or more?), elliptical, 2 mm long, with the long axis perpendicular to the length of the pod.

DISCUSSION: This species is known from several specimens from the Painted Hills assemblage. Brown (1937b) concluded that the pods were preserved without any venation and interpreted the striations as artifacts of preservation. However, the best-preserved specimen (pl. 50, fig. 2) clearly shows the presence of closely spaced transverse veins, similar to those observed in various extant genera. The generic name *Micropodium* was established for fossil pods from the late Oligocene of southeastern France (Saporta *in* Heer, 1861; Saporta, 1873) and was later applied by Brown (1937b) to the Bridge Creek specimens. However, a first-hand comparison between the John Day specimens and those from France has not been made.

Brown (1937b) indicated the possibility that these small pods could be dwarf pods of *Cercis*. These pods differ from those of *Cercis maurerae* in the flora by the shorter pod length, the small number of seeds, and the close proximity of adjacent seeds.

LECTOTYPE: We designate as the lectotype UCMP 1766 (Lesquereux, 1883, pl. 51, fig. 8; reillustrated here as pl. 50, fig. 1).

ADDITIONAL SPECIMEN: UCMP 12812.

OCCURRENCE: Painted Hills.

Leguminosae gen. et. sp. indet.
(leaflet)
(Plate 50, figs. 3–5, 8–10)

Fraxinus integrifolia auct. non Moench. Newberry, 1883, U.S. Nat. Mus. Proc. 5, p. 509; 1898, U.S. Geol. Surv. Monogr. 35, p. 128, pl. 49, figs. 1–3. Knowlton, 1902, U.S. Geol. Surv. Bull. 204, p. 84.

Fraxinus oregonensis Knowlton and Cockerell, 1919, U.S. Geol. Surv. Bull. 696, p. 296 (new name for Newberry's species).

Umbellularia oregonensis (Knowlton and Cockerell) Chaney, 1925c, Carnegie Inst. Wash. Pub. 349, p. 60, pl. 1, figs. 1, 3, 5, 7.

Cladrastis oregonensis (Knowlton and Cockerell) Brown, 1946, *pro parte* (leaflets only), J. Wash. Acad. Sci. 36, p. 349 (synonymies for *Fraxinus oregonensis* and *Umbellularia oregonensis* only).

DISCUSSION: Legume leaflets, readily recognizable by their lanceolate to elliptical outline, entire margin, bluntly acute apices, brochidodromous venation, and short, transversely striate petiolules, are a common component in the Painted Hills assemblage. The generic identity of these isolated leaflets remains uncertain.

SPECIMENS: UCMP 12813–12816; USNM 7090.

OCCURRENCE: Painted Hills, Fossil, Cove Creek (Pentecost Ranch).

Family LYTHRACEAE

Decodon brownii n. sp.

(leaf)

(Plate 50, figs. 11–13)

DIAGNOSIS: Lamina incomplete, apparently long-elliptical, with apical portion missing; base acute to cuneate; lamina length estimated at 4–5 cm, width estimated at 1.5–2.0 cm, length to width ratio ~3; petiole length 0.5 cm; margin entire; venation brochidodromous; primary vein stout, course apparently straight to slightly curved; secondaries moderately to widely acute (~65°), probably 10–15 pairs, straight to slightly sinuous in course between midvein and margin but abruptly curved near the margin to form brochidodromous loops that join into an intramarginal vein; tertiary veins random to orthogonal reticulate, marginal tertiaries abmedially brochidodromous; higher order veins indistinct.

DISCUSSION: This species is based on three fragmentary specimens. The specimens conform to *Decodon* in the distinct series of brochidodromous loops of secondaries that form an intramarginal vein characterized by a series of arcs and in the abmedially brochidodromous marginal tertiaries (pl. 50, fig. 12).

Fossil occurrences of *Decodon* are known on the basis of permineralized fruits from the Eocene Clarno Nut Beds of Oregon (Manchester, 1994b) and the Princeton chert of British Columbia (Cevallos-Ferriz and Stockey, 1988), seeds from the Tertiary of Europe and Asia (see Friis, 1985), and leaves from the Miocene floras of Seldovia Point, Alaska (*Decodon alaskana*) and Collawash, Oregon (Wolfe and Tanai, 1980). *Decodon brownii* is distinguished from *D. alaskana* Wolfe and Tanai by the narrower lamina and regular, non-looped course of the intramarginal vein. The one extant species of *Decodon* is a deciduous subshrub native to swampy habitats of eastern North America.

ETYMOLOGY: This species in named in recognition of the contributions of Roland W. Brown to paleobotany.

HOLOTYPE: UF 10386

PARATYPES: 10474, 10564.

OCCURRENCE: Fossil, Iron Mountain.

OK ✓

Family COMBRETACEAE

Terminalia oregona (Lakhanpal) n. comb.
(fruit)
(Plate 51, figs. 1–4)

Halesia oregona Lakhanpal, 1958, *pro parte*, Univ. Calif. Pub. Geol. Sci. 35, p. 36, pl. 9, fig. 1; pl. 10, fig. 4 only (Rujada flora).

Terminalia sp. Brown, 1959, *pro parte*, J. Paleont. 33, p. 128; pl. 24, fig. 16 only.

cf. *Terminalia* Manchester and Meyer, 1987, Oreg. Geol. 49, p. 121–22, fig. 6P.

DISCUSSION: *Terminalia* was first recognized in the Bridge Creek flora by Brown (1959), although the species was not named. He illustrated three specimens, one from the Fossil assemblage of the Bridge Creek flora and one each from the Lyons and Willamette floras. Lakhanpal (1958) illustrated smaller specimens of the same fruit type under the name *Halesia oregona*. However, the fossils differ from fruits of *Halesia* by the absence of an intramarginal vein. They correspond to *Terminalia* in the Combretaceae in the presence of a fusiform, longitudinally ribbed central body with lateral wings having fine, closely spaced parallel veins that extend to the margin without looping or forming a marginal vein. The fruits have a pedicel with no indication of perianth scars, and there is a disk and protrusion at the apex.

Brown (1959) observed that the smaller specimens of this species are similar to *Terminalia estamina* MacGinitie from the Eocene Chalk Bluffs flora of California. He noted that the fossil fruits are particularly similar to *T. paniculata* Roth from the western part of India and that "if this identification is correct, we have here an apparent subtropical relict held over from the late Eocene into Oligocene floras" (Brown, 1959, p. 128).

Superficially, the impressions of *Terminalia oregona* samaras in the Bridge Creek flora are similar to those of *Craigia*, but they can be distinguished by the structure of the central body and venation of the valves. The *Terminalia* fruits differ from those of *Craigia* in the more closely spaced veins of the wing and absence of a marginal vein, the longitudinal ribbing and greater relative length of the central body, and the presence of an apical disk and stylar protrusion.

Terminalia is a genus of 150–250 evergreen to deciduous trees of wide tropical distribution.

NOMENCLATURE: *Halesia oregona* Lakhanpal from the Rujada flora was based on four syntypes, two of which were fruits and two of which were leaves. We now designate the fruit specimen UCMP 5242 (Lakhanpal, 1958, pl. 10, fig. 4) as the lectotype for the species.

x ADDITIONAL SPECIMENS: UF 7032, 10497, 10682; USNM 42355.

OCCURRENCE: Fossil.

to locate 7032
10497a OK
30 DEC. 1994
dmj

Family ANACARDIACEAE

Rhus lesquereuxii n. sp.

(leaf)

(Plate 51, figs. 5, 6; Plate 52, figs. 1–5)

Dipteronia insignis (Lesquereux) Brown (not *Myrica insignis* Lesquereux). Brown, 1940, J. Wash. Acad. Sci. 30, p. 351, fig. 17.

DIAGNOSIS: Leaf compound with at least three leaflets; lamina oblong to obovate; apex acuminate; base obtuse, asymmetrical; length 5–8.5 cm, width 2.1–3.7 cm, length to width ratio ~2 to 3; petiolule normal, 1–2 mm on lateral leaflets, 1 cm on terminal leaflet; margin serrate apically to entire basally; teeth convex on both apical and basal sides; sinuses angular, usually fed by an abaxial branch of the secondary vein; venation pinnate, craspedodromous to eucamptodromous; primary vein straight to slightly curved; secondary veins moderately to widely acute, often branched near the margin, ~12 pairs, thickness moderate, course curved; intersecondary veins simple, often arising at nearly right angles, seldom extending more than one-third the distance to the margin; tertiary veins transversely ramified to percurrent, arising at nearly right angles from secondaries; higher order venation indistinct.

DISCUSSION: The rounded teeth, with sinuses often fed by a vein arising from a secondary (pl. 52, fig. 2), and the presence of transversely ramified to percurrent tertiary veins (pl. 51, fig. 6) are consistent with the assignment of this species to *Rhus*. The Bridge Creek material is distinguished from *Rhus varians* Lakhanpal of the Rujada flora in being less frequently toothed and having an attenuate apex and more ramified secondaries near the margin.

The sumacs include about 200–250 species of deciduous or evergreen trees, shrubs, and lianas, distributed in North America, the Mediterranean, and southeastern Asia.

NOMENCLATURE: The epithet *insignis* was originally established for leaves from the Florissant flora that were attributed to *Myrica* (Lesquereux, 1876, 1878) and subsequently transferred to *Dipteronia* (Brown, 1936). Brown (1940) later identified a Bridge Creek specimen to the same species; however, we consider the Bridge Creek specimen to be distinct from the Florissant species.

ETYMOLOGY: This species is named after Leo Lesquereux in recognition of his pioneering contributions to paleobotany in the United States.

HOLOTYPE: UF 10473.

PARATYPES: UF 10382–10384, 10393, 10536. OK ✓

OCCURRENCE: Painted Hills, Fossil, Iron Mountain, Lost Creek, Twickenham.

Rhus sp.

(fruit)

Plate 52, figs. 6)

DISCUSSION: Widely elliptical, longitudinally ribbed endocarp impressions corresponding in morphology to *Rhus* have been recovered that might correspond to the same species as the leaves described above.

ok

SPECIMEN: UF 10681.
OCCURRENCE: Fossil.

Toxicodendron wolfei n. sp.
(leaflet)
(Plate 52, fig. 7; Plate 53, figs. 1–4)

DIAGNOSIS: Lamina elliptical; apex acute to acuminate; base obtuse, sometimes asymmetrical; length ~8–10 cm; width ~3–4.4 cm, length to width ratio ~2.1; petiol(ule) normal, 4.5 mm; margin entire; venation pinnate, cladodromous and extending to the margin; primary vein moderately thick, curved; secondary veins moderately to widely acute (~55–75°), ramified, ~12–15 pairs, thickness moderate, course curved, basal secondary veins recurved; intersecondary veins occasional, simple, often less acute than secondaries and sometimes arising at 60–85°, extending one-third to one-half the distance to the margin; tertiary veins transversely ramified to sometimes weakly percurrent, arising at widely acute angles from both upper and lower sides of secondaries, some extending to the margin; quaternary veins randomly oriented, branched, usually freely ending within the intercostal area.

DISCUSSION: This species conforms to the Anacardiaceae in having secondaries that approach very close to or terminate at the entire margin and tertiary veins that often ramify and weaken within the intercostal area (pl. 53, figs. 2, 4). The margin is generally entire, although sometimes undulate. *Toxicodendron wolfei* is distinguished from *Rhus lesquereuxii* by the absence of distinct teeth, the tendency toward larger size and a smaller length to width ratio, and the presence of tertiaries that are more ramified and less often percurrent.

Toxicodendron wolfei is distinguished from *T. magnifolia* from the Miocene Weaverville flora (MacGinitie, 1937) by its generally smaller size, more ramified intercostal tertiary venation, fewer secondaries (12–15 versus 14–19 pairs), and elliptical rather than ovate shape.

Toxicodendron, which includes the poison ivies and poison oaks, is a genus of shrubs and climbers often included in the genus *Rhus*. The systematics and ecology of extant *Toxicodendron* was reviewed by Gillis (1971). There are 15 species, distributed in eastern Asia, North America, and South America.

ETYMOLOGY: This species is named for Jack A. Wolfe in recognition of his many contributions to paleobotany and paleoclimatology.

HOLOTYPE: UF 10379.

PARATYPES: UCMP 12702; UF 10378, 10380, 10385.

ADDITIONAL SPECIMEN: UF 10381.

OCCURRENCE: Cove Creek (Knox Ranch, Pentecost Ranch), Iron Mountain, Lost Creek.

Family MELIACEAE

Cedrela merrillii (Chaney) Brown
(leaf, seed)
(Plate 54, figs. 1–12)

Cedrela merrilli (Chaney) Brown, 1937, J. Wash. Acad. Sci. 27, p. 511, Manchester and Meyer, 1987, Oreg. Geol. 49, p. 121, figs. 6I–K.
Rhus merrilli Chaney, 1927, Carnegie Inst. Wash. Pub. 346, p. 125–126, pl. 16, figs. 1, 2.
Acer sp.? Newberry, 1898, U.S. Geol. Surv. Monogr. 35, p. 115, pl. 46, fig. 8.
Pinus knowltoni(?) auct. non Chaney. Mason, 1927 *pro parte*, Carnegie Inst. Wash. Pub. 346, p. 148, pl. 3, fig. 3 only.

DISCUSSION: *Cedrela merrilli* is represented by both leaflets and winged seeds. Although Chaney (1927) referred the leaflets to *Rhus*, they lack the cladodromous secondary venation and ramified tertiary venation typical of *Rhus*, and were subsequently assigned to *Cedrela* by Brown (1937a). Secondary veins approach the margin very closely, as in *Rhus*, but they are eucamptodromous to weakly brochidodromous, and the tertiaries are forked-percurrent to coarsely reticulate. These characters, along with the long elliptical shape, asymmetrical base, apparently attenuate apex, stout midrib, and predominantly smooth margin with occasional low crenate teeth, are consistent with those of *Cedrela* and the closely related Asian genus *Toona*.

The original generic determination based on leaves is corroborated by associated membranous-winged seeds (pl. 54, figs. 3–9). The seeds consist of an oval seed body with an elongate wing. The wing lacks venation except for a single more or less medial vein and typically shows a crease just inside the distal margin (pl. 54, figs. 11, 12). Such a crease is also seen in extant *Cedrela* and is due to compaction by adjacent seeds within the fruit. The fossil seeds are highly variable in shape, evidently depending on the position of individual seeds within the fruit (as in extant representatives). The Bridge Creek species appears similar to the extant *Cedrela mexicana* in having leaves with secondary veins originating at high angles and curving abruptly upward near the margin and in the morphology of the seeds. Seeds of the related Asian genus *Toona* (formerly lumped in *Cedrela*) are similar, but in the one species that we examined (*Toona sinensis*), a crease was not apparent in the seed wing and one of the lateral margins of the wing is more strongly thickened than in *Cedrela*. This distinction probably reflects differences in the way the seeds are borne within the capsular fruit. In *Cedrela*, the seeds each have a single terminal wing and are attached to the distal part (apex) of the columella, with the wing oriented toward the base of the fruit, whereas in *Toona*, the seeds are either winged at both ends and attached toward the apex of the columella, or single-winged and attached to the base (proximal part) of the capsule with the wing oriented apically (Pennington and Styles, 1975).

There are six to eight extant species of *Cedrela* in Mexico and tropical South America. They include deciduous and evergreen trees and shrubs and are primarily tropical in distribution. *Cedrela* has also been recognized in the

Florissant flora of Colorado and in Miocene floras of the Pacific Northwest (Brown, 1937a,c; MacGinitie, 1953; Chaney and Axelrod, 1959).

ok ✓

ADDITIONAL SPECIMENS: UF 10472 (leaf). UCMP 12704; UF 10279, 10280, 10293, 10294, 10869–10877 (seeds).

OCCURRENCE: Fossil (leaf and seed), Cove Creek (Pentecost Ranch)(seed), Iron Mountain (seed), Crooked River (leaf and seed), Lost Creek (seed).

Family SAPINDACEAE

We adopt the broad treatment of Sapindaceae, including Aceraceae and Hippocastanaceae, as supported by phylogenetic investigations (Judd et al., 1994; Zomlefer, 1994).

Genus *Acer*

The maples are common in all of the Bridge Creek assemblages. The 110–200 extant species of maples are deciduous or rarely evergreen trees and shrubs distributed in North America, southeastern Asia, western Malesia, and Europe. The terminology used below to describe fruit and leaf characters is from Wolfe and Tanai (1987, pp. 57–61).

Acer is the most diverse genus in the Bridge Creek flora. Seven morphotypes can be distinguished on the basis of leaves, while at least six morphotypes can be distinguished from fruits. Combining some of these leaf and fruit types together under the same species names, Wolfe and Tanai (1987) recognized seven species in the Bridge Creek flora in their systematic revision of *Acer* in the Tertiary of western North America. Because of the diversity of maples in the Bridge Creek flora, the association of leaf and fruit types as members of the same species is speculative. Although Wolfe and Tanai (1987) treated leaves and fruits within the same species concepts, we prefer a more conservative approach and in most cases have treated the fruits and leaves separately. The holotypes for *Acer ashwillii*, *A. glabroides*, *A. kluckingii*, *A. manchesteri*, and *A. osmontii* are leaves, while those for *A. cranei* and *A. oligomedianum* are fruits. Strong evidence for conspecificity of fruits and leaves occurs only in the case of *A. osmontii*. Therefore, in this treatment, both leaves and the probable fruits of *A. osmontii* are considered together under that name, but the other species of *Acer* are considered separately for leaves and fruits as indicated in the following sequence:

1. *A. osmontii* leaf and fruit
2. *A. ashwillii* leaf
3. *A. glabroides* leaf
4. *A. kluckingii* leaf
5. *A. manchesteri* leaf
6. *Acer* sp. 1 leaf (*A. oligomedianum* sensu Wolfe and Tanai)
7. *Acer* sp. 2 leaf (newly recognized)
8. *A. cranei* fruit
9. *A. oligomedianum* fruit
10. *Acer* sp. A fruit (*A. ashwillii* sensu Wolfe and Tanai)

11. *Acer* sp. B fruit (*A. glabroides* sensu Wolfe and Tanai)
12. *Acer* sp. C fruit (*A. manchesteri* sensu Wolfe and Tanai)

Characters and tendencies useful for discriminating these species are summarized in Tables 7 and 8.

Acer osmontii Knowlton

(leaf, fruit)
(Plate 57, figs. 1, 2; Plate 60, figs. 10–12)

Acer osmonti Knowlton, 1902, U.S. Geol. Surv. Bull. 204, p. 72, pl. 13, fig. 3. Chaney, 1927, *pro parte*, Carnegie Inst. Wash. Pub. 346, p. 126–128; pl. 18, figs. 8, 9 only. Wolfe and Tanai, 1987, J. Fac. Sci., Hokkaido Univ. 22, p. 146–150; pl. 28, figs. 1, 2, 4; pl. 29, fig. 2; pl. 31, figs. 1, 2, 4–6; Manchester and Meyer, 1987, Oreg. Geol. 49, p. 121, fig. 6F.

DISCUSSION: This species is based on leaves and fruits that each show characters of the extant *Macrophylla* group, section *Macrophylla* of *Acer* (Wolfe and Tanai, 1987). *Acer osmontii* includes the largest leaves and fruits of the Bridge Creek maples. The leaves are five- to seven-lobed, with lobes and large teeth characterized by rounded arcuate sinuses and up to two subsidiary teeth on their lower flanks (pl. 57, figs. 1, 2). The angle between adjacent primary veins ranges from 40 to 60°. It is difficult to obtain complete leaves of this species, because the size (up to at least 22 cm long and wide, UF 10777) usually exceeds that of blocks of shale from which the leaves are collected. These leaves closely resemble those of extant section *Macrophylla* (e.g., *Acer macrophyllum*) in the large size of the lamina, the arcuate sinuses, and large, widely spaced teeth. The fruits (pl. 60, figs. 10–12) are readily distinguished from the other Bridge Creek maple fruits by their large size (length 4.2–5.8 cm) combined with the markedly inflated nutlet and low attachment angle (15–35°).

Acer osmontii is also known on the basis of both leaves and fruits in the Lyons, Gumboot Mountain, and Twickenham assemblages, and from fruits only in the Nichols Spring, Woods Hollow, and Kennedy Ranch assemblages (Wolfe and Tanai, 1987). The *Macrophylla* group is disjunct today between the western North American *Macrophylla* section (*A. macrophyllum*) and the Asian section *Lithocarpa* (e.g., *A. diabolicum*, *A. franchetii*, and *A. thomsonii*).

HOLOTYPE: UCMP 2505 of Knowlton (1902), a leaf.

ADDITIONAL SPECIMENS: UCMP 12720; UF 10291, 10627–10630, 10794–10796 (fruits). UF 10777–10779 (leaves).

OCCURRENCE: Painted Hills (leaf and fruit), Fossil, (fruit and one fragmentary leaf), Cove Creek (Knox Ranch, Pentecost Ranch) (leaf, fruit), Iron Mountain (leaf, fruit), Crooked River (fruit), Lost Creek (fruit).

TABLE 7
Distribution of Diagnostic Foliar Characters among Species of *Acer* from the Bridge Creek Flora

Characters	Taxa[1]						
	Aas	Agl	Akl	Ama	Aos	A1	A2
5–7 primary veins originating from base of lamina			x		x		
Primary veins in palinactinodromous organization (laterals arising above the base)				?		x	
Only 3 primary veins	x	x		x			x
Lobe sinuses curved					x		
Lobe sinuses deeply incised [2]	x					x	
Margin finely serrate	x	x				x[3]	
Trend of first lateral primaries typically < 45° to midvein	x	x					
Veins within lowermost intercostal area forming chevron pattern							x

[1] Abbreviations: Aas = *A. ashwillii*, Agl = *A. glabroides*, Akl = *A. kluckingii*, Ama = *A. manchesteri*, Aos = *A. osmontii*, A1 = *A.* sp. 1, A2 = *A.* sp. 2.

[2] Commonly incised to ~80% of the length of the medial lobe.

[3] Fine teeth confined mostly to apical portions of lobes.

Acer ashwillii Wolfe and Tanai
(leaf)
(Plate 55, figs. 1–4)

Acer ashwillii Wolfe and Tanai, 1987, *pro parte*, J. Fac. Sci., Hokkaido Univ. 22, p. 77–78, pl. 22, fig. 4 only; pl. 24, figs. 1–4; pl. 25, figs. 9, 13–14; text fig. 12F; Manchester and Meyer, 1987, Oreg. Geol. 49, p. 121, fig. 6D.

DISCUSSION: *Acer ashwillii* was described by Wolfe and Tanai (1987) on the basis of both leaves and fruits and placed in section *Trilobata* of the *Macrantha* group. We treat the fruits separately under "*Acer* sp. A fruit." *A.*

TABLE 8
Distribution of Diagnostic Fruit Characters among Species of *Acer* from the Bridge Creek Flora

Characters	Taxa[1]					
	Acr	Aol	Aos	Aa	Ab	Ac
Fruits large (length > 42 mm)			x			
Nutlet semicircular in lateral view			x			
Nutlet markedly elongate (length to width ratio > 2.8)	x					
Nutlet with well-defined medial flange					x	
Nutlet width > 5 mm		x	x			x
Nutlet width < 4 mm				x		
Nutlet flattened						x

[1] Abbreviations: Acr = *A. cranei*, Aol = *A. oligomedianum*, Aos = *A. osmontii*, Aa = *A.* sp. A, Ab = *A.* sp. B, Ac = *A.* sp. C.

ashwillii leaves are deeply three-lobed with attenuate lobe apices, often with a lobation developed on each of the outer lobes and with one or more pairs of lobations on the medial lobe (pl. 55, figs. 1–4). The margin is finely serrate with closely spaced sharp teeth. The lateral primaries are two-thirds to three-quarters as long as the medial primary and the angle between adjacent primaries is 30–45°. The leaves of this species are variable in size (4–10.5 cm long) and are sometimes asymmetrical. Wolfe and Tanai (1987, p. 78) emphasized that the leaves of this species conform to those of extant section *Trilobata* in the three-lobed condition and type of areolation, but they also observed that "leaves of *Trilobata* have very short lateral lobes or are unlobed."

We have observed these leaves to co-occur with *Acer* sp. A fruits in three assemblages (Fossil, Crooked River, and Lost Creek). In addition, Wolfe and Tanai cited both leaves and fruits in the Iron Mountain, Butler Basin, and Kennedy Ranch assemblages. These leaves and the fruits of *Acer* sp. A are both particularly abundant in the assemblage at Fossil. The co-occurrence data support the opinion of Wolfe and Tanai (1987) that these organs represent the same species. However, fruits of *Acer* sp. C and *Acer cranei* also occur at the same localities as *A. ashwillii* leaves.

10783 not in
10785 drawer

HOLOTYPE: UCMP 9036 (leaf).

ADDITIONAL SPECIMENS: UF 10421, 10422, 10782–10791.

OCCURRENCE: Fossil, Iron Mountain, Butler Basin.

Acer glabroides Brown emend. Wolfe and Tanai
(leaf)
(Plate 55, figs. 5–7)

Acer glabroides Brown emend. Wolfe and Tanai, 1987, *pro parte* (leaves only), J. Fac. Sci., Hokkaido Univ. 22, p. 122, 124; pl. 23, figs. 1, 2 only.

Acer glabroides Brown, 1937, U.S. Geol. Surv. Prof. Paper 186-J, p. 180 (but excluding all figured specimens).

Acer osmonti auct. non Knowlton. Chaney 1927, *pro parte*, Carnegie Inst. Wash. Pub. 346, p. 126, pl. 18, fig. 5 only.

DISCUSSION: *Acer glabroides* leaves are rare in the Bridge Creek flora. They are small (length ~4–7 cm) and shallowly trilobate with the median lobe twice as wide as the laterals and uniformly tapered to an acute apex (pl. 55, figs. 5–7). The leaves are also characterized by a low angle between adjacent primaries (20–35°), about four to six abmedial secondary veins, and small, rounded teeth of uniform size. They are distinguished from *Acer* leaf sp. 2 (one specimen of which was attributed to *A. glabroides* by Wolfe and Tanai, 1987) in the straight course of the lateral primaries, narrower angle between the lateral primaries, fewer external secondaries, and smaller size. They are distinguished from *A. ashwillii* in the absence of lobations, lack of attenuate apices, generally smaller size, and shallower incision between lobes.

Wolfe and Tanai (1987) included fruits of *Acer* sp. B within their circumscription of *A. glabroides*, although there is no proof that they actually belong to the same species. These fruits occur at Iron Mountain as well as at Crooked River, yet the foliage co-occurs only in the latter assemblage.

One of the leaf specimens illustrated by Wolfe and Tanai (1987, pl. 27, fig. 9) as *Acer kluckingii* from Cove Creek (Pentecost Ranch) also appears to conform closely to *A. glabroides*, although it has a greater angle between adjacent secondaries and we hesitate to formally place that specimen in synonymy.

LECTOTYPE: UCMP 108 (pl. 55, fig. 5) was designated as the lectotype by Wolfe and Tanai (1987) from the collection of Chaney (1927) that was included in the synonymy of Brown (1937).

ADDITIONAL SPECIMENS: UF 10313, 10423, 10424.

OCCURRENCE: Fossil, Cove Creek, Crooked River.

Acer kluckingii Wolfe and Tanai
(leaf)
(Plate 56, fig. 4)

Acer kluckingi Wolfe and Tanai, 1987, *pro parte*, J. Fac. Sci., Hokkaido Univ. 22, p. 84, 85; pl. 27, fig. 11 only.

DISCUSSION: Wolfe and Tanai (1987) recognized this species from the Cove Creek assemblage on the basis of both leaves and fruits. They illustrated three specimens of leaves, including the holotype. The two illustrated paratypes are missing critical features of the leaf base and are thus difficult to evaluate; no new material has been recovered subsequently. On the basis of the holotype, *A. kluckingii* is distinguished by the presence of five primary veins. The basal lateral primaries arise from the same point as the inner primaries and enter basal lobations. The first pair of lateral primaries diverge at relatively broad angles (~70°). On the basis of the holotype alone, this leaf appears to be sufficiently distinctive to justify Wolfe and Tanai's (1987) treatment of it as a separate species, although additional material is needed to define its range of characters.

The fruits that Wolfe and Tanai attributed to *A. kluckingii* are treated here under *Acer* sp. A.

OCCURRENCE: Pentecost Ranch.

Acer manchesteri Wolfe and Tanai
(leaf)
(Plate 56, figs. 1–3, 5)

Acer manchesteri Wolfe and Tanai, 1987, *pro parte* (leaves only), J. Fac. Sci., Hokkaido Univ. 22, p. 188–192; pl. 32, figs. 1, 2, 5–10 only; text figs. 18G, H.

DISCUSSION: *Acer manchesteri* was described by Wolfe and Tanai (1987) on the basis of both leaves and fruits, although we treat the fruits separately as *Acer* sp. C. The lobes of the leaf are widely arrayed as indicated by the high angle (40–70°) between adjacent primaries, and the base of the lamina is cordate to broadly rounded and lacks teeth (pl. 56, figs. 1–5). Wolfe and Tanai (1987) considered this species to represent an extinct section basal to the extant *Platanoidea* group of *Acer*.

LECTOTYPE: The holotype as illustrated by Wolfe and Tanai is UCMP 9203 (a leaf), although another unillustrated specimen (UCMP 9216, a leaf) was cited as the holotype in the text of the same publication. Because an illustration is required to validate the publication of a new species, the former is hereby designated the lectotype. ~~It is reillustrated here as pl. 56, fig. 4~~.

ADDITIONAL SPECIMENS: UF 10812–10818.

OCCURRENCE: Iron Mountain, Crooked River. ok ✓

Acer sp. 1
(leaf)
(Plate 58, figs. 1–3)

Acer oligomedianum Wolfe and Tanai, 1987, *pro parte* (leaves only), J. Fac. Sci., Hokkaido Univ. 22, p. 110; pl. 26, figs. 3, 7, 8, 10 only; text fig. 14L.

Acer osmonti auct. non Knowlton. Chaney, 1927, *pro parte*, Carnegie Inst. Wash. Pub. 346, p. 126–128; pl. 17, fig. 6 only.

DISCUSSION: Although leaves of this morphology were included by Wolfe and Tanai (1987) with fruits of *Acer oligomedianum*, our evaluation of co-occurrence evidence suggests they more likely correspond to the fruits attributed by Wolfe and Tanai to *A. glabroides*, here termed *Acer* sp. B. *Acer oligomedianum* fruits occur together with the *Acer* sp. 1 leaf at only one assemblage (Crooked River). However, *Acer* sp. B fruits co-occur with *Acer* sp. 1 leaves at two assemblages (Crooked River and Iron Mountain).

The distinctive leaves of *Acer* sp. 1 are three-lobed, with the sinuses more deeply incised than in any of the other Bridge Creek species (incised to ~80% of the length of the medial lobe; incision depth within 1 to 1.5 cm of the base), with lateral lobes usually nearly as long as the medial (pl. 58, figs. 1–3). Although basically three-lobed with a primary vein leading to each of the lobes, there are actually five primary veins, usually palinactinodromously (or sometimes nearly palmately) arranged with the outer pair of primaries leading into the lowermost lateral lobations. The medial lobe widens above its base and has two or three lobations; the lateral lobes have one or two lobations on their basal sides. The angle between adjacent primaries ranges from 44 to 54°.

Wolfe and Tanai (1987) placed this species (on the basis of the assumed union of fruits and leaves), along with several other species from the Tertiary of the Pacific Northwest, in an extinct section, *Columbiana*, with some characters in common with the extant section *Glabra*.

SPECIMENS: UF 10310–10312, 10315, 10781.

OCCURRENCE: Cove Creek (Pentecost Ranch), Iron Mountain, Crooked River.

Acer sp. 2
(leaf)
(Plate 59, figs. 1–3)

Acer osmonti auct. non Knowlton. Chaney 1927, *pro parte,* Carnegie Inst. Wash. Pub. 346, p. 126, pl. 18, fig. 1 only.

DESCRIPTION: Leaves palmately trilobed, medial lobe about twice as wide at its base as lateral lobes; primary vein of lateral lobes 0.6–0.8 as long as the medial lobe; lobe sinuses angular; apex missing; base rounded to sometimes cordate; length estimated at 6.5–10 cm, width 4.6–9 cm; length to width ratio 1.1–1.4; petiole >1.5 cm (incomplete specimen); margin serrate; teeth simple, mostly one per secondary vein; sinuses variable, sharp to rounded; venation actinodromous; three primary veins, medial primary straight, lateral primaries uniformly curved; secondaries craspedodromous, medial secondaries arising at about 40° from the midvein, outer lateral secondaries curved, arising at 35–50° from the primary; abmedial tertiary veins originating from the basal pair of secondary veins of the medial lobe, joining with secondary veins of the lateral primaries to form a series of chevrons pointing toward the sinus.

DISCUSSION: This species is distinct from other Bridge Creek maples, including those treated by Wolfe and Tanai (1987). It is distinguished by the chevron pattern described above and the closely spaced abmedial secondaries (usually about ten). The species is also characterized by a rounded to cordate base and uniformly curved primaries (pl. 59, figs. 1–3). It is distinguished from leaves of *A. osmontii* by having fewer lobes and primary veins (three versus five to seven), angular lobe sinuses, and more secondary veins along each lateral primary.

ok✓ SPECIMENS: UF 10292, 10425, 10792, 10809.
OCCURRENCE: Fossil, Crooked River.

Acer cranei Wolfe and Tanai
(fruit)
(Plate 60, figs. 1, 16)

Acer cranei Wolfe and Tanai, 1987, J. Fac. Sci., Hokkaido Univ. 22, p. 101, pl. 25., figs. 2, 3, 7, 8, 10–12.
Acer osmontii auct. non Knowlton. Chaney, 1927, *pro parte*, Carnegie Inst. Wash. Pub. 346, p. 126, pl. 18, fig. 7.
Acer negundoides auct. non MacGinitie. Brown, 1935, J. Paleont. 9, p. 580, pl. 69, figs. 9, 10.

DISCUSSION: *Acer cranei* was described by Wolfe and Tanai (1987) on the basis of fruits from the Bridge Creek flora. The fruits are small (2–2.5 cm length) and distinguished by an elongate nutlet with a relatively straight proximal margin forming a sharply acute angle with the proximal end of the attachment scar. The attachment angle ranges from 25 to 60°. The samaras are similar to those of extant *Acer negundo* (placed by some systematists into a separate genus, *Negundo*) in the elongate nutlet and variable attachment angle. Although extant *A. negundo* leaves are compound with three to five leaflets, similar leaves or leaflets are not known from the Bridge Creek flora.

This species occurs at most localities of the Bridge Creek flora and is also known from Nichols Spring and Sumner Spring. A similar species, *Acer macginitiei* Wolfe and Tanai (1987), with smaller fruits is present in the Florissant and Beaverhead floras.

HOLOTYPE: USNM 396053 (cited in text, Wolfe, 1987, p. 101) or UCMP 9322 (as given in figure caption, Wolfe and Tanai, 1987, p. 172).

ADDITIONAL SPECIMENS: UF 10288, 10308, 10309, 10624–10626, 10797–10800. ✓ ok

OCCURRENCE: Painted Hills, Fossil, Cove Creek (Knox Ranch, Pentecost Ranch), Iron Mountain, Crooked River, Lost Creek.

Acer oligomedianum Wolfe and Tanai
(fruit)
(Plate 60, figs. 2, 3, 13)

Acer oligomedianum Wolfe and Tanai, 1987, *pro parte* (fruits only), J. Fac. Sci., Hokkaido Univ. 22, p. 110; pl. 26, figs. 1, 2, 9 only; text fig. 14L.

DISCUSSION: The nutlet of this species was apparently hard and inflated, as indicated by the deep impression made in the shale. Although similar to fruits of *Acer* sp. C in general form, they are readily distinguished as indicated in our discussion of *A.* sp. C.

Acer oligomedianum, which has a fruit as its holotype, was described by Wolfe and Tanai along with the leaves treated here as *Acer* sp. 1. The fruits are also known from the Lyons flora (Meyer, 1973, pl. 4, fig. 5). The proposed leaf type was not recovered at Lyons. *A. oligomedianum* fruits are rare in the Bridge Creek flora, represented by only a few specimens from two assemblages.

HOLOTYPE: USNM 396076 (a fruit, but a leaf is given the same number in the plates of Wolfe and Tanai, 1987).

ok ADDITIONAL SPECIMENS: UF 10300, 10301, 10517, 10518, 10618.

OCCURRENCE: Crooked River, Lost Creek.

Acer sp. A
(fruit)
(Plate 60, figs. 4–6, 15)

Acer ashwilli Wolfe and Tanai, 1987, *pro parte* (fruits only), J. Fac. Sci., Hokkaido Univ. 22, p. 77–78, pl. 22, figs. 2, 5–7, 9 only.

Acer kluckingi Wolfe and Tanai, 1987, *pro parte* (fruits only), J. Fac. Sci., Hokkaido Univ. 22, p. 84, 85, pl. 27, figs. 4–7, 10 only.

DISCUSSION: The fruits of this species are small (2.5–3.4 cm long) and have a small, moderately inflated elliptical nutlet with several fine ribs; the wing has a pronounced dorsal sulcus and is extended only slightly along the dorsal side of the nutlet. This fruit type is common at most localities of the Bridge Creek flora and is also recorded by Wolfe and Tanai (1987) from the Kennedy Ranch and Sumner Spring localities. According to Wolfe and Tanai (1987, p. 78), "association of leaves and fruits of *A. ashwillii* at several Bridge Creek localities leaves little doubt that the two organs are conspecific." Indeed, *Acer ashwillii* leaves are found in association with *Acer* sp. A fruits at six localities. It should be noted, however, that *Acer cranei* fruits, presumed to be negundoid, and not matched by Wolfe and Tanai to any of the fossil leaf types, occur at all of the same localities as *Acer* sp. A.

SPECIMENS: UF 10609–10611, 10613, 10801–10807.

ok OCCURRENCE: Painted Hills, Fossil, Cove Creek (Pentecost Ranch), Iron Mountain, Crooked River, Lost Creek, Butler Basin.

Acer sp. B
(fruit)
(Plate 60, figs. 7, 8, 17)

Acer glabroides Brown emend. Wolfe and Tanai, 1987, *pro parte* (fruits only), J. Fac. Sci., Hokkaido Univ. 22, p. 122, 124, pl. 23, figs. 3–5 only.

DISCUSSION: Fruits of this species are relatively small (2.0–2.5 cm long) and are distinguished by triangular-shaped nutlets that are moderately inflated with a pronounced medial flange. The attachment angle in the fruits is about 25–55°, and the wing usually extends along most of the distal margin of the nutlet (pl. 60, fig. 17).

Wolfe and Tanai (1987) considered fruits of this type to belong to the same species as the leaves of *Acer glabroides*, although they occur together at only one assemblage. Leaves of the latter species occur at Fossil, an assemblage in which maple fruits are abundant and yet no fruits of *Acer* sp. B have been observed there. The only types of leaves that occur exclusively at the localities with *Acer* sp. B fruits are *Acer oligomedianum*, *Acer manchesteri*, and *Acer* sp. 2.

✓ok

SPECIMENS: UF 10287, 10302, 10305, 10341, 10617, 10632.

OCCURRENCE: Iron Mountain, Crooked River.

Acer sp. C
(fruit)
(Plate 60, figs. 9, 14)

Acer manchesteri Wolfe and Tanai, 1987, *pro parte* (fruits only), J. Fac. Sci., Hokkaido Univ. 22, p. 188–192, pl. 32, figs. 9–12 only. Manchester and Meyer, 1987, Oreg. Geol. 49, p. 121, fig. 6G.

Acer glabroides auct. non Brown (per Wolfe and Tanai, 1987, p. 188). Brown, 1937, *pro parte*, U.S. Geol. Survey Prof. Paper 186-J, p. 180, pl. 58, fig. 15 only.

DISCUSSION: This type of fruit is similar in size and gross appearance to that of *Acer oligomedianum*, but as noted by Wolfe and Tanai (1987), the two species are readily distinguished by characters of the nutlet. This species has pronounced proximal and distal keels, which are absent in *A. oligomedianum*, and the attachment angle is typically higher in this species (40–60° versus 25–40° in *A. oligomedianum*). In *Acer* sp. C., the wing extends along the distal margin of the nutlet to the attachment scar, whereas in *A. oligomedianum*, it extends only about halfway to the distal margin of the nutlet. In addition, the nutlet veins of *Acer* sp. C maintain their identity without coalescing in passing onto the wing, whereas in *A. oligomedianum* the nutlet veins tend to coalesce distally, both near the apical margin of the nutlet and as they pass into the wing.

This fruit type occurs with leaves of *Acer manchesteri* at three assemblages (Cove Creek, Iron Mountain, and Crooked River), and was considered to be conspecific by Wolfe and Tanai (1987). However, leaves of *Acer* sp. 1 (called *A. oligomedianum* by Wolfe and Tanai) also occur at the same three localities. Similar fruits are illustrated along with leaves of *Acer dasycarpoides* from the Miocene of the northern Bohemian Basin (Bůžek, 1971, pl. 40, figs. 3–5).

✓ok

SPECIMENS: UF 7026, 10306, 10619–10623, 10808.

OCCURRENCE: Painted Hills, Fossil, Cove Creek (Knox Ranch), Iron Mountain, Crooked River, Lost Creek.

Aesculus sp.
(leaf)
(Plate 59, fig. 4)

DESCRIPTION: Lamina obovate; apex missing; base cuneate, slightly asymmetrical; length at least 10 cm (incomplete), width at least 7 cm; petiolule up to 12 mm long, 1.0–1.8 mm thick; margin serrate, lacking teeth in basal portion of lamina; teeth small, two ranked with larger tooth fed by a secondary vein, about two teeth between secondaries, apparently nonglandular, pointed apically with convex basal flanks and short apical flanks, sinuses apparently acutely angular; venation pinnate, craspedodromous, primary vein sometimes curved in basal portion of lamina; secondary veins closely spaced, numerous and thin relative to midvein, straight to curved, distinctly parallel; tertiary veins percurrent, slightly sinuous, sometimes branched, closely spaced, oblique to midvein; strong abmedial tertiaries near the margin curve into teeth; quaternaries and possibly quinternaries forming quadrangular areoles with straight to curved, simple to once-branched veinlets.

DISCUSSION: Two fragmentary leaflets show characters consistent with *Aesculus*, providing the first known Oligocene occurrence of this genus in North America. One of the most distinctive features of *Aesculus*, the palmately compound leaves, cannot be confirmed from the presently available specimens. Nevertheless, the fossil laminae appear to represent leaflets and share many features with leaflets of *Aesculus*, including the obovate shape, the asymmetry and decurrent nature of the base, the tendency for the midrib to curve at the base, the absence of teeth near the base, the presence of small teeth in two ranks, the markedly parallel and closely spaced secondaries, and the closely spaced tertiaries that range from perpendicular to oblique in relation to the secondaries.

Aesculus includes 13 extant species of deciduous trees and shrubs that are native to eastern and western North America, southeast Asia, and southern Europe.

✓ac SPECIMENS: UCMP 12817; UF 10762.

OCCURRENCE: Cove Creek (Pentecost Ranch).

Dipteronia sp.
(fruit)
(Plate 60, fig. 18)

Dipteronia insignis auct. non (Lesquereux) Brown. Brown, 1959, J. Paleont. 33, p. 127, pl. 24, fig. 12.

DESCRIPTION: Fruit a schizocarpic samara with an approximately circular wing 2.8 cm in diameter. Seed flattened, orbicular in outline, 5–6 mm in diameter, centrally positioned within the fruit wing and linked to the attachment scar by a thick, straight to slightly curved funicle; wing with veins radiating in all directions from the seed.

DISCUSSION: In the Bridge Creek flora, *Dipteronia* is known from a single samara (pl. 60, fig. 18). The specimen is virtually identical to fruits of extant *Dipteronia sinensis* from China (pl. 60, fig. 19), but it cannot be determined from the single isolated fruit whether this species represents the similar extinct genus *Bohlenia*, with fruits borne in threes (Wolfe and Wehr, 1987), or *Dipteronia*, with fruits borne in pairs. The fruits assigned to *Bohlenia* were never found in attachment to the foliage on which the name is based.

The specimen was first attributed to *Dipteronia* (Brown, 1959) and then to *Bohlenia* without assignment to species by Wolfe and Wehr (1987), who noted that its size is larger than any specimen of either *Bohlenia americana*, from Republic, or *Bohlenia insignis* from Florissant. The genus *Bohlenia* was described by Wolfe and Wehr (1987) on the basis of leaflets (including the holotype) and associated fruits from the middle Eocene Republic flora. The fruits are samaras that are virtually identical to those of *Dipteronia* except that they are borne in threes rather than in pairs. Tricarpellate fruits of *Acer* occasionally occur in addition to the usual bicarpellate condition, and it is not surprising that *Dipteronia* or its close relative might also have tricarpellate fruits. The name *Dipteronia insignis* (Lesquereux) Brown, applied to this fruit by Brown (1959), is based on leaves that are herein treated as *Rhus lesquereuxii*.

Dipteronia is a genus of two species of deciduous trees endemic to central and southern China.

SPECIMEN: USNM 42351.

OCCURRENCE: Painted Hills.

Family CORNACEAE

Cornus sp.

(leaf)

(Plate 61, figs. 1, 4)

DESCRIPTION: Lamina asymmetrical, ovate; apex acute; base asymmetrical; length 4.5–8.0 cm, width 2.0–3.5 cm, length to width ratio ~1.9–2.3; petiole not preserved; margin entire; venation eucamptodromous; primary vein distinctly curved, thickness distinctly weakening in the upper half of the lamina; secondaries narrowly acute, strongly curved, sometimes slightly sinuous, about four or five pairs, the uppermost pair branching from the midrib in the central one-third of the lamina and extending nearly to the apex where they converge with the midrib; tertiaries strongly percurrent, straight to sinuous, at right angles to the midvein; higher order venation indistinct.

DISCUSSION: Only three specimens of *Cornus* are known from the Bridge Creek flora. The specimens previously referred by Chaney (1927) to *Cornus ovalis* Lesquereux belong to *Plafkeria* (leaves) and *Hydrangea* (flower).

Several features of the fossil specimens are common to extant *Cornus*. (1) The uppermost secondaries arise at very narrowly acute angles and follow an arcuate course, converging toward the midrib near the apex. (2) The midrib and secondaries are of the same thickness in the upper half of the leaf, but the midrib is distinctly thickened near the base. (3) The basal secondaries arise at or just above the leaf base. (4) Tertiaries are percurrent, sinuous, and perpendicular to the midrib, and (5) The curvature of the lamina results in folding or lateral distortion when the leaf is compressed.

The dogwoods are deciduous shrubs to small trees that prefer shaded sites, with 40 to 45 species distributed mainly in eastern and western North America, Europe, and eastern Asia.

SPECIMENS: UCMP 12705; UF 10281; USNM 458406.

OCCURRENCE: Fossil, Cove Creek (Pentecost Ranch), Butler Basin.

Family AUCUBACEAE

Although the monotypic family Aucubaceae is sometimes considered to belong to the Cornaceae, phylogenetic analyses (Xiang et al., 1993) show that it falls well outside of the Cornaceae. Hence, we follow Airy Shaw (1973) in regarding it as a separate family.

Aucuba smileyi n. sp.

(leaf)

(Plate 61, figs. 2, 3)

DIAGNOSIS: Lamina elliptical; apex acute; base acute, decurrent at petiole; length 7.3 cm, width 2.4 cm, length to width ratio 3; petiole incomplete, 1.6 mm wide; margin thickened, broadly crenate but with small, widely spaced teeth, usually one tooth per crenation; teeth serrate to nearly dentate, extending 0.5–1.0 mm beyond margin, basal side concave to convex, apical side convex, usually rounded at the tip; texture apparently coriaceous; venation pinnate, craspedodromous; primary vein stout, slightly curved; secondary veins narrowly acute, arising from midrib at 40–45°, curving upward near the margin, six pairs; tertiary veins weakly percurrent, course often sinuous to zig-zag, marginal tertiary veins abmedially brochidodromous; quaternary veins randomly oriented, forming medium to large (~1 mm) pentagonal areoles; veinlets linear, branched up to four times.

DISCUSSION: This species is based on a single complete leaf specimen. Features in common with modern species of *Aucuba* include the crenate margin with one small papilliform tooth per crenation, many branched veinlets, and tertiary and higher order veins with irregular courses. The splotched coloration on the surface of the preserved fossil leaf is uncommon among other specimens at this locality and corresponds to the pattern of differential pigmentation seen in both cleared and uncleared modern leaves of *Aucuba*.

The three to four extant species of *Aucuba* are evergreen shrubs native to eastern Asia. The evergreen habit may account for the scarcity of this species in the Bridge Creek flora. *Aucuba* is also known from the Eocene Republic flora of Washington (Wehr and Hopkins, 1994).

ETYMOLOGY: The species is named after Charles J. Smiley (1924–1996), in recognition of his contributions to paleobotany.

ok ✓ HOLOTYPE: UF 10478.

OCCURRENCE: Iron Mountain.

Family ICACINACEAE

Palaeophytocrene sp.
(endocarp)
(Plate 61, fig. 6)

DESCRIPTION: Endocarp impression elliptical, length 2.9 cm long; width estimated at 2.5 cm, with about eight longitudinal rows of up to ten elliptical apertures 1-2.5 mm in diameter, adjacent apertures sometimes coalesced.

DISCUSSION: The genus *Palaeophytocrene* was established by Reid and Chandler (1933) to accommodate fossils with pitted endocarps similar to those of extant *Phytocrene* and related genera of Icacinaceae. The fossil genus was first recognized in the Eocene of England and was subsequently recorded from the Eocene Clarno Formation (Scott, 1954; McKee, 1970; Manchester, 1994b), where it is common, and as impressions from the Eocene of Chalk Bluffs, California (MacGinitie, 1969, p. 132). *Palaeophytocrene* is known only from a single specimen in the Iron Mountain assemblage and a few specimens from the Nichols Spring locality of Ashwill (1983, fig. 4C). Most Icacinaceae, including *Phytocrene* and close relatives, are distributed today in the tropics; thus the presence of *Palaeophytocrene* in temperate vegetation seems anomalous. ✓ok

SPECIMEN: UF 10400.

OCCURRENCE: Iron Mountain.

Family RHAMNACEAE

Paliurus blakei (Chaney) n. comb.
(leaf)
(Plate 61, figs. 5, 7, 8)

Ceanothus blakei Chaney, 1927, *pro parte*, Carnegie Inst. Wash. Pub. 346, p. 128, pl. 16, figs. 4, 8 only.

DESCRIPTION: Lamina ovate; apex attenuate; base asymmetrical, broadly rounded and slightly cordate, basal margin of lamina arising slightly above the divergence of primary veins; length ~5 cm, width at widest portion 3 cm; length to width ratio 1.7; petiole of medium thickness, at least 0.4 cm long; margin serrate; teeth inconspicuous, oriented apically, concave to convex on apical side, straight to slightly convex on basal side, usually rounded, principal vein enters either the tooth or the supraadjacent sinus, distinctly glandular; sinuses angular; venation actinodromous, perfect basal acrodromous with lateral primaries extending two-thirds to three-quarters of the length of the lamina; midvein moderate, straight to curved; lateral primaries weaker, distinctly curved; about five pinnate secondaries originating from the midrib in upper half of lamina, much weaker near the apex, eucamptodromous, curved; about seven secondaries originating abmedially from lateral primaries, eucamptodromous, curved; tertiary veins thin, weakly percurrent to weakly reticulate, closely spaced, sinuous, often oriented at nearly right angles to the midvein; quaternaries and quinternaries reticulate, often orthogonal, forming small, well-developed quadrangular to pentagonal areoles, veinlets once or twice branched.

DISCUSSION: This species is represented only by a few specimens. It is similar to leaves of *Cercidiphyllum*, but is readily distinguished by smaller teeth and fewer primary veins. Assignment to Rhamnaceae is justified by the palmate venation with a midvein and two strong lateral primaries that produce successive abmedial branches to the margin, the transverse percurrent tertiaries, and the small, blunt, glandular teeth. Similar leaves occur in some species of both *Ceanothus* and *Paliurus*. A winged fruit of *Paliurus* (UF 10881) has been collected from a new locality (UF loc. 259) of uncertain stratigraphic position (but also containing *Paracarpinus* and *Cedrelospermum* leaves and *Tilia pedunculata* fruits) about two miles northeast of the main Crooked River localities, providing additional evidence that *Paliurus* was present.

Paliurus is a genus of eight species of trees and shrubs distributed in southern Europe, Asia Minor, and eastern Asia.

ADDITIONAL SPECIMEN: USNM 458408.

OCCURRENCE: Crooked River.

Hovenia oregonensis n. sp.
(leaf)
(Plate 62, figs. 1–4)

Ceanothus blakei Chaney 1927, *pro parte,* Carnegie Inst. Wash. Pub. 346, p. 128–130, pl. 16, fig. 7 only.

Leaf similar to *Morus* Manchester and Meyer, 1987, Oreg. Geol. 49, p. 1118, fig. 4A.

DIAGNOSIS: Lamina ovate; apex apparently acute; base asymmetrical, broadly rounded to acute, basal margin delimited for 0.3–0.6 cm by lowermost secondary veins; length ~6–12 cm, width at widest portion 3–7 cm; length to width ratio 1.7; petiole inflated, 1.4 cm long; margin serrate; teeth oriented apically, straight to concave on apical side, straight to slightly concave on basal side, usually rounded, principal vein enters medially, glandular at the tip; highly reduced glandular teeth sometimes present along the base; sinuses angular; venation pinnate, eucamptodromous; primary vein moderate, thinning near the apex, curved; secondary veins narrowly acute, ~4–5 pairs, the basal pair originating from the petiole, course uniformly curved and converging with the next higher pair, occasionally branched; intersecondaries simple, occasional, extending about one-quarter to one-third of the distance to the margin, arising at higher angles than the secondaries; tertiary veins percurrent, closely spaced, sinuous, occasionally branched, often oriented at nearly right angles to the midrib; marginal tertiary veins arise from secondaries and are abmedially brochidodromous or craspedodromous into teeth; higher vein orders distinct, quaternary and quinternary veins orthogonal; quinternary veins forming small, well-developed quadrangular to pentagonal areoles, occasionally giving rise to simple or once-branched veinlets.

DISCUSSION: Although similar in general form to the leaves of *Paliurus blakei*, this species has larger leaves with thicker tertiary veins. The fossil specimens share the following characters with extant *Hovenia*: (1) pronounced ovate shape, (2) larger leaves than typical for other genera of Rhamnaceae, (3) asymmetrical base delimited in part by the lowermost pair of secondaries, (4) eucamptodromous secondaries closely approaching the margin, (5) uppermost pairs of secondaries arch toward the apex, (6) small glandular teeth along the base, and (7) small areoles that occasionally contain veinlets.

Hovenia oregonensis can be distinguished from *Paliurus blakei* by the following characters: (1) larger and better developed teeth, (2) longer petiole, (3) a larger proportion of the base defined by the basal veins, (4) stronger tertiaries, (5) tertiaries in the area abmedial from the basal secondaries strongly percurrent (rather than random as in *P. blakei*), and (6) small areoles about half the size of those in *P. blakei*.

Hovenia is a genus of two to five extant species of deciduous trees or shrubs distributed in eastern and southern Asia.

ETYMOLOGY: The epithet *oregonensis* refers to the state of Oregon where this species was discovered.

HOLOTYPE: UF 10359.

PARATYPES: UCMP 97 (Chaney's specimen), 12706; UF 10371, 10431, 10466, 10471; USNM 458407.

Cited not TYPE ca

OCCURRENCE: Fossil, Cove Creek, Iron Mountain, Crooked River, Lost Creek.

Family VITACEAE

Vitis sp.
(seed)
(Plate 63, fig. 1)

Vitis sp. Brown, 1959, J. Paleont. 33, p. 127, pl. 24, fig. 17.

DESCRIPTION: Seed subglobose, bilaterally symmetrical, obovate in dorsiventral view with a slightly undulating outline; apex rounded; base (hilar end) broadly acute; length 6 mm, width 4.3 mm; ventral infolds straight, diverging apically, extending from a position well above the seed base and terminating at about two-thirds of the length of the seed toward the apex.

DISCUSSION: This species is represented by a single impression specimen. Although the ventral side of the seed is preserved in good detail, the counterpart, which would show the dorsal side of the seed, is not available. The pair of ventral infolds clearly indicates that the seed belongs to the Vitaceae. The eleven extant genera of Vitaceae can be distinguished on the basis of characters including seed shape and size, relative length and shape of the ventral infolds, shape of the chalaza, presence or absence of a raphal ridge or groove, and surface sculpture (Tiffney and Barghoorn, 1976).

Seeds with short divergent ventral infolds occur in some of the extant species of *Ampelopsis* and *Vitis*. *Vitis* seeds generally have a chalaza-apex groove (sensu Tiffney and Barghoorn, 1976), but *Ampelopsis* seeds lack such a groove and instead have a ridge in the same position. The fossil does not possess a chalaza-apex groove and therefore appears to be closer to some

Ampelopsis. We retain Brown's assignment to *Vitis*, recognizing that it may instead belong to *Ampelopsis*. Until additional specimens are recovered, we hesitate to make a formal reassignment.

Vitis includes about 60–70 species of deciduous climbing shrubs distributed in the Northern Hemisphere, while *Ampelopsis* has two species in temperate and subtropical America and Asia.

SPECIMEN: USNM 42356.

OCCURRENCE: Crooked River.

Family OLEACEAE

Fraxinus sp.
(fruit)
(Plate 63, figs. 4, 5)

DESCRIPTION: Samara elongate, bilaterally symmetrical, narrow oblanceolate, length 23–25 mm (estimated from incomplete specimens), width 6 mm; pedicel persistent, 2.3 mm long, broadening with calyx scar at base of fruit; venation consisting of numerous fine, longitudinal veins. Seed preserved as a dark elliptical body at base of the samara, 12–15 mm long, 3.5–4 mm wide.

DISCUSSION: Two faintly preserved winged fruits on a single piece of shale confirm the presence of *Fraxinus* in the Bridge Creek flora. Although the samaras are fragmentary and the apex is missing in both fruits, enough is preserved to be certain of their generic identity. The extreme rarity of these samaras suggests that the genus was probably growing at some distance from the lake side. Although *Fraxinus* was recognized previously in the Bridge Creek flora, the leaves on which it was based do not show unequivocal diagnostic characters of the genus.

The ashes include 65 to 70 extant species of deciduous (one species is evergreen) trees distributed in middle to sometimes low latitudes of the Northern Hemisphere. The fossil record of this genus has recently been reviewed in the context of a detailed analysis of samaras from the middle Eocene of southeastern North America (Call and Dilcher, 1992).

✓ok SPECIMENS: UF 10545, 10546.

OCCURRENCE: Fossil.

Family CAPRIFOLIACEAE

Diplodipelta reniptera (Becker) Manchester and Donoghue
(infructescence)
(Plate 63, figs. 2, 6, 7)

Dodonaea reniptera Becker 1961, Geol. Soc. Am. Mem. 82, p. 82, pl. 26, figs. 3–8 (Upper Ruby River Basin, Montana).

DESCRIPTION: Infructescence samara-like with two large bract-wings joining in the axis of fruit symmetry; length 9–16 mm, width 10–16 mm; wings rounded, entire-margined, forming a cordate junction with adjacent wing and supplied with about 10-15 veins that fan out from the fruit axis with occasional dichotomies forming a reticulum with loops at the wing margin. Fruit body narrowly elliptical, longitudinally ribbed and with a persistent epigynous calyx of several elongate sepals.

DISCUSSION: This species is uncommon in the Bridge Creek flora, represented only by a few specimens from the Crooked River assemblage. The specimens do not show sufficient details for a complete description of *Diplodipelta*, but they conform to the species known from larger suites of specimens from Florissant, Colorado, and Ruby, Montana, which form the basis for recognizing this extinct genus of Caprifoliaceae (Manchester and Donoghue, 1995). The Bridge Creek specimens share the same bract morphology and venation, thin pedicel, and narrow fruit with epigynous sepals as those illustrated previously as *Ptelea cassiodes* Lesquereux from Florissant (e.g., MacGinitie, 1953) and as *Dodonaea reniptera* Becker from the Ruby River Basin of southwestern Montana (Becker, 1961). Like extant *Dipelta* of China (pl. 63, fig. 3), these infructescences have wings formed by the enlargement of bracts and have elongate fruits with persistent epigynous sepals. However, the fossil species differs from the three modern species of *Dipelta* in having two fruits per bract complex and in the interfusion of adjacent wing-forming bracts (Manchester and Donoghue, 1995). Paired fruits, but without persistent bracts, also occur in other extant genera of the Caprifoliaceae, such as *Lonicera* and *Abelia*, and can be viewed as a primitive condition in this family.

SPECIMENS: UCMP 12717; UF 10463–10465. ✓ ok

OCCURRENCE: Crooked River.

Family RUBIACEAE

Pinckneya dilcheri n. sp.
(seed)
(Plate 63, figs. 8–10)

DIAGNOSIS: Seed small, winged; consisting of an elliptical seed body surrounded by a planar, entire-margined wing forming an elliptical to obliquely rounded outline with a constriction at the hilar end; wing membranous, markedly reticulate; seed length (including wing) 5.0–6.0 mm, width 3.4–4.2 mm; seed body length (without wing) 1.7–2.3 mm, width 0.8–1.2 mm.

DISCUSSION: These small wind-dispersed seeds are virtually identical to those of extant *Pinckneya* (pl. 63, fig. 11), a genus with a single extant species of deciduous shrubs to small trees growing along streams and in swamps in the southeastern United States. Details of similarity include the dorsal curvature, ventral scar, reticulate cell pattern of the wing that continues over the seed body, and thickening of the wing just inside the margin.

ETYMOLOGY: This species is named after David L. Dilcher in recognition of his contributions to angiosperm paleobotany.

HOLOTYPE: UF 10644.

PARATYPES: USNM 458381; UF 10642, 10643.

OCCURRENCE: Crooked River. ok ✓

Family BIGNONIACEAE

Catalpa sp.

(seed)
(Plate 63, figs. 12–14)

DESCRIPTION: Seed flattened, winged, fusiform in outline, bisymmetrical, length 2.2–3.0 mm, width 5.2–8.0 mm; central bilobed embryo 1.2–2.2 mm long, 4–5.5 mm wide, consisting of a short radicle and a pair of cotyledons; cotyledons thick, outspread; wing transversely striate, striae diverging from hilum and extending toward both ends of the seed; distal margins of the wings frayed, irregular, formed of freely ending hairs representing the continuation of the striations.

DISCUSSION: Several specimens of a small bignoniaceous seed have been recovered from two assemblages. Assignment to the Bignoniaceae is supported by the wide, finely striate wing and the bilobed central body representing the spread cotyledons. In comparisons with extant Bignoniaceae, seeds with horizontally striate wings and hairy distal wing margins were found to be diagnostic of *Catalpa*. The fossil seeds are small relative to the seeds of most extant species of *Catalpa*. Seeds of extant *Catalpa bungei* C. A. Meyer are 10–20 mm wide and 1.5–2 mm high, with bilobed embryo 5–8 mm wide and 1.5–2 mm high. Small seeds of *Catalpa* were previously recognized from the late Oligocene of southern France (*Catalpa microsperma* Saporta, 1889). The genus has also been reported on the basis of leaves from the Oligocene Creede flora of southern Colorado (Wolfe and Schorn, 1990).

Catalpa is a genus of deciduous or rarely evergreen trees with 11–13 extant species and is disjunct between eastern North America and eastern Asia.

SPECIMENS: UF 10570, 10571, 10755, 10756; USNM 458377–458379.

ck

OCCURRENCE: Fossil, Crooked River.

UNKNOWN DICOTYLEDONOUS LEAVES

Although it is not common practice in paleobotanical floristic treatments to illustrate and discuss unidentified species, a brief consideration of each of the unknown taxa is necessary to document the known diversity and to invite comparisons with similar leaves in other Tertiary floras.

Unknown dicotyledonous leaf sp. 1

(Plate 64, figs. 1, 2)

DISCUSSION: This species is known from a single fragmentary leaf with a finely serrate margin and eucamptodromous venation.

SPECIMEN: UCMP 12818.

OCCURRENCE: Crooked River.

Unknown dicotyledonous leaf sp. 2

(Plate 64, figs. 3, 4)

cf. *Sorbus* Manchester and Meyer, 1987, Oreg. Geol. 49, p. 121, fig. 6H.

DISCUSSION: This species is represented by asymmetrical laminae with acute teeth and craspedodromous venation. It may be related to *Dipteronia*.
SPECIMENS: UF 7027, 10511.
OCCURRENCE: Fossil.

Unknown dicotyledonous leaf sp. 3

(Plate 64, fig. 5)

DISCUSSION: This species has a cordate base, a long petiole, a lobed and toothed margin, and palmate venation with three primary veins. It may be a variant leaf of *Acer*.
SPECIMEN: UF 10826.
OCCURRENCE: Fossil.

Unknown dicotyledonous leaf sp. 4

(Plate 64, fig. 6)

DISCUSSION: This species is known from a single elongate leaf with unusually high-angle secondary veins. The secondaries are at right angles to the midvein in the lower half of the lamina.
SPECIMEN: UCMP 12819.
OCCURRENCE: Painted Hills.

Unknown dicotyledonous leaf sp. 5

(Plate 64, fig. 7)

DISCUSSION: This species is known from a single specimen with palmate venation and lobing.
SPECIMEN: UF 10427.
OCCURRENCE: Iron Mountain.

Unknown dicotyledonous leaf sp. 6

(Plate 64, figs. 8, 9)

DISCUSSION: This species is known from a pinnate leaf having two sessile lateral leaflets attached to an incomplete rachis. The leaflets are ovate and have attenuate tips. The margin is finely serrate. Although some aspects of the leaf appear rosaceous, there are no prickles on the rachis.
SPECIMEN: UCMP 12820.
OCCURRENCE: Painted Hills.

Unknown dicotyledonous leaf sp. 7

(Plate 65, figs. 1, 2)

DISCUSSION: This species is known from a lanceolate leaf showing fine, rounded marginal teeth.
SPECIMEN: UF 10368.
OCCURRENCE: Fossil.

Unknown dicotyledonous leaf sp. 8

(Plate 65, fig. 3)

DISCUSSION: This leaf is cordate with a thick petiole, palmate venation, and apparently entire margin.
SPECIMEN: UF 10827.
OCCURRENCE: Fossil.

Unknown dicotyledonous leaf sp. 9

(Plate 65, figs. 4, 5)

Rhododendron chaneyi Brown, 1946, J. Wash. Acad. Sci. 36, p. 352, fig. 15.

DISCUSSION: This leaf could be fagaceous (e.g., *Castanopsis*). The margin is mostly entire, but with a few tiny spinose teeth at the terminus of some secondary veins (pl. 65, fig. 5). The presence of such teeth precludes assignment to *Rhododendron*.
SPECIMEN: USNM 42377.
OCCURRENCE: Crooked River.

Unknown dicotyledonous leaf sp. 10

(Plate 65, fig. 6)

DISCUSSION: This species is known from the apical portion of an entire-margined leaf with smoothly arched secondary veins that loop very close to the margin.
SPECIMEN: UCMP 12822.
OCCURRENCE: Lost Creek.

Unknown dicotyledonous leaf sp. 11

(Plate 66, figs. 1–4)

Juglans acuminata? auct. non Al. Braun. Knowlton 1902, U.S. Geol. Surv. Bull. 204, p. 35, pl. 3, fig. 5.

Fraxinus denticulata auct. non Heer. Chaney 1927, Carnegie Inst. Wash. Pub. 346, p. 132, pl. 19, figs. 5–7.

DISCUSSION: This species has an elliptical leaf with an acute base, semicraspedodromous to brochidodromous secondaries, percurrent tertiaries, and a margin that varies from entire to toothed with inconspicuous, widely spaced teeth.

SPECIMENS: UCMP 12823, 12824; USNM 8486.

OCCURRENCE: Painted Hills, Cove Creek.

Unknown dicotyledonous leaf sp. 12

(Plate 67, figs. 1, 2)

DISCUSSION: This species is represented by an elliptical lamina with very fine, widely spaced marginal teeth and a long petiole.

SPECIMEN: UF 10322.

OCCURRENCE: Crooked River.

Unknown dicotyledonous leaf sp. 13

(Plate 67, fig. 3)

DISCUSSION: This species has an elliptical lamina with pinnate secondary veins, closely spaced percurrent tertiary veins that form an obtuse angle with the midvein, and small teeth along the margin.

SPECIMEN: UF 10773.

OCCURRENCE: Cove Creek.

Unknown dicotyledonous leaf sp. 14

(Plate 67, fig. 4)

DISCUSSION: This species has an elliptical leaf with relatively thin semicraspedodromous pinnate secondary veins and widely spaced teeth.

SPECIMEN: UF 10825.

OCCURRENCE: Iron Mountain.

Unknown dicotyledonous leaf sp. 15

(Plate 67, figs. 5, 6)

DISCUSSION: This species has a long elliptical leaf with a thin lamina and serrated margin. The semicraspedodromous pinnate secondaries are irregular in course. There is a general similarity with leaves of *Sambucus*.

SPECIMENS: UF 10526, 10527.

OCCURRENCE: Fossil.

Unknown dicotyledonous leaf sp. 16
(Plate 68, figs. 1, 2)

DISCUSSION: This is an elliptical-obovate leaf with an entire or undulating margin, pinnate camptodromous secondary veins that are irregular in course, and percurrent tertiaries. The leaf may represent an unusual specimen of *Parrotia brevipetiolata*, although it lacks the characteristic base delimited by the lowermost secondary veins.

SPECIMEN: UF 10363.

OCCURRENCE: Fossil.

Unknown dicotyledonous leaf sp. 17
(Plate 68, figs. 3, 4)

DISCUSSION: This species is known from an ovate-elliptical leaf or leaflet with an entire margin. The base is not preserved. It could be a legume leaflet, but the presence or absence of a pulvinus is not known.

SPECIMEN: UF 10467.

OCCURRENCE: Fossil.

Unknown dicotyledonous leaf sp. 18
(Plate 69, fig. 1)

DISCUSSION: This species is known from the basal part of a large entire-margined leaf. Its affinities could be with Lauraceae, but the specimen is too incomplete to make a positive determination.

SPECIMEN: UF 10579.

OCCURRENCE: Fossil.

Unknown dicotyledonous leaf sp. 19
(Plate 69, figs. 2, 3)

DISCUSSION: This is an elliptical leaf or leaflet with an asymmetrical base, camptodromous secondary veins, and tiny simple teeth.

SPECIMEN: UF 10327.

OCCURRENCE: Crooked River.

Unknown dicotyledonous leaf sp. 20
(Plate 69, fig. 4)

DISCUSSION: This is an elliptical leaf with straight pinnate secondaries arising at a low angle from the midvein. The margin is serrate.

SPECIMEN: UF 10728.

OCCURRENCE: Iron Mountain.

Unknown dicotyledonous leaf sp. 21
(Plate 69, figs. 5, 6)

DISCUSSION: This leaf is entire-margined with thin secondary veins and brochidodromous venation. Similar leaves occur in Magnoliaceae, Lauraceae, and other dicotyledonous families.
SPECIMEN: USNM 458411.
OCCURRENCE: Crooked River.

Unknown dicotyledonous leaf sp. 22
(Plate 69, fig. 7)

DISCUSSION: This species is represented by a single leaf with an entire margin, palmate venation, percurrent tertiary veins, and an attenuate apex.
SPECIMEN: UF 10265.
OCCURRENCE: Crooked River.

Unknown dicotyledonous leaf sp. 23
(Plate 70, figs. 1, 2)

Salix californica auct. non Lesquereux Chaney 1927, Carnegie Inst. Wash. Pub. 346, p. 103, pl. 8, fig. 8.

DISCUSSION: This leaf is elliptical with an entire margin and attenuate apex. The fossil retains some of the original leaf cuticle, which is rarely preserved in the Bridge Creek flora. Resistant cuticle is a feature of many extant Lauraceae.
SPECIMENS: UCMP 21.
OCCURRENCE: Crooked River.

Unknown dicotyledonous leaf sp. 24
(Plate 70, fig. 3)

DISCUSSION: This leaf, with an entire margin, brochidodromous venation, percurrent tertiary veins, and orthogonal areolation, is similar to the leaves of some genera of Menispermaceae.
SPECIMEN: UF 10578.
OCCURRENCE: Lost Creek.

Unknown dicotyledonous leaf sp. 25
(Plate 70, figs. 4, 7)

DISCUSSION: This leaf or leaflet from Fossil has an entire margin and is similar in some respects to the leaflets of *Rhus*.
SPECIMEN: UF 10372.

OCCURRENCE: Fossil.

Unknown dicotyledonous leaf sp. 26
(Plate 70, figs. 5, 6)

DISCUSSION: This leaf is elliptical with pinnate venation and occasional minute teeth that are fed by the secondary veins. It is similar in some respects to *Quercus*, but it does not possess the pattern of venation characteristic of other oaks from Bridge Creek.
SPECIMEN: UF 10326.
OCCURRENCE: Crooked River.

Unknown dicotyledonous leaf sp. 27
(Plate 71, figs. 1, 2)

DISCUSSION: This species is represented by two relatively large leaves with cordate bases, palmate venation, and evenly spaced serrations.
SPECIMENS: UF 10828; USNM 458403.
OCCURRENCE: Fossil, Crooked River.

Unknown dicotyledonous leaf sp. 28
(Plate 72, figs. 1, 2)

DISCUSSION: This species is represented by an entire-margined leaf with pinnate camptodromous venation.
SPECIMEN: UCMP 12825.
OCCURRENCE: Butler Basin.

Unknown dicotyledonous leaf sp. 29
(Plate 72, fig. 3)

DISCUSSION: This species is represented by an incomplete, faintly preserved, compound leaf showing three attached leaflets that appear to have been very thin. The leaflets are incomplete apically but appear to be entire-margined.
SPECIMEN: UF 10394.
OCCURRENCE: Fossil.

Unknown dicotyledonous leaf sp. 30
(Plate 72, fig. 4)

DISCUSSION: This leaf has large, rounded, shallow crenations and pinnate secondaries arising at high angles from the midvein.
SPECIMEN: UF 10525.

OCCURRENCE: Iron Mountain.

Unknown dicotyledonous leaf sp. 31

(Plate 72, fig. 5)

DISCUSSION: The leaf has an entire margin, pinnate camptodromous secondary venation, and percurrent tertiaries.

SPECIMEN: UF 10823.

OCCURRENCE: Fossil.

MONOCOTYLEDONS

Family ZINGIBERACEAE

Zingiberopsis sp.

(leaf)

(Fig. 3; Plate 73, figs. 4, 6)

DESCRIPTION: Lamina large, length estimated at ~40 cm (at least 26 cm long in the incomplete specimen), width 11 cm; apex and base unknown; margin entire, texture thin; venation pinnate, with a thick midcosta and fine, closely spaced parallel secondary veins oriented about 23° from the midvein; secondary veins of two orders, approximately every fifth vein slightly thicker than the others; small cross veins connect between adjacent parallel veins.

DISCUSSION: This species is represented by a single specimen from Iron Mountain. Although highly fragmentary and ranging in quality of preservation within the specimen, the margin and fine parallel secondary veins can be seen clearly in some parts (pl. 73, fig. 6). The thin lamina was folded along its midvein, so that only one half is visible on the reassembled slab of shale. Only the upper half of the lamina is shown in pl. 73, fig. 5, but the full specimen also shows the basal part of the lamina, as reconstructed in fig. 3.

In all of its preserved features, this leaf conforms to the fossil genus *Zingiberopsis* Hickey as emended by Hickey and Peterson (1978). This genus accommodates fossil leaves that are similar to various extant genera of Zingiberaceae, particularly *Alpinia*. *Zingiberopsis* is known mostly from late Cretaceous, Paleocene, and early Eocene localities (Hickey and Peterson, 1978), but the Bridge Creek specimen confirms its presence in the Oligocene. *Alpinia* and other extant Zingiberaceae are mostly tropical to subtropical in distribution. The occurrence of *Zingiberopsis* in the Bridge Creek flora introduces the possibility that this species may have been adapted to cooler conditions than many extant Zingiberaceae.

SPECIMEN: UF 10374.

OCCURRENCE: Iron Mountain.

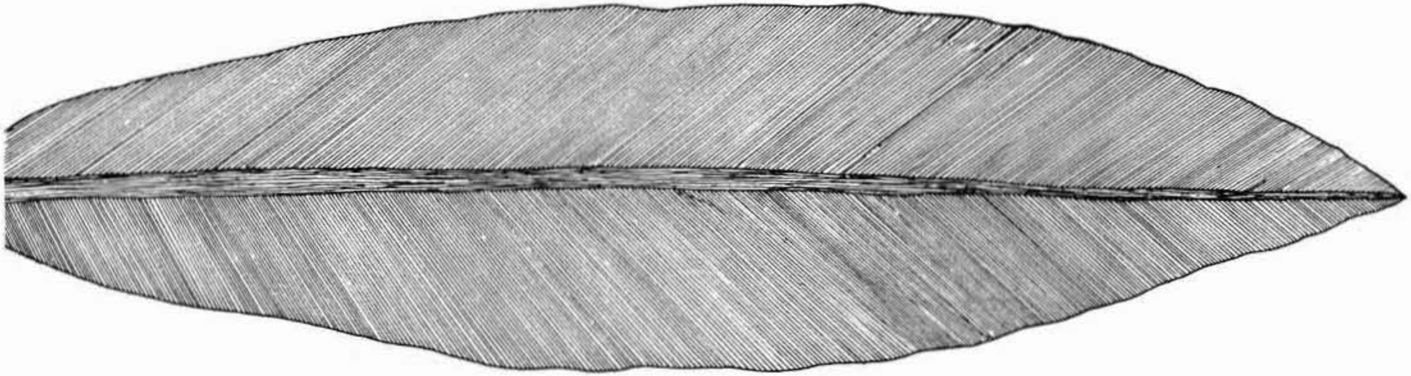

Figure 3. Reconstruction of the leaf of Zingiberopsis sp. from Iron Mountain. Compare with Pl. 73, figs. 4, 6.

UNKNOWN MONOCOTYLEDONOUS LEAVES

Typhoides buzekii n. gen. et sp.

(leaf)

Plate 73, figs. 1–3

DIAGNOSIS: Lamina long, strap-shaped with parallel margins, width 8–21 mm; venation parallel, without a thickened midvein, with two or three orders of parallel veins; thickest set of veins 0.8–1.2 mm apart, with three to five thinner veins between them; wavy cross veins traversing between the adjacent thick veins.

DISCUSSION: These linear, strap-like leaves lack a differentiated midvein, but have multiple orders of parallel veins arranged in alternating sets with thin, wavy, transverse cross veins between the thickest longitudinal veins. Leaves with this pattern of architecture occur among different genera of monocots. Although such fossil leaves are commonly presumed to represent cattails and have been placed in the extant genus *Typha*, the same venation pattern occurs in *Sparganium*. Without features of epidermal anatomy or associated reproductive structures, assignment to a particular modern genus cannot be made with certainty. In the absence of characters to establish the precise identity relative to modern genera, we attribute the remains to a new fossil genus, *Typhoides*. These leaves may have close affinity to those from Europe assigned to the fossil genus *Typhaeloipum* Unger. The type species of *Typhaeloipum* shows anatomical features, including arrangement of air sacs and of stomata, that indicate it is closer to *Sparganium* than to *Typha* (Unger, 1852). The anatomical structure of the Bridge Creek fossils has not been investigated.

ETYMOLOGY: This species is named in memory of Dr. Čestmir Bůžek (1933–1992) to recognize the importance of his many contributions to Tertiary paleobotany.

HOLOTYPE: UF 10724,

PARATYPES: UF 10725, 10726.

OCCURRENCE: Fossil, Cove Creek (Knox Ranch, Pentecost Ranch), Iron Mountain, Crooked River, Lost Creek.

Unknown Monocotyledonous leaf

(Plate 73, fig. 5)

Monocotyledonous plant Knowlton, 1902, U.S. Geol. Surv. Bull. 204, p. 28, pl. 1, figs. 7,8.

Monocotyledonous leaf Manchester and Meyer, 1987, Oreg. Geol. 49, p. 116, fig. 3A.

DISCUSSION: This foliar segment is truncated at the base and is elongate with parallel venation consisting of sets of several fine veins alternating with coarse veins, apparently without cross veins. This material appears similar to that described and illustrated by Lakhanpal (1958, p. 38) as "Monocotyledonous plant" from the Rujada flora.

ADDITIONAL SPECIMEN: UCMP 9313.
OCCURRENCE: Painted Hills, Fossil.

"Potamogeton" parva Brown
(leaf)

Potamogeton parva Brown, 1940, J. Wash. Acad Sci. 30, p. 348, fig. 16.

We have reexamined the single leaf specimen on which this species was based, and it is not well enough preserved to confirm its generic identity, although Brown's assignment might be correct.

OCCURRENCE: Crooked River.

FRUITS AND SEEDS OF UNDETERMINED AFFINITIES

Beckerosperma n. gen.
Beckerosperma ovalicarpa n. comb.
(seed)
(Plate 74, figs. 1–8)

Albizzia ovalicarpa Becker, 1960, Palaeontographica Abt. B, 107, p. 109, pl. 20, figs. 9–11, pl. 30, figs. 16–20 (Mormon Creek).

Unidentified winged seeds, Manchester and Meyer, 1987, Oreg. Geol. 49, p. 121, fig. 6E.

DIAGNOSIS: Seed winged, roughly elliptical in outline, entire-margined with a slight rounded cleft at one end, length 6.5–10.0 mm, width 4.5–5.5 mm, with a flattened pyriform central body 2.5–3.0 mm long, 1.5–2.1 mm wide, central body rounded basally and acute apically, oriented obliquely, with its long axis 15–30° to the long axis of the entire seed; wing membranous, usually with a crease parallel to one of the curved margins of the seed, without veins except for a single longitudinal vein that vascularizes the base of the central body and becomes thinner both apically and basally as it approaches the wing margins.

DISCUSSION: These seeds are identical to those that Becker (1960) illustrated and described from the Mormon Creek flora of probable early Oligocene age in the upper Ruby River Basin of southwestern Montana. Becker interpreted the imprints to represent halves of leguminous seeds separated at the juncture of the cotyledons. This would be an unlikely dispersal strategy. It is clear from the study of numerous additional specimens for which both counterparts are available that the seeds are membranous-winged, very different from the hard, thick, rounded seeds of *Albizzia*.

Despite the distinctive appearance of these seeds, the familial affinities remain uncertain. They may represent an extant genus that has not yet been determined. In the absence of knowledge concerning its extant affinities, we feel that it is worthy of naming.

ETYMOLOGY: We establish the genus *Beckerosperma* in recognition of the contributions of Herman F. Becker to Tertiary paleobotany.

ADDITIONAL SPECIMENS: UF 7034, 10647–10678.

OCCURRENCE: Fossil, Cove Creek (Knox Ranch), Iron Mountain, Crooked River, Lost Creek.

cited specimens 10654, 10655, 10665–10669, 10776 not in drawe.

Potanospira fryi n. gen. et sp.
(seed or fruit)
(Plate 74, figs. 9–13)

Ulmus brownellii auct. non Lesquereux. Chaney 1927 *pro parte*, Carnegie Inst. Wash. Pub. 346 p. 113, pl. 13, fig. 4, fruit only.

DIAGNOSIS: Seed (or fruit?) flattened, winged, nearly circular to elliptical; central body thick, once coiled in the plane of the wing; wing extending in a single plane from the central body, finely striate with radially arranged striae that extend fully to the wing margin, without a marginal vein; striations stronger over the central body; wing with an incision leading to the outer limb of the central body; a thin vascular stipe or funicle arising from the inner side of the coiled seed body and forming the margin of the wing cleft, protruding beyond the margin of the wing.

DISCUSSION: Although highly distinctive, these seeds or fruits have not yet been identified to an extant genus or family. The coiled central body superficially resembles coiled embryos of the Sapindaceae. One of these specimens was incorrectly illustrated as *Ulmus brownellii* Lesquereux by Chaney (1927, pl. 13, fig. 4). The same species is represented by one specimen from the Eocene Gosner Road locality of the Clarno Formation (UF loc. 238) and by two specimens from the Miocene Poison Creek locality (USGS loc. 8923), nine miles north of Weiser, Idaho.

ETYMOLOGY: The generic name derives from *Potana* (Gr = wing) + *spira* (Gr = coil), referring to the morphology. The species is named after paleobotanist Wayne L. Fry.

HOLOTYPE: UF 10332.

PARATYPES: UF 10331, 10572, 10573, 10574. ak ✓

OCCURRENCE: Fossil, Crooked River.

Saportaspermum occidentalis n. gen. et sp.
(seed)
(Plate 74, figs. 14–20)

DIAGNOSIS: Seed winged, consisting of an ovate to elliptical seed body with a lateral elongate wing; length 10–12 mm, width 3.8–5 mm; seed body 3.2–4.0 mm long, 2–2.5 mm wide, oriented with long axis at 40° angle to long axis of wing; wing thickened along one of its lateral margins in continuation with apex of seed body, without veins, margin of wing rounded to nearly straight.

DISCUSSION: These disseminules are considered to be seeds rather than fruits because of the absence of veins in the wing. They are similar in size and gross form to seeds of *Cedrela*, but they differ in shape and orientation of the seed body and in their lack of a distal crease inside the wing margin. Similar seeds occur in the upper Oligocene of Manosque, France and were treated by Saporta (1867) as *Embothrium tenerum* (Saporta 1867, pl. 9, fig. 7; Muséum National d'Histoire Naturelle Paris no. 13539).

ETYMOLOGY: The generic name derives its roots from Gaston de Saporta, French paleobotanist, and *spermum* (Gr = seed). The epithet *occidentalis* refers to the western occurrence of this species.

HOLOTYPE: UF 10638.

✓ OK

PARATYPES: UF 10639, 10640, 10866–10868.

OCCURRENCE: Fossil, Iron Mountain, Crooked River, Lost Creek.

Unknown fruit sp. A

(Plate 74, figs. 21, 22)

DISCUSSION: The most complete specimen of this species is the broken terminal portion of an infructescence about 2.5 cm long showing three pedicellate fruits and the departure of a more basal pedicel that is broken. The arrangement is cymose, with the largest fruits most apical. Internodes between adjacent pedicels are 3–4 mm long and the pedicels themselves are 0.6 mm thick and 6–8 mm long. Each of the pedicels is recurved just below the fruit attachment, giving the impression of drooping fruits. Fruits are ovoid, rounded basally, and generally rounded apically, usually with an apical rostrum; they are 7–10 mm long and 4–6.3 mm wide. The hypogynous calyx is persistent, campanulate and tightly sheathes the fruit; the top of the calyx forms a transverse line on the fruit impression at one-half to one-third of the distance from the fruit apex. Five equally spaced, fine meridional lines are seen in the impression of one of the fruits, suggesting that the complete fruit had about ten such sutures or veins.

SPECIMENS: UCMP 12718, 12719; UF 10880.

OCCURRENCE: Fossil, Crooked River.

Unknown fruit sp. B

(Plate 74, figs. 23)

DISCUSSION: This specimen is an ellipsoidal fruit 1.1 cm wide and 1.7 cm long, with fine longitudinal striations and a peg-like pedicel 0.5 cm thick and 0.7 cm long.

SPECIMEN: UF 10348

OCCURRENCE: Crooked River.

Unknown fruit sp. C

(Plate 75, figs. 1–5)

DISCUSSION: The fruits are ellipsoidal, 7–10 mm long and 6–7 mm wide, and are borne on slender pedicels 7 mm long that arise on panicles from woody twigs. Two styles can be observed at the apex in some specimens (pl.

75, fig. 5), but there may have been more that were obliterated in the process of compression. There is no perianth scar at the junction of the pedicel and the fruit, but there appear to be remnants of perianth at the fruit apex (pl. 75, figs. 2, 3), indicating that the flowers had inferior ovaries.

SPECIMENS: UF 10645, 10863, 10864.

OCCURRENCE: Crooked River.

Unknown fruit sp. D
(Plate 75, fig. 6)

DISCUSSION: The affinities of this species, represented by a single specimen, remain undetermined at this time. The infructescence is a raceme 3.6 cm long with six or more sessile capsules borne laterally on an axis about 1 mm thick. The capsules are woody, ovate to elliptical, 5–7 mm wide and 7–8 mm long, with at least four thin persistent styles each about 1 mm long.

SPECIMEN: UF 10347.

OCCURRENCE: Crooked River.

Unknown fruit sp. E
(Plate 75, fig. 7)

DISCUSSION: This species is known from a single specimen showing the broken terminal portion of a racemose infructescence about 2.5 cm long, with oppositely arranged pedicellate lateral fruits and a terminal fruit. The pedicels are relatively stout, about 1 mm thick and 4–5.5 mm long, and appear to broaden at the attachment with the base of the fruit. Fruits are globose, rounded apically and basally, and the fruit impressions show three thin, equally spaced meridional ribs, indicating that the complete fruits had about five meridional grooves. The hypogynous calyx is thick and appears to have had ten longitudinal sutures; it extends over the lower one-third to one-quarter of the fruit.

SPECIMEN: UF 10641.

OCCURRENCE: Iron Mountain.

APPENDIX

Synonymies of Taxa from Previous Works

This appendix shows taxa that have been recognized by earlier works, followed by the names to which they are referred in this work. Only specimens from selected publications are included here, and in most cases, only illustrated specimens are listed. In cases where a species was newly described in a publication, it is indicated by "new species" following that author's name. All plate and figure numbers refer to those of the original publication.

J. S. NEWBERRY, 1883 and 1898

Newberry, J. S. 1883. Brief descriptions of fossil plants, chiefly Tertiary, from western North America. Proc. U.S. Nat. Mus. 5: 502–514.

Newberry, J. S. 1898. The later extinct floras of North America. U.S. Geol. Surv. Mon. 35: 1–295, pl. 1–68.

Newberry first published his descriptions of the Bridge Creek species in 1883, although these were not accompanied by illustrations. The plates for the same species were later assembled by Hollick, who edited the posthumous publication of Newberry (1898). Species that were first described in the 1883 publication are so noted below.

Sequoia heerii Lesquereux
    = *Metasequoia* sp. Plate 47, fig. 7.
Monocotyledon, gen. et sp.?
    Accepted. Plate 46, fig. 9 (specimen missing).
Populus polymorpha Newberry (new species first described in 1883)
    = *Alnus heterodonta* (Newberry) new comb. Plate 46, figs. 3, 4; plate 47, fig. 4; plate 49, figs. 4, 7, 8 (specimen missing), 9.
    Indeterminate specimen. Plate 58, fig. 4.

Betula angustifolia Newberry (new species first described in 1883)
  Accepted. Plate 46, fig. 5; plate 47, fig. 5.
Betula heterodonta Newberry (new species first described in 1883)
  = *Alnus heterodonta* (Newberry) new comb. Plate 44, figs. 1–3, 4 (specimen missing); plate 45, fig. 1 (specimen missing).
  = *Betula angustifolia* Newberry. Plate 45, fig. 6.
Betula sp. ? Newberry
  Indeterminate catkin. Plate 57, fig. 4 (specimen missing).
Alnus serrulata fossilis Newberry, new species
  = *Betula angustifolia* Newberry. Plate 46, fig. 6.
Alnus sp. ? Newberry
  = *Alnus* seed catkin. Plate 46, fig. 7.
Quercus consimilis Newberry (new species first described in 1883)
  Accepted. Plate 43, figs. 2–4, 5 (specimen missing).
  = *Quercus* spp. (acorns and cupules). Plate 43, figs. 7–10 (latter two specimens missing).
Quercus paucidentata Newberry (new species first described in 1883)
  = *Quercus* cf. *Q. consimilis*. Plate 43, fig. 1.
Quercus simplex Newberry (new species first described in 1883)
  = *Quercus consimilis* Newberry. Plate 43, fig. 6.
Ulmus speciosa Newberry (new species first described in 1883)
  Accepted. Plate 45, figs. 2–4.
  = *Craigia oregonensis* (Arnold) Kvaček, Bůžek, and Manchester. Plate 45, fig. 7.
  = *Ulmus* sp. 1. Plate 45, fig. 8.
  = *Ulmus* sp. indet. Plate 45, fig. 5.
Ficus? condoni Newberry (new species first described in 1883)
  = *Platanus condonii* (Newberry) Knowlton. Plate 56, fig. 1 (specimen missing); plate 57, fig. 1; plate 58, fig. 1 (specimen missing).
Ficus planicostata Lesquereux
  = *Plafkeria obliquifolia* (Chaney) Wolfe. Plate 46, fig. 1.
Berberis simplex Newberry (new species first described in 1883)
  = *Mahonia simplex* (Newberry) Arnold. Plate 56, fig. 2.
Liquidambar europaeum Al. Braun
  = *Liquidambar* sp. Plate 47, figs. 1, 2.
  = *Platanus* infructescence. Plate 47, fig. 3.
Platanus aspera Newberry (new species first described in 1883)
  = *Platanus exaspera* new species. Plate 42, figs. 1–3; plate 59, fig. 3.
  = *Tilia aspera* (Newberry) LaMotte. Plate 44, fig. 5.
Crataegus flavescens Newberry (new species first described in 1883)
  = *Crataegus merriamii* (Knowlton) new comb. Plate 48, fig. 1.
Cassia sp.? Newberry
  = *Cercidiphyllum crenatum* (Unger) Brown. Plate 46, fig. 10.

Acer sp.? Newberry
  = *Cedrela merrillii* (Chaney) Brown. Plate 46, fig. 8.
Rhamnus eridani Unger
  Status uncertain. Plate 48, fig. 7 (specimen missing).
Grewia crenata (Unger) Heer
  = *Cercidiphyllum crenatum* (Unger) Brown. Plate 46, fig. 2; plate 48, figs. 2,3.
Fraxinus affinis Newberry (new species first described in 1883)
  = *Quercus consimilis* Newberry. Plate 49, fig. 5.
Fraxinus denticulata Heer?
  Indeterminate from original illustration. Plate 49, fig. 6 (specimen missing).
Fraxinus integrifolia Newberry (new species first described in 1883)
  = Leguminosae gen. et sp. indet. (leaflet). Plate 49, figs. 1 (specimen missing), 2, 3.

L. LESQUEREUX, 1883

Lesquereux, L. 1883. Contributions to the fossil flora of the Western Territories, part III: The Cretaceous and Tertiary floras. U.S. Geol. Surv. Terr. 8: 1–283, pl. 1–59.

Sequoia langsdorfii Brgt.
  = *Metasequoia* sp. Plate 50, figs. 2–4 (all specimens missing).
Myrica diversifolia Lesquereux
  = *Crataegus merriamii* (Knowlton) new comb. Plate 50, fig. 10.
Alnus carpinoides Lesquereux, new species
  = *Betula angustifolia* Newberry. Plate 51, fig. 5.
  = cf. *Betula angustifolia* Newberry. Plate 50, fig. 11 (specimen missing).
  = *Alnus* seed catkin. Plate 51, fig. 4a.
  Indeterminate. Plate 51, fig. 4.
Betula elliptica Saporta
  = cf. *Alnus*. Plate 51, fig. 6.
Quercus pseudo-alnus Ettingshausen
  = *Alnus* cf. *A. heterodonta* Newberry. Plate 53, figs. 1–3, 6, 7.
  Indeterminate. Plate 53, figs. 4, 5.
Quercus furcinervis Rossmassler
  = *Quercus* sp. (acorn). Plate 53, fig. 8.
  = cf. *Quercus consimilis* Newberry. Plate 53, figs. 9–12 (all specimens missing).
  Indeterminate. Plate 53, figs. 13, 14.
Quercus drymeja Unger
  = cf. *Quercus consimilis* Newberry. Plate 54, fig. 4 (specimen missing).

Quercus breweri Lesquereux, new species
    = *Quercus consimilis* Newberry. Plate 54, figs. 6, 7.
    = cf. *Quercus consimilis* Newberry. Plate 54, fig. 5 (specimen missing).
    = *Quercus berryi* Trelease. Plate 54, fig. 9.
    = *Quercus* sp. indet. Plate 54, fig. 8 (specimen missing).
Ulmus pseudo-americana Lesquereux, new species
    = *Ulmus speciosa* Newberry. Plate 54, fig. 10.
Grewia auriculata Lesquereux, new species
    = *Cercidiphyllum crenatum* (Unger) Brown. Plate 55, fig. 1.
Ailanthus ovata Lesquereux, new species
    Indeterminate stem. Plate 51, fig. 7.
    = *Micropodium ovatum* (Lesquereux) Brown. Plate 51, fig. 8.

Lesquereux incorrectly referred to the following specimens as coming from the Bridge Creek flora:
    Betula parce-dentata Lesquereux, new species. Plate 50, fig. 12.
    Alnus corrallina Lesquereux, new species. Plate 51, fig. 1 only.

F. H. KNOWLTON, 1902

Knowlton, F. H. 1902. Fossil flora of the John Day basin, Oregon. U.S. Geol. Surv. Bull. 204: 1–153, pl. 1–17.

Although Knowlton included 46 Bridge Creek taxa in his checklist, only the illustrated specimens are included here.

Monocotyledonous plant
    Accepted. Plate 1, figs. 7, 8.
Myrica personata Knowlton, new species
    = Juglandaceae (*Juglandiphyllites cryptatus* or *Carya* sp. leaflet). Plate 3, fig. 2.
Juglans acuminata? Al. Braun
    = Unknown dicot leaf sp. 11. Plate 3, fig. 5.
Juglans cryptata Knowlton, new species
    = *Juglandiphyllites cryptatus* (Knowlton) new comb. Plate 6, figs. 4, 5.
Hicoria? sp.
    Indeterminate (possibly *Alnus*). Plate 5, fig. 2.
Betula heteromorpha Knowlton, new species
    = *Alnus heterodonta* (Newberry) new comb. Plate 3, figs. 6, 7; plate 5, fig. 1.
Betula bendirei Knowlton, new species
    = *Alnus heterodonta* (Newberry) new comb. Plate 4, fig. 2.
Alnus macrodonta Knowlton, new species
    = *Alnus heterodonta* (Newberry) new comb. Plate 4, fig. 1.

Quercus oregoniana Knowlton, new species
    = *Alnus heterodonta* (Newberry) new comb. Plate 6, figs. 2, 3, plate 7, fig. 1 (specimen missing).
Ulmus newberryi Knowlton, new species
    = *Ulmus speciosa* Newberry. Plate 9, fig. 4.
Cinnamomum bendirei Knowlton, new species
    = *Cinnamomophyllum bendirei* (Knowlton) Wolfe. Plate 10, fig. 4.
Crataegus flavescens Newberry
    = *Crataegus merriamii* (Knowlton) new comb. Plate 10, fig. 1.
Acer osmonti Knowlton, new species
    Accepted. Plate 13, fig. 3.
Acer sp.
    = cf. *Acer* sp. 1. Plate 13, figs. 1, 2.
Sapindus merriamii Knowlton, new species. Plate 9, fig. 5.
    = *Crataegus merriamii* (Knowlton) new comb.

R. W. CHANEY, 1927

Chaney, R. W. 1927. Geology and paleontology of the Crooked River basin, with special reference to the Bridge Creek flora. Carnegie Inst. Wash. Publ. 346: 45–138, pl. 1–20.

Pteris silvicola Hall, *in* Chaney, new species
    = *"Pteris" silvicola*, Hall *in* Chaney. Plate 8, figs. 2, 4, 5, 6 (latter two specimens missing), 7.
Salix californica Lesquereux
    = Unknown dicot leaf sp. 23. Plate 8, fig. 8.
    = *Litseaphyllum presanguinea* (Chaney and Sanborn) Wolfe. Plate 8, figs. 9,11.
    Indeterminate. Plate 8, fig. 10.
Myrica diforme (Berry) Chaney new comb.
    = *Comptonia columbiana* Dawson. Plate 9, figs. 1, 3, 5 (specimen missing).
Carpinus grandis Unger
    = *Paracarpinus chaneyi* Manchester and Crane. Plate 9, figs. 6, 10.
    = *Palaeocarya* cf. *olsonii* (Brown) Manchester. Plate 9, figs. 7–9.
    = *Ostrya oregoniana* Chaney. Plate 9, fig. 11.
Ostrya oregoniana Chaney, new species
    Accepted. Plate 9, fig. 12; plate 10, figs. 1–4.
Alnus carpinoides Lesquereux
    = Betulaceous catkin. Plate 10, fig. 5.
Fagus pacifica Chaney, new species
    Accepted. Plate 10, figs. 6–9.

Castanea orientalis Chaney, new species
    = *Quercus consimilis* Newberry. Plate 12, figs. 1, 4.
Quercus clarnensis Trelease
    = *Quercus berryi* Trelease. Plate 10, figs. 10, 11 (specimens missing), 12, 13 (specimen missing); plate 11, figs. 1 (specimen missing), 2–6, 9, 10.
    Indeterminate. Plate 11, fig. 7.
Quercus cf. *ramaleyi* Cockerell
    = cf. Ulmaceae. Plate 11, fig. 8.
Ulmus brownellii Lesquereux
    = *Cedrelospermum lineatum* (Lesquereux) Manchester. Plate 12, figs. 3, 6–8; plate 13, figs. 1, 3, 6.
    = *Potanospira fryi* new genus and species. Plate 13, fig. 4.
Ulmus speciosa Newberry
    = *Craigia oregonense* (Arnold) Kvaček, Bůžek, and Manchester. Plate 12, fig. 5.
Celtis obliquifolia Chaney
    = *Plafkeria obliquifolia* (Chaney) Wolfe. Plate. 13, fig. 12.
Asarum circularis Chaney, new species
    = *Tilia circularis* (Chaney) Manchester. Plate 13, fig. 11.
Odostemon simplex (Newberry) Cockerell
    = *Mahonia simplex* (Newberry) Brown. Plate 14, figs. 7–9, 11.
Umbellularia oregonensis Chaney(?)
    = *Rosa* fruit. Plate 14, fig. 2.
Philadelphus bendirei (Knowlton) Chaney, new comb.
    = *Cinnamomophyllum bendirei* (Knowlton) Wolfe. Plate 17, figs. 1, 2 (specimens missing).
    = cf. *Cercidiphyllum*. Plate 17, fig. 3.
    Status uncertain. Plate 17, fig. 4 (specimen not observed).
    = cf. *Ostrya oregoniana* Chaney (fruit). Plate 17, fig. 5 (specimen missing).
Amelanchier grayi Chaney, new species
    Accepted. Plate 14, figs. 3, 4.
    Indeterminate. Plate 14, fig. 5.
Crataegus newberryi Cockerell
    = *Crataegus merriamii* (Knowlton) new comb. Plate 14, figs. 6, 10.
Rosa hilliae Lesquereux
    Accepted. Plate 13, figs. 8, 9; Plate 14, fig. 1.
    = Rosaceae, prickly stem. Plate 13, fig. 10.
Prunus coveus Chaney, new species
    = *Pterocarya* sp. Plate 15, fig. 1.
    = *Rosa hilliae* Lesquereux Plate 15, fig. 3.
    = *Amelanchier covea* (Chaney) Chaney and Axelrod. Plate 15, fig. 6.
    Indeterminate (cf. *Amelanchier*). Plate 15, fig. 4.
    Indeterminate. Plate 15, fig. 2.

Cercis sp.
 = *Cercis maurerae* new species. Plate 15, fig. 5.
Rhus merrilli Chaney, new species
 = *Cedrela merillii* (Chaney) Brown. Plate 16, figs. 1, 2.
Rhus praeovata Chaney, new species
 = *Fothergilla praeovata* (Chaney) new comb. Plate 15, figs. 8, 9.
Acer osmonti Knowlton
 = *Acer* sp. 1. leaf. Plate 17, fig. 6.
 = *Acer glabroides* Brown *emend.* Wolfe and Tanai. Plate 18, fig 5.
 = *Acer* sp. 2. leaf. Plate 18, fig. 1.
 = *Acer* sp. indet. Plate 18, fig. 3 (specimen missing).
 = *Acer cranei* Wolfe and Tanai. Plate 18, fig. 7.
 Accepted. Plate 18, figs. 8, 9 (specimens missing).
Ceanothus blakei Chaney, new species
 = *Paliurus blakei* (Chaney) new comb. Plate 16, figs. 4, 8.
 Indeterminate. Plate 16, fig. 6.
 = *Hovenia oregonensis* new species. Plate 16, fig. 7.
 = cf. *Cinnamomophyllum bendirei* (Knowlton) Wolfe. Plate 16, fig. 9 (specimen missing).
Nyssa crenata Chaney
 = *Flectorivus microdontos* n. sp. Plate 15, fig. 11.
Cornus ovalis Lesquereux
 = *Plafkeria obliquifolia* (Chaney) Wolfe. Plate 19, figs. 1 (specimen missing), 2, 3.
 = *Hydrangea* sp. Plate 19, fig. 4 (specimen missing).
Arbutus matthesii Chaney, new species
 Indeterminate. Plate 20, fig. 5.
Fraxinus denticulata Heer
 = Unknown dicot leaf sp. 11. Plate 19, figs. 5–7.

H. L. MASON, 1927

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 = *Metasequoia* sp. Plate 1, fig. 4.
Torreya sp.
 = *Torreya masonii* new species. Plate 1, figs. 5, 6.
Pinus torreyana Parry
 = *Pinus johndayensis* new species. Plate 1, fig. 3; plate 2, fig. 3.
Pinus knowltoni Chaney
 = *Pinus johndayensis* new species. Plate 2, fig. 1.

Pinus knowltoni? Chaney
    = *Cedrela merrillii* (Chaney) Brown. Plate 3, fig. 3.
Abies sp. 2
    = *Metasequoia* sp. Plate 4, fig. 3.
Sequoia langsdorfii (Brong.) Heer
    = *Metasequoia* sp. Plate 5, figs. 4, 8.

R. W. BROWN, 1935–1959

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    Accepted. Plate 68, figs. 8 (same specimen as Newberry's *Cassia* sp., pl. 46, fig. 10), 9, 10 (same specimen as Newberry's *Grewia crenata*, pl. 47, fig. 2).
Acer negundoides MacGinitie
    = *Acer cranei* Wolfe and Tanai. Plate 69, figs. 9, 10 (latter specimen missing).

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Cladrastis oregonensis Brown, new species
    Accepted. Fig. 1.
Micropodium ovatum (Lesquereux) Brown, new comb.
    Accepted. Fig. 2.

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Celtis obliquifolia Chaney
    = *Plafkeria obliquifolia* (Chaney) Wolfe. Plate 48, fig. 6 (same specimen as Lesquereux's *Ficus planicostata*, pl. 46, fig. 1).
Ptelea miocenica Berry
    = *Craigia oregonensis* (Arnold) Kvaček, Bůžek, and Manchester. Plate 51, fig. 4 (same specimen as Newberry's *Ulmus speciosa*, pl. 45, fig. 7).
Acer glabroides Brown, new name
    = *Acer* sp. C fruit. Plate 58, fig. 15.

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Fagus pacifica Chaney
Accepted. Fig. 11.
Cercidiphyllum crenatum (Unger) Brown
Accepted. Fig. 9.
Cedrela merrilli (Chaney) Brown, new comb.
Accepted. Not illustrated.

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Accepted. Plate 56, fig. 16.

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Callitris potlachensis Brown
= *Tetraclinis potlachensis* (Brown) new comb. Fig. 6.
Potamogeton parva Brown, new species
= Possibly *Potamogeton* Fig. 16.
Sassafras bendirei (Knowlton) Brown, new comb.
= *Cinnamomophyllum bendirei* (Knowlton) Wolfe. Not illustrated.
Dipteronia insignis (Lesquereux) Brown
= *Rhus lesquereuxii* new species. Fig. 17.
Limnanthemum circularis (Chaney) Brown, new comb.
= *Tilia circularis* (Chaney) Manchester. Not illustrated.
Banksites lineatus Lesquereux
= *Cedrelospermum lineatum* (Lesquereux) Manchester. Fig. 11.
Porana speirii Lesquereux
= *Florissantia speirii* (Lesquereux) Manchester. Fig. 12.

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Zelkova hesperia Brown, new species
= *"Zelkova" hesperia* Brown. Fig. 3.
Rhododendron chaneyi Brown, new species
= Unknown dicot leaf 9. Fig. 15.

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Koelreuteria oregonensis Arnold
    = *Craigia oregonensis* (Arnold) Kvaček, Bůžek and Manchester. Plate 24, figs. 6, 7.
Metasequoia occidentalis (Newberry) Chaney
    = *Metasequoia* sp. Plate 24, figs. 10, 11.
Dipteronia insignis (Lesquereux) Brown
    = *Dipteronia* sp. fruit. Plate 24, fig. 12.
Terminalia sp.
    = *Terminalia oregona* (Lakhanpal) new comb. Plate 24, fig. 16.
Vitis sp (seed
    Accepted. Plate 24, fig. 17.

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(Numbers in italic type refer to principal discussion or systematic description)

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2–4. *"Pteris" silvicola* Hall in Chaney (p. 55).
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   3. UF 10448, Crooked River (loc. 258a), ×2.
   4. UF 10505, Fossil (loc. 250). Specimen showing sori, ×3.

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   UF 10187, Crooked River (loc. 258a).

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   9. UF 10340a, paratype, ~~Lost Creek~~ (loc. 241), ×2.5.
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   11. UCMP 12629a, paratype, Butler Basin (loc. P-4211), ×2.
   12. UCMP 12630, paratype, Butler Basin (loc. P-4211), ×2.

) Iron Mountain


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PLATE 2

1, 2. *Cunninghamia chaneyi* Lakhanpal (p. 59).
   1. UCMP 12632, Painted Hills (loc. 3741).
   2. UCMP 12633, Painted Hills (loc. 3741). Cone scale, ×2.

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   = 10387 – – – ✓4. UF 10378a, Iron Mountain (loc. 241).
   5. UCMP 12635, Fossil (loc. P-5203). Ovulate cone.
   6. UCMP 12637, Painted Hills (loc. 3741). Ovulate cone.
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   ✓9. UF 10336, Lost Creek (loc. 243a).

11. Caddis fly larval case constructed of *Metasequoia* leaves (p. 62).
   ✓ UF 10479, Fossil (loc. 250).

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PLATE 3

1–9. *Tetraclinis potlachensis* (Brown) new comb. (p. 63).
  1. USNM 42333, Lost Creek or Crooked River, ×2.5.
  2. UF 10163, Lost Creek (loc. 244), ×2.5.
  3. UF 10164, Lost Creek (loc. 244), ×2.5.
  4. UF 10165, Lost Creek (loc. 243a), ×2.5.
  5. USNM 450636, Lost Creek or Crooked River. Seed cone, before preparation, showing a single cordiform cone scale, ×2.5.
  6. USNM 450636, Lost Creek or Crooked River. Same specimen as in fig. 5, with one of the cone scales partially removed, showing two additional scales in lateral view, ×2.5.
  7. UF 10151a, Lost Creek (loc. 244), ×2.5.
  8. UF 10151b, Lost Creek (loc. 244), ×2.5.
  9. UF 10152, Lost Creek (loc. 243), ×2.5.

10–14. *Fokieniopsis praedecurrens* (Knowlton) new comb., probable foliage of *T. potlachensis* (p. 64).
  10. UF 10155, Lost Creek (loc. 244), ×2.5.
  11. UF 10154, Lost Creek (loc. 243), ×2.5.
  12. UF 10153a, Lost Creek (loc. 244), ×2.5.
  13. UF 10158a, Lost Creek (loc. 244), ×2.5.
  14. UF 10161a, Lost Creek (loc. 243), ×2.5.

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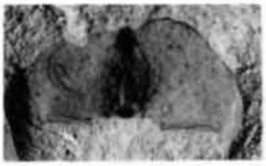

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PLATE 4

1. *Abies* sp. (p. 65).
    UF 6991, Fossil (loc. 250).
2. *Keteleeria ptesimosperma* new species (p. 65).
    UCMP 12638, holotype, Iron Mountain (loc. P-4210), ×2.

3–7. *Pinus johndayensis* new species (p. 66).
    3. UF 10352, paratype, Fossil (loc. 250). Immature ovulate cone.
    4. UCMP 9316, holotype, Fossil (loc. P-5203).
    5. UF 6996, paratype, Fossil (loc. 250).
    6. UF 10354, paratype, Fossil (loc. 250). Silicone cast showing dorsal umbos of cone scales.
    7. UCMP 12707, paratype, Cove Creek (Knox Ranch, P-5405).

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PLATE 5

1–7. *Pinus johndayensis* new species (p. 66).
  1. UF 10452, paratype, Fossil (loc. 250). Fascicle showing bulbous base with persistent sheath.
  2. UF 10451, paratype, Fossil (loc. 250). Fascicle showing bulbous base, persistent sheath, and at least four needles.
  3. UF 10401, paratype, Fossil (loc. 250). Winged seed.
  4. UF 10436, paratype, Cove Creek (Knox Ranch, loc. 245). Disarticulated winged seed.
  5. UF 10450a, paratype, Fossil (loc. 250). Pollen cone.
  6. UF 10356, paratype, Cove Creek (loc. 247). Disarticulated winged seed.
  7. UF 10438, paratype, Fossil (loc. 250). Winged seed with poorly developed body.

8, 11. *Cinnamomophyllum knowltonii* new species (p. 68).
  8. UF 10373a, holotype, Cove Creek (Knox Ranch, loc. 245).
  11. UF 10370, paratype, Cove Creek (Knox Ranch, loc. 245), ×3.

9, 10. *Cinnamomophyllum bendirei* (Knowlton) Wolfe (p. 68).
  9. USNM 8490, lectotype, Painted Hills.
  10. UF 10524, Iron Mountain (loc. 241).


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PLATE 6

1–3. *Litseaphyllum presanguinea* (Chaney and Sanborn) Wolfe (p. 69).
    1. UCMP 22, Crooked River (loc. 3748).
    2. UF 10318, Crooked River (loc. 258a).
    3. Detail from fig. 2, ×3.
4, 5. *Nuphar* sp. (p. 70).
    4. UF 10426, Fossil (loc. 250). Rhizome envelope with circular root scars, ×2.
    5. UF 10684, Fossil (loc. 250). Elliptical leaf scars.
6. Nympheaceae gen. et sp. indet. (p. 70).
    UF 10859, Fossil (loc. 250), ×2.
7–10. *Mahonia simplex* (Newberry) Arnold (p. 71).
    7. UF 10183b, Crooked River (loc. 258a).
    8. UCMP 12652, Cove Creek (Pentecost Ranch, loc. PA-2).
    9. UCMP 12651, Cove Creek (Pentecost Ranch, loc. PA-2).
    10. USNM 7046, Holotype, Painted Hills.


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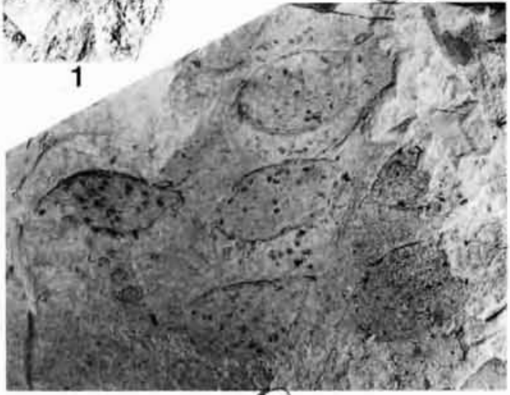
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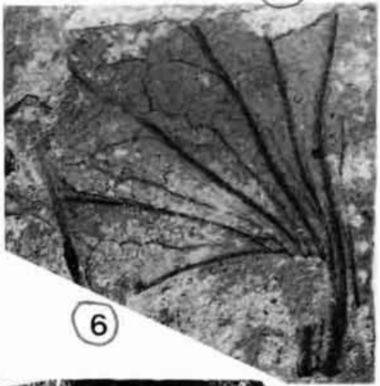
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PLATE 7

l available 1. cf. *Menispermum* (p. 72).
  ✓ JODA 1085A, Painted Hills, ×4.

2–4, 7, 8. *Cercidiphyllum crenatum* (Unger) Brown, leaves (p. 73).
  2. UCMP 12656, Painted Hills (loc. 3741-1).
  3. UCMP 12659, Iron Mountain (loc. P-4210).
  4. UCMP 12655, Painted Hills (loc. 3741).
  7. UCMP 12654a, Iron Mountain (loc. P-4210).
  8. Detail from fig. 6, ×3.

5, 6. *Cercidiphyllum crenatum* (Unger) Brown, fruits (p. 73).
  ✓5. UF 10698, Iron Mountain (loc. 240).
  ✓6. UF 10591, Cove Creek (Knox Ranch, loc. 245).

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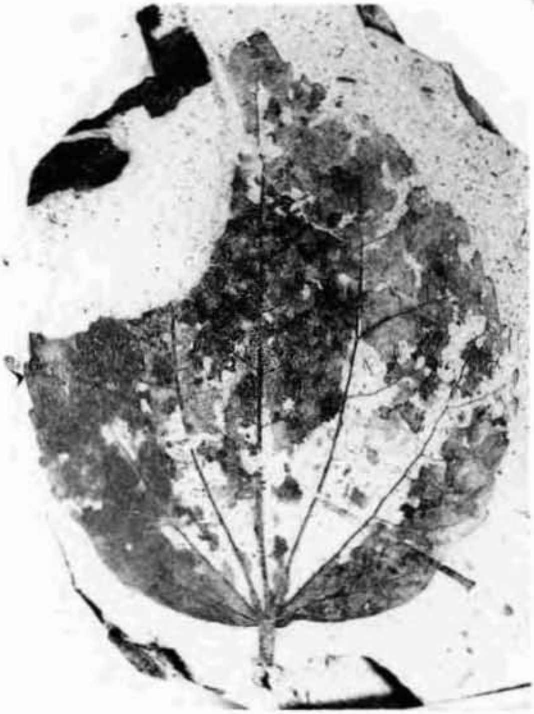

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PLATE 8

1\. *Cercidiphyllum crenatum* (Unger) Brown (p. 73).
  UF 10692a, Cove Creek (Knox Ranch, loc. 245).
2–8\. *Fothergilla praeovata* (Chaney) new comb. (p. 74).
  2\. UCMP 91, holotype, Crooked River (loc. 3748).
  3\. Detail from fig. 2, ×3.
  4\. USNM 458390, Crooked River (loc. 8778).
  5\. Detail from fig. 4, ×3.
  6\. USNM 458389, Crooked River (loc. 8778a).
  7\. UCMP 90, paratype, Crooked River (loc. 3748).
  8\. Detail from fig. 7, ×3.
9\. Hamamelidaceous gen. et sp. indet. infructescence (p. 77).
  USNM 458380, Fossil (loc. 9420), ×1.5.

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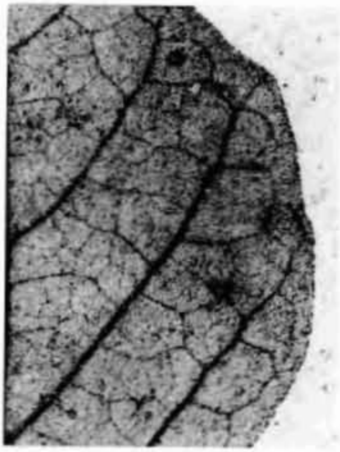

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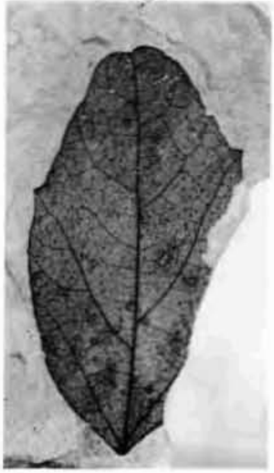

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PLATE 9

1. *Liquidambar* sp. (p. 75).
   USNM 7095, Painted Hills

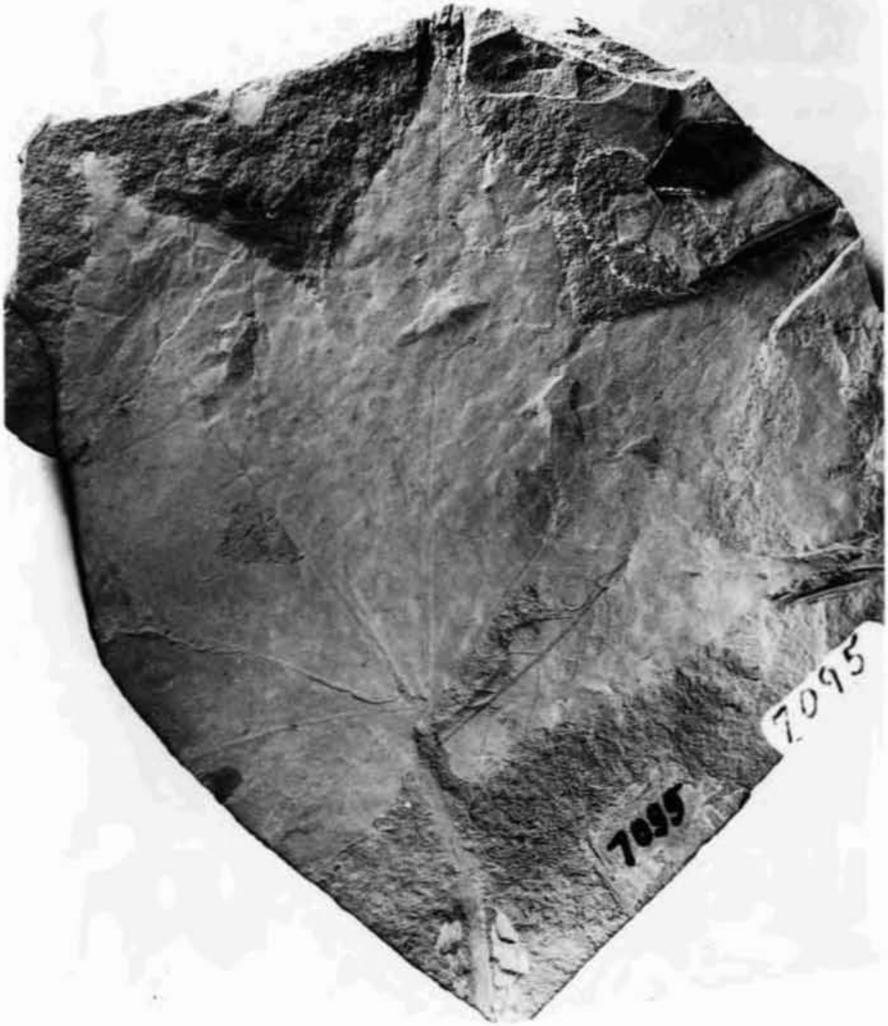

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PLATE 10

1–4. *Parrotia brevipetiola* new species (p. 76).
  1. UF 10360, holotype, Fossil (loc. 250).
  2. Detail from fig. 1, ×3, showing short, inflated petiole, and basal margin delimited by secondary veins.
  3. UF 10361, paratype, Fossil (loc. 250).
  4. Detail from fig. 3, ×3.

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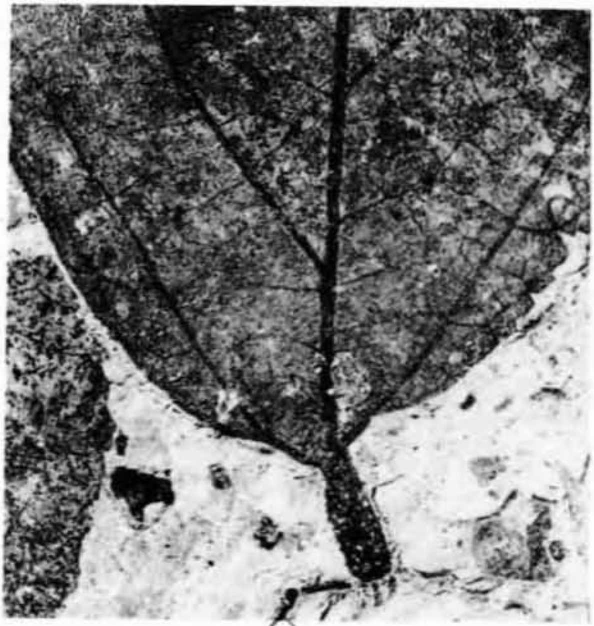

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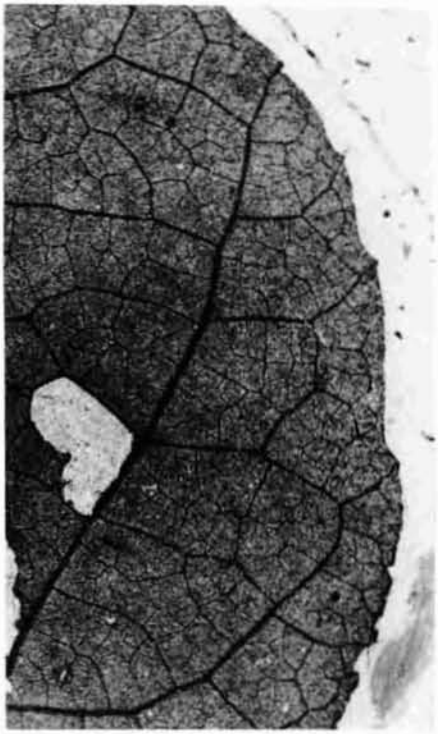

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PLATE 11

1–4. *Parrotia brevipetiola* new species (p. 76).
  1. UF 10365, paratype, Fossil (loc. 250).
  2. Detail from fig. 1, ×3.
  3. UF 10367, paratype, Fossil (loc. 250).
  4. UF 10362, paratype, Fossil (loc. 250).

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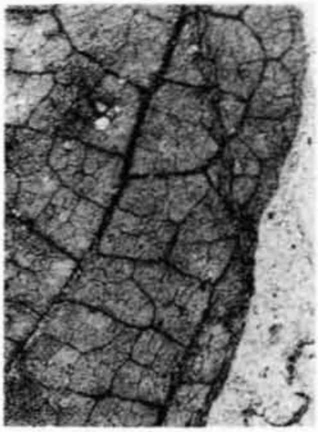

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PLATE 12

1, 2. *Platanus exaspera* new species (p. 79).
  1. UF 6997, holotype, Fossil (loc. 250).
  2. Detail from fig. 1, ×3.

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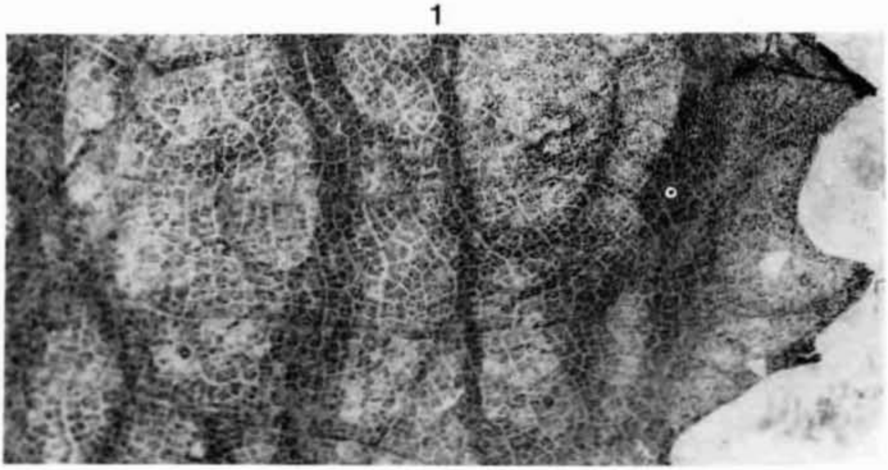

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PLATE 13

1, 3. *Platanus exaspera* new species (p. 79).
    1. UF 10176a, paratype, Crooked River (loc. 258a).
    3. UF 10342a, Crooked River (loc. 258a).
2. Platanaceous infructescence (p. 80).
    UF 10603a, Lost Creek (loc. 243b).
4. *Platanus condonii* (Newberry) Knowlton (p. 77).
    UF 7002, Fossil (loc. 250).

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PLATE 14

1. *Platanus condonii* (Newberry) Knowlton (p. 77).
USNM 458413, Painted Hills, ×0.67.

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PLATE 15

1–3. *Platanus condonii* (Newberry) Knowlton (p. 77).
    1. USNM 7085, lectotype, Painted Hills, ×0.5.
    2. Natural size of a portion of the specimen in fig. 1.
    ✓ 3. UF 10595, Fossil (loc. 250). Basal laminar appendage.
4–6. *Platanus* sp. infructescence (p. 80).
    ✓ 4. UF 10601, Fossil (loc. 250).
    ✓ 5. UF 6998, Fossil (loc. 250).
    6. Detail from fig. 5, ×3.
7. *Platanus* sp. fruitlet (p. 80).
    ✓ UF 10602, Lost Creek (loc. 243b), ×3.

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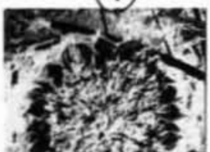

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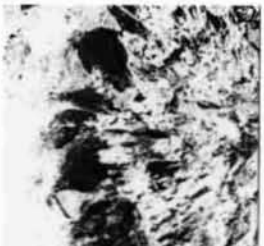

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PLATE 16

1–8, 12. *Cedrelospermum lineatum* (Lesquereux) Manchester, leaves (p. 80).
  - ✓1. UF 10169, Crooked River (loc. 258a).
  - ✓2. UF 10174b, Crooked River (loc. 258a).
  - 3. Detail from fig. 2, ×3.
  - ✓4. UF 10179, Crooked River (loc. 258a).
  - 5. Detail from fig. 4, ×3.
  - ✓6. UF 10633, Fossil (loc. 250).
  - ✓7. UF 10608, Fossil (loc. 250).
  - 8. Detail from fig. 6, ×3.
  - ✓12. UF 10178, Crooked River (loc. 258a).

9–11. *Cedrelospermum lineatum* (Lesquereux) Manchester, fruits (p. 80).
  - 9. USNM 42336, Crooked River (loc. 8778), ×2.5.
  - ✓10. UF 10185, Crooked River (loc. 258a), ×2.5.
  - ✓11. UF 10186, Crooked River (loc. 258a), ×2.5.

13, 14. "*Zelkova*" *hesperia* Brown (p. 85).
  - 13. USNM 42365a, Crooked River (loc. 8778a).
  - 14. USNM 42365b, Detail from counterpart of the specimen in fig. 13, ×3.


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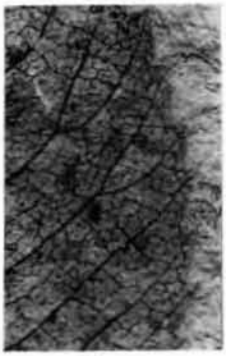
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PLATE 17

1–4. *Ulmus chaneyi* Tanai and Wolfe (p. 82).
  - ✓1. UF 7004, Fossil (loc. 250). need to locate counterpart
  - 2. Detail from fig. 1, ×3.
  - ✓3. UF 10520, Fossil (loc. 250).
  - 4. Detail from fig. 3, ×3.

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PLATE 18

1–6. *Ulmus speciosa* Newberry (p. 83).
  1. UCMP 12728, Painted Hills (loc. 3741).
  2. Detail from fig. 1, ×3.
  3. UCMP 12722, Fossil.
  4. UCMP 12721, Painted Hills (loc. 3741).
  5. Detail from fig. 4, ×3.
  6. USNM 458391, Crooked River (loc. 8778), ×3.

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PLATE 19

1–5. *Ulmus* sp. 1 (p. 83).
    1. UO 2734, Painted Hills.
    2. Detail from fig. 1, ×3.
    ↘3. UF 10173, Crooked River (loc. 258a).
    4. Detail from fig. 3, ×3.
    5. UCMP 12726, Painted Hills (loc. 3741-1).

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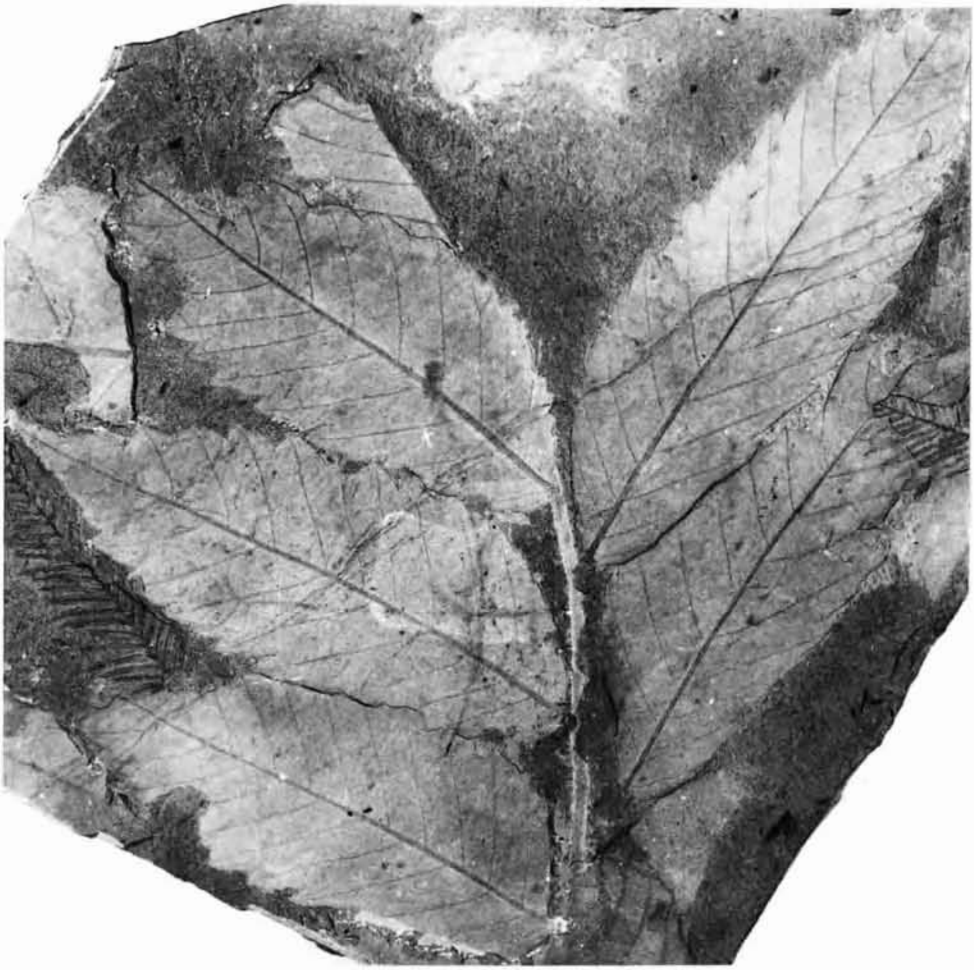

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PLATE 20

1–4. *Ulmus* sp. 2 (p. 84).
  1. UF 10521, Fossil (loc. 250).
  2. Detail from fig. 1, ×3.
  3. UF 10522, Fossil (loc. 250).
  4. UF 10634, Fossil (loc. 250).

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PLATE 21

1, 2, 4. *Ulmus* sp. B fruit (p. 85).
- 1. UF 10171a, Crooked River (loc. 258a), ×2.5.
- 2. UF 10569a, Crooked River (loc. 258a), ×2.5.
- 4. UF 10830, Fossil (loc. 250), ×2.5.

3, 5. *Ulmus* sp. A fruit (p. 84).
- 3. UF 7037, Crooked River (loc. 258), ×2.5.
- 5. UF 10757, Crooked River (loc. 258a), ×2.5.

6–10. *Fagus pacifica* Chaney (p. 86).
- 6. USNM 9213, Painted Hills. Nut showing styles and lateral wings, ×2.5.
- 7. UF 10636, Fossil (loc. 250). Cupule on peduncle, ×2.
- 8. UF 7008, Fossil (loc. 250). Cupule in lateral view, ×2.
- 9. UF 7009, Fossil (loc. 250). Opened cupule in transverse view, x2.
- 10. UF 10776, Fossil (loc. 250), ×2.

11–16. *Quercus* spp. acorns (p. 90).
- 11. UF 10213a, Crooked River (loc. 258a).
- 12. UCMP 12670, Painted Hills (loc. 3741).
- 13. UF 10216b, Crooked River (loc. 258a).
- 14. UCMP 12671, Painted Hills (loc. 3741).
- 15. UCMP 12821, Iron Mountain (loc. P-4210).
- 16. UCMP 9317, Fossil (loc. P-5203).


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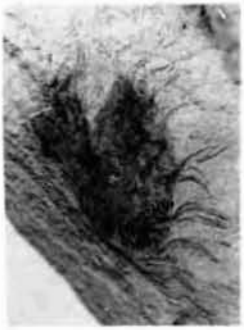
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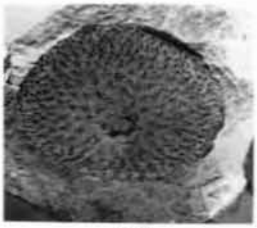
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PLATE 22

1–6. *Fagus pacifica* Chaney (p. 86).
  1. UF 7010, Fossil (loc. 250).
  2. UF 10598, Fossil (loc. 250).
  3. Detail from fig. 2, ×3.
  4. UF 10597, Fossil (loc. 250).
  5. Detail from fig. 4, ×3.
  6. UF 10214a, Crooked River (loc. 258a).

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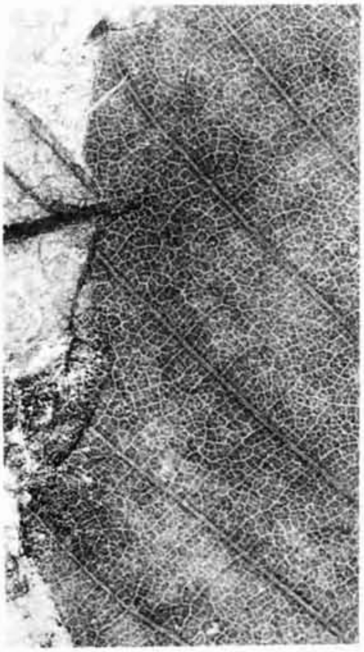

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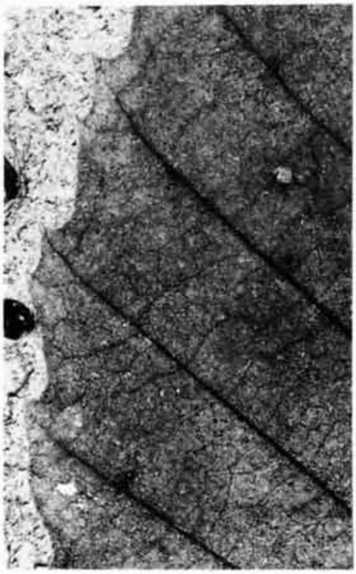

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PLATE 23

1–17. *Quercus berryi* Trelease (p. 88).
  1. UCMP 1774, lectotype, Painted Hills
  2. UF 10192, Crooked River (loc. 258a).
  3. Detail from fig. 2, ×3.
  4. UF 10191, Crooked River (loc. 258a).
  5. UF 10193, Crooked River (loc. 258a).
  6. UF 10210, Crooked River (loc. 258a).
  7. Detail from fig. 6, ×3.
  8. UF 10189, Crooked River (loc. 258a).
  9. UF 10199, Crooked River (loc. 258a).
  10. UF 10205, Crooked River (loc. 258a).
  11. Detail from fig. 10, ×3.
  12. UF 10204, Crooked River (loc. 258a).
  13. UF 10194, Crooked River (loc. 258a).
  14. Detail from fig. 13, ×3.
  15. UF 10207, Crooked River (loc. 258a).
  16. UF 10202, Crooked River (loc. 258a).
  17. UF 10203, Crooked River (loc. 258a).

note variation in leaf size


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PLATE 24

1–8. *Quercus consimilis* Newberry (p. 89).
  1. USNM 7058, lectotype, Painted Hills.
  2. UCMP 12664, Painted Hills (loc. 3741).
  3. Detail from fig. 2, ×3.
  4. UF 10516, Fossil (loc. 250).
  5. USNM 7125, Painted Hills.
  6. USNM 7063, Painted Hills.
  7. UCMP 12665, Painted Hills (loc. 3741).
  8. Detail from fig. 7, ×3.

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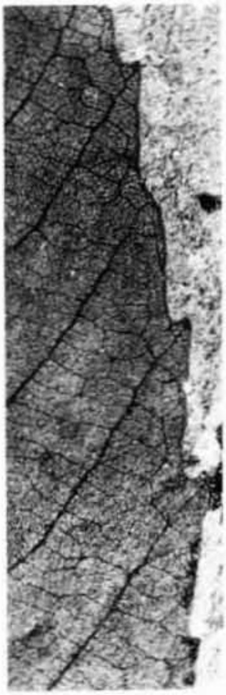

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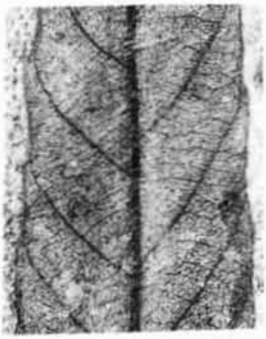

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PLATE 25

1–9. *Alnus heterodonta* (Newberry) new comb. (p. 92).

  1. USNM 7072, lectotype, Painted Hills.
  2. UCMP 12677, Painted Hills (loc. 3741).
  3. UCMP 12682, Cove Creek (Pentecost Ranch, loc. PA-2).
  4. UCMP 12679, Painted Hills (loc. 3741).
  5. Detail from fig. 4, ×3.
  6. UCMP 12826, Fossil (loc. PA-15).
  7. UCMP 12681, Cove Creek (Pentecost Ranch, loc. PA-2).
  8. ✓ UF 10254, Crooked River (loc. 258a).
  9. UCMP 12678, Painted Hills (loc. 3741).

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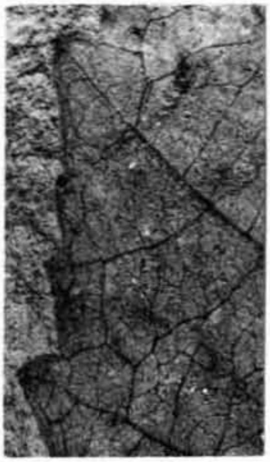

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PLATE 26

1–4. *Alnus heterodonta* (Newberry) new comb. (p. 92).
   1. UF 10167, Crooked River (loc. 258a).
   2. Detail from fig. 1, ×3.
   3. UF 10226, Crooked River (loc. 258a).
   4. Detail from fig. 3, ×3.

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PLATE 27

1–4. *Alnus newberryi* new species (p. 93).
  - ✓1. UF 7015, holotype, Fossil (loc. 250). counterpart
  - 2. Detail from fig. 1, ×3.
  - 3. UCMP 12683, paratype, Painted Hills (loc. 3741).
  - 4. Detail from fig. 3, ×3.

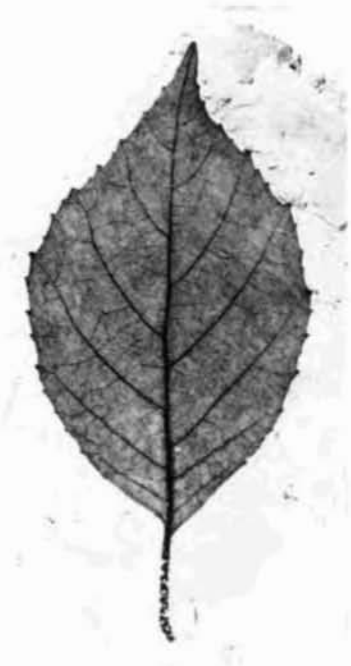

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PLATE 28

1–3. *Alnus newberryi* new species (p. 93).
  1. UCMP 12729, paratype, Butler Basin (loc. 3931).
  2. UCMP 12684, paratype, Fossil (loc. PA-15).
  3. UCMP 12685, paratype, Fossil (loc. PA-15).

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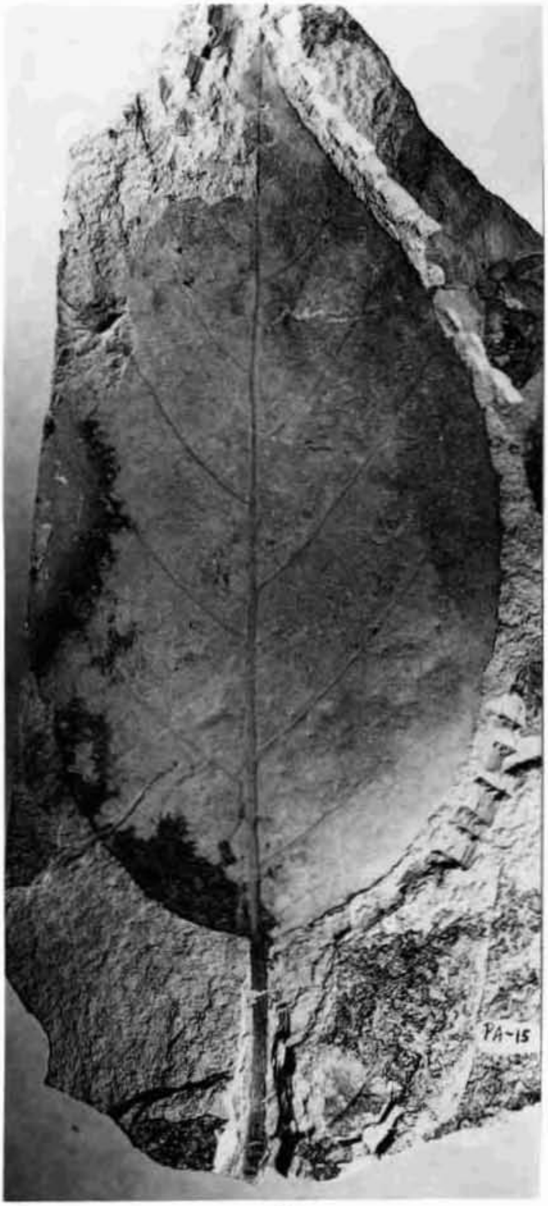

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PLATE 29

1–3. *Alnus* spp. variable morphotypes, (p. 94).
  1. UF 10224, Crooked River (loc. 258a).
  2. UF 10168, Iron Mountain (loc. 241).
  3. UF 10232b, Crooked River (loc. 258a).

4, 11, 12. *Alnus* sp. infructescences (p. 94).
  4. UF 10236b, Crooked River (loc. 258a).
  11. UF 10245, Crooked River (loc. 258a).
  12. UCMP 12687, Cove Creek (loc. 125).

5, 7–10. *Alnus* sp. pollen catkins (p. 94).
  5. UF 10850b, Crooked River, (loc. 258a).
  7. UF 10853, Crooked River (loc. 258a).
  8. UF 10230a, Crooked River (loc. 258a).
  9. UF 10843, Fossil (loc. 250).
  10. UF 10392, Iron Mountain (loc. 241).

6. *Alnus* sp. fruit (p. 94).
  UF 10811b, Iron Mountain (loc. 240), ×4.

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PLATE 30

1–6. *Betula angustifolia* Newberry, leaves (p. 94).
  1. UCMP 7075, lectotype, Painted Hills.
  2. USNM 7091, Painted Hills.
  3. Detail from fig. 2, ×3.
  4. UCMP 12675, Painted Hills (loc. 3741).
  5. UCMP 12673, Painted Hills (loc. 3741).
  6. Detail from fig. 5, ×3.

7. *Betula angustifolia* Newberry, bract (p. 94).
  USNM 458387, Painted Hills, ×4.

8, 9. *Betula angustifolia* Newberry, fruits (p. 94).
  8. USNM 489736, Painted Hills, ×5.
  9. USNM 458384, Painted Hills (loc. 8641), ×4.

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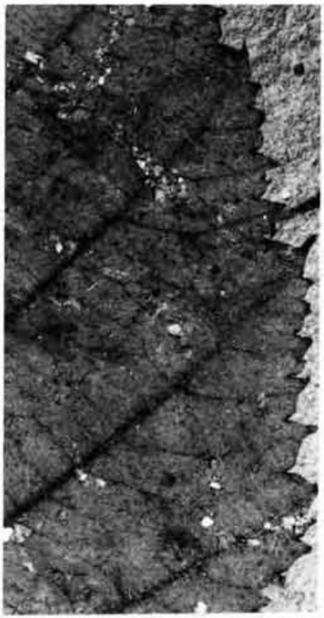

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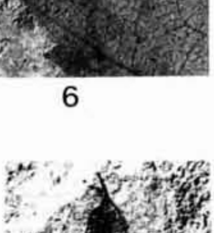

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PLATE 31

- 1–4. *Ostrya oregoniana* Chaney, leaves (p. 96).
  - 1. UCMP 34, holotype, Crooked River (loc. 3748).
  - 2. Detail from fig. 1, ×3.
  - ↘3. UF 10262, Crooked River (loc. 258a).
  - ↘4. UF 10258, Crooked River (loc. 258a).
- 5–7. *Ostrya oregoniana* Chaney, fruits (p. 96).
  - ↘5. UF 6100, Crooked River (loc. 258a), ×2.
  - ↘6. UF 10270, Crooked River (loc. 258a), ×2.
  - 7. USNM 458393, Crooked River (loc. 8778a), ×2.
- 8–10. *Paracarpinus chaneyi* Manchester and Crane (p. 98).
  - ↘8. UF 6097, holotype, Fossil (loc. 250).
  - 9. Detail from fig. 8, ×3.
  - ↘10. UF 6098, Fossil (loc. 250).


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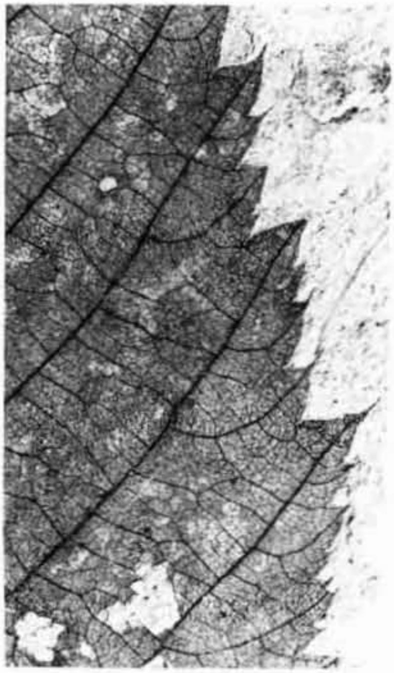
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PLATE 32

1. *Paracarpinus chaneyi* Manchester and Crane (p. 98).
    UF 10590, Cove Creek (Knox Ranch, loc. 245).

2–5. *Asterocarpinus perplexans* (Cockerell) Manchester and Crane (p. 97).
    2. UF 10588, Fossil (loc. 250), ×1.5.
    3. UF 10587a, Iron Mountain (loc. 241), ×1.5.
    4. UF 10586, Fossil (loc. 250), ×1.5.
    5. UF 6095, Crooked River (loc. 258a), ×3.

6, 7. *Cruciptera* sp. (p. 101).
    6. UF 9327, Crooked River (loc. 258a), ×2.
    7. UF 10646a, Fossil (loc. 250), ×3.

8–11. *Comptonia columbiana* Dawson (p. 99).
    8. UF 10766, Lost Creek (loc. 243a).
    9. UF 10770, Lost Creek (loc. 243a).
    10. UF 10493a, Lost Creek (loc. 243a).
    11. Detail from fig. 10, ×3.

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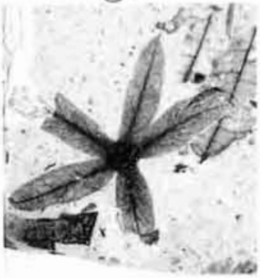

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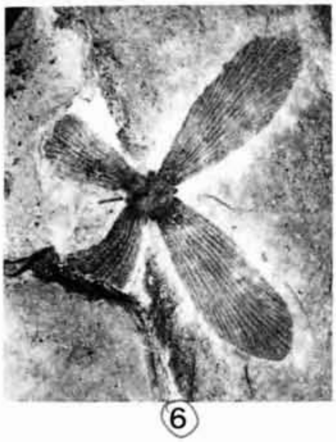

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PLATE 33

1–2. *Carya* sp. 1 (p. 100).
  1. UF 10481a, Fossil (loc. 250).
  2. Detail from fig. 1, ×3.

3–6. *Juglandiphyllites cryptatus* (Knowlton) new comb. (p. 101).
  3. UF 10485, Fossil (loc. 250).
  4. UCMP 2503, lectotype, Painted Hills.
  5. UF 10483a, Fossil (loc. 250).
  6. Detail from fig. 5, ×3.

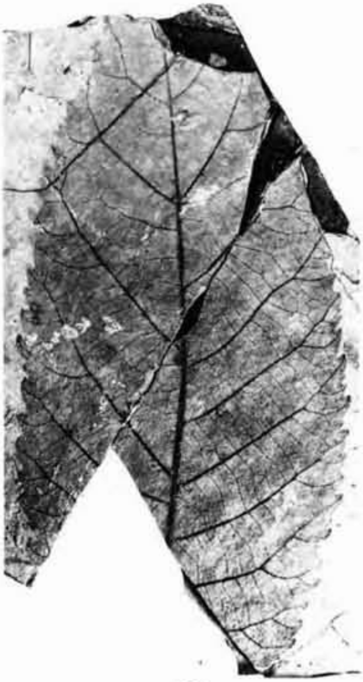

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PLATE 34

1, 4. *Juglandiphyllites cryptata* (Knowlton) new comb. (p. 101).
    1. UF 10490, Fossil (loc. 250).
    4. UF 10482, Fossil (loc. 250).
2, 3. *Carya* sp. A (p. 100).
    2. UF 7007, Fossil (loc. 250). previously figured Machester & Meyer, 1987
    3. UCMP 12810, Cove Creek (Pentecost Ranch, loc. PA-2).
5. cf. *Juglans* sp. (p. 103).
    UF 10592, Fossil (loc. 250). Silicone cast.
6–8. *Palaeocarya* cf. *olsonii* (p. 103).
    6. JODA 4467, Painted Hills.
    7. UF 7013, Fossil (loc. 250).
    8. UF 10269, Crooked River (loc. 258a).


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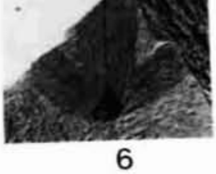
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PLATE 35

1–3. *Juglans wheelerensis* new species (p. 102).
  1. UF 10600, holotype, Fossil (loc. 250).
  2. Detail from fig. 1, ×3.
  3. UF 10860, paratype, Fossil (loc. 250).

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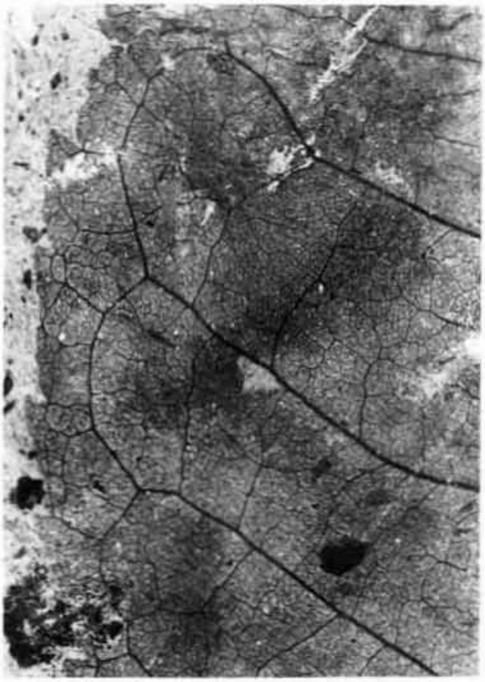

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PLATE 36

- 1–5. *Pterocarya* sp. (p. 104).
  - ✓1. UF 10488a, Butler Basin (loc. 248).
  - 2. Detail from fig. 1, ×3.
  - 3. UCMP 12696, Butler Basin (loc. P-4211).
  - 4. UCMP 12695, Butler Basin (loc. 3931).
  - 5. Detail from fig. 4, ×4.
- 6. *Pterocarya occidentalis* Manchester fruit (p. 105).
  - ✓ UF 10489, Butler Basin (loc. 248), ×2.5.
- 7. *Pterocarya hupehensis* Skan., modern fruit for comparison (p. 105) (Ho-'Chang Chow 732) Hupeh, China, ×2.5.

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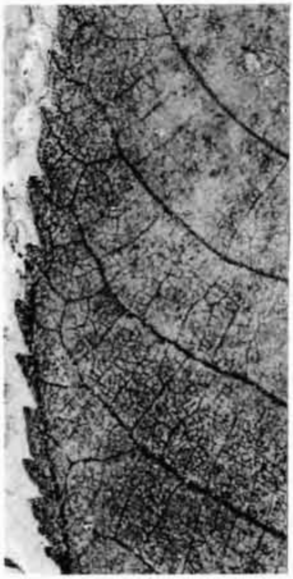

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PLATE 37

1–5, 7. *Flectorivus microdontos* new species (p. 106).
    1. UCMP 92, paratype, Crooked River (loc. 3748).
    2. Detail from fig. 1, ×3.
    3. UF 10317, holotype, Crooked River (loc. 258a).
    4. Detail from fig. 3, ×3.
    5. Detail from fig. 3, ×10.
    7. USNM 458395, paratype, Crooked River (loc. 8778).

6. *Pterostyrax hispida*, extant species for comparison (p. 106).
    USGS cleared leaf 1118b, ×3.

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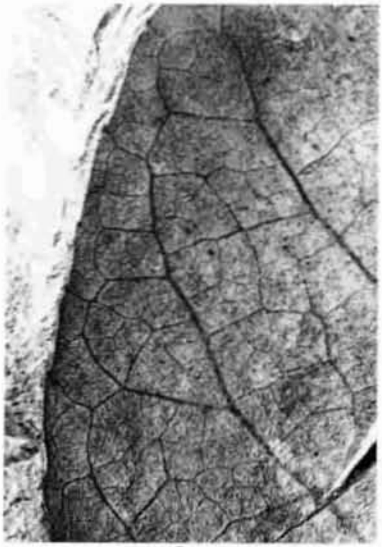

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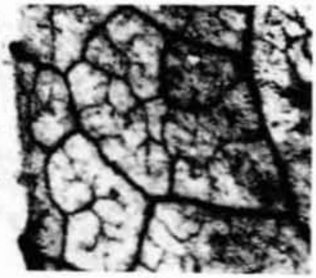

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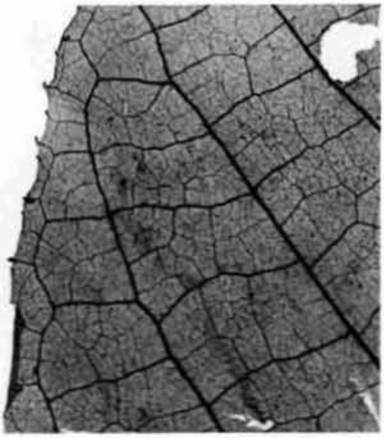

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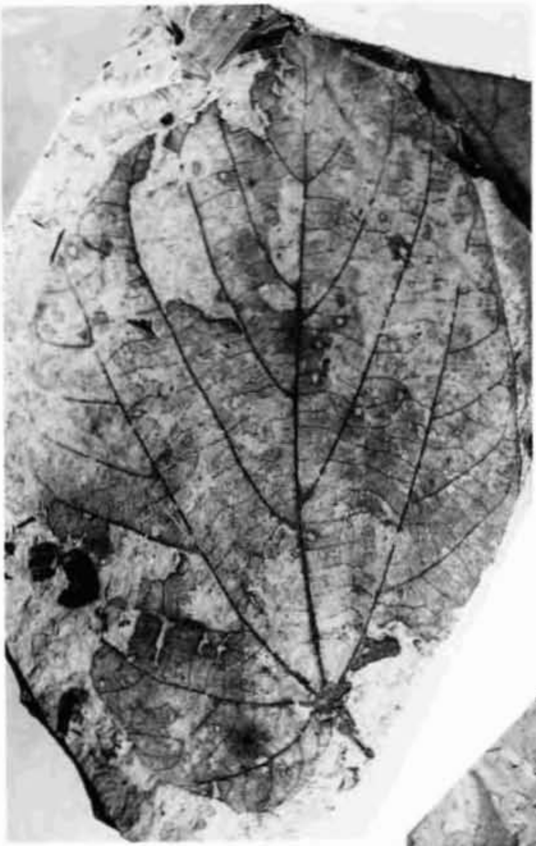
PLATE 38

1–4. *Plafkeria obliquifolia* (Chaney) Wolfe (p. 108).
    1. UCMP 12714, Cove Creek (Knox Ranch, loc. PA-12).
    2. Detail from fig. 1, ×3.
    3. UF 10264, Crooked River (loc. 258a).
    4. UCMP 12715A, Cove Creek (Pentecost Ranch, loc. PA-2).



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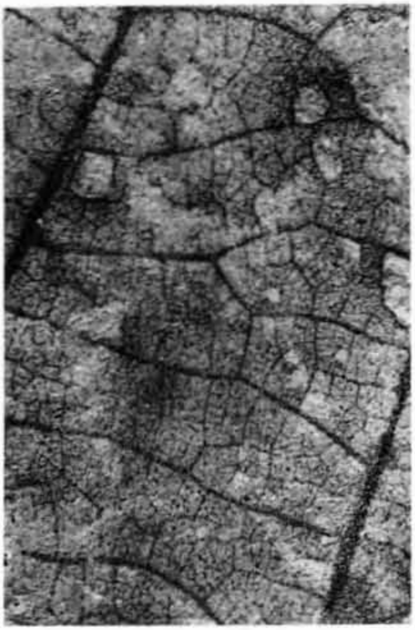

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PLATE 39

1–4. *Plafkeria obliquifolia* (Chaney) Wolfe (p. 108).
   1. UF 10316, Crooked River (loc. 258a).
   2. USNM 458397, Crooked River (loc. 8778a).
   3. UCMP 8, holotype, Crooked River (loc. 3748).
   4. UF 10344a, Crooked River (loc. 258a).


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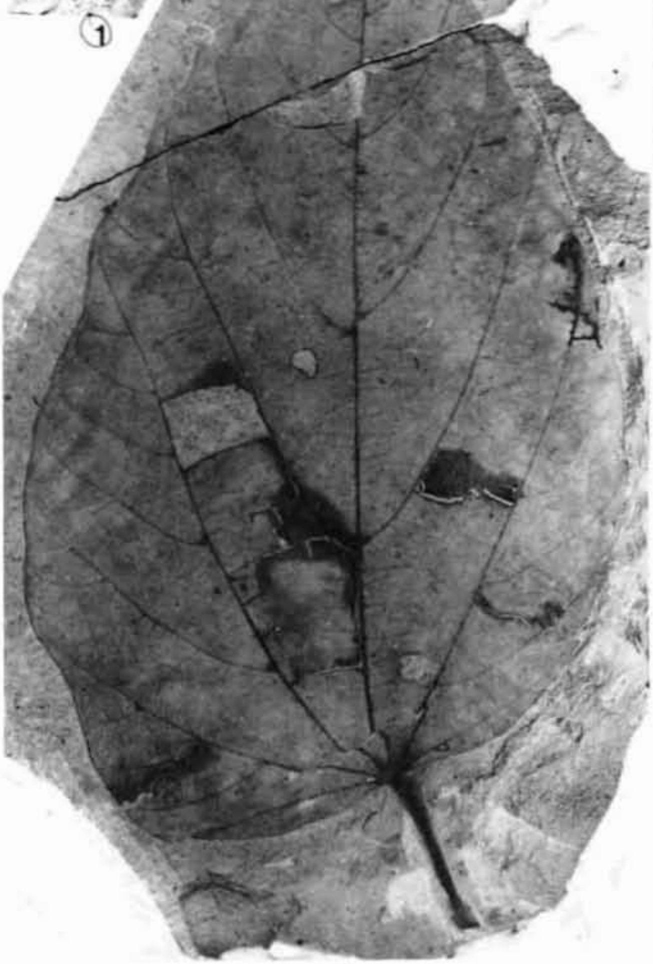
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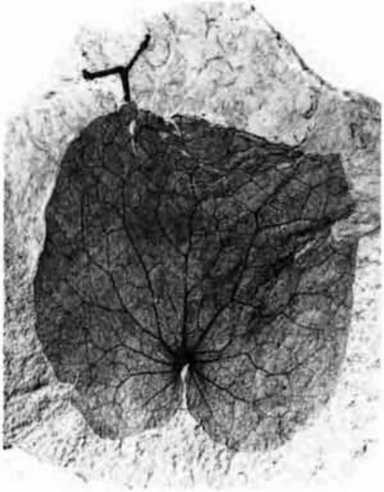
PLATE 40

1, 2. *Tilia circularis* (Chaney) Manchester (p. 110).
  1. UCMP 72, holotype, Crooked River (loc. 3748).
  2. UF 10616, Fossil (loc. 250).

3–6. *Tilia pedunculata* Chaney (p. 111).
  3. UF 10615, Iron Mountain (loc. 241). previously figured Manchester 1991
  4. UCMP 12694, Iron Mountain (loc. 132).
  5. UCMP 12713, Cove Creek (Pentecost Ranch, loc. PA-2).
  6. UCMP 12808, Crooked River (loc. 3748).

7–9. *Craigia oregonensis* (Arnold) Kvaček, Bůžek and Manchester (p. 107).
  7. UCMP 12690, Iron Mountain (loc. P-4210).
  8. UF 7033, Fossil (loc. 250). previously figured Manch & Meyer, 1987
  9. UF 10711, Fossil (loc. 250).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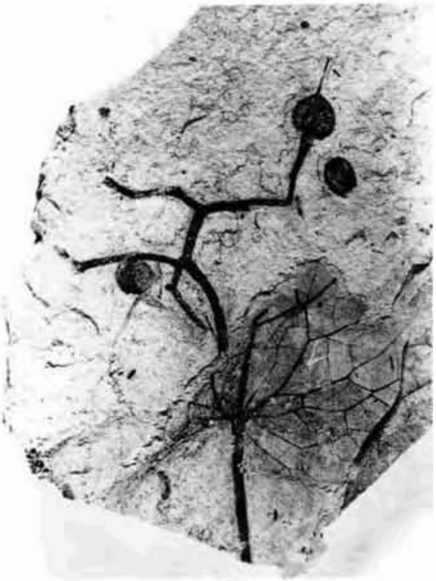
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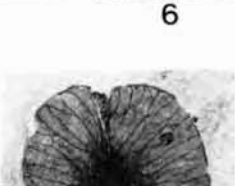
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PLATE 41

1–3. *Tilia aspera* (Newberry) LaMotte (p. 111).
   1. USNM 458399, Painted Hills (loc. 8641).
   2. UCMP 710, Painted Hills.
   3. USNM 458398, Painted Hills (loc. 8641).

4. *Tilia fossilensis* new species (p. 112).
   UF 10612a, paratype, Fossil (loc. 250).

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PLATE 42

1. *Tilia fossilensis* new species (p. 112).
   ↘UF 10376a, holotype, Fossil (loc. 250).

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PLATE 43

1–3. *Tilia fossilensis* new species (p. 112).
  1. Detail from Plate 42, fig. 1, ×3.
  2. UF 10432, paratype, Fossil (loc. 250).
  3. UF 10492, paratype, Fossil (loc. 250), ×0.5.

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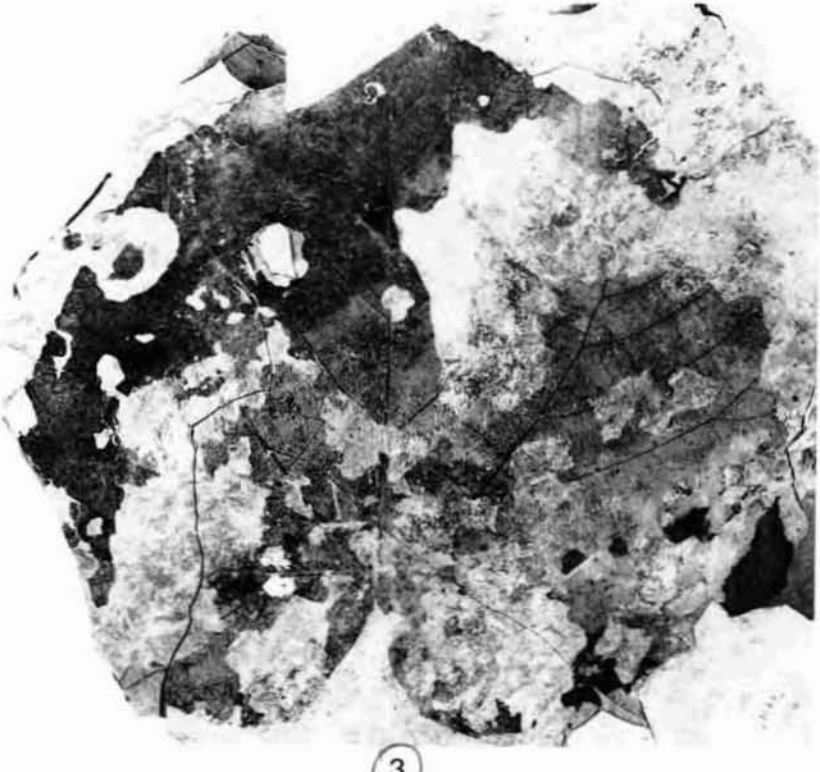

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PLATE 44

1–5. *Tilia lamottei* new species (p. 113).
  1. UCMP 12711a, holotype, Cove Creek (Pentecost Ranch, loc. PA-2)
  2. Detail from fig. 1, ×3.
  3. Detail from fig. 1, ×5.
  4. Detail from fig. 5, ×3.
  5. UF 10491, paratype, Cove Creek (Knox Ranch, loc. 245).

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PLATE 45

1–4. *Florissantia speirii* (Lesquereux) Manchester (p. 114).
  1. UF 7031, Fossil (loc. 250).
  2. UCMP 12691, Cove Creek (Pentecost Ranch, loc. PA-2).
  3. UF 10408, Fossil (loc. 250).
  4. UF 7036, Fossil (loc. 250), ×2.5.

5, 6, 9, 10. *Ribes* sp. (p. 115).
  5. UF 10476, Iron Mountain (loc. 241).
  6. Detail from fig. 5, ×3.
  9. UF 10631, Fossil (loc. 250).
  10. Detail from fig. 9, ×3.

7, 8. *Hydrangea florissantia* Cockerell (p. 115).
  7. UF 10266, Crooked River (loc. 258a).
  8. UCMP 12697, Iron Mountain (loc. 241).

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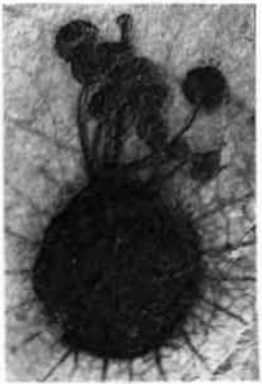

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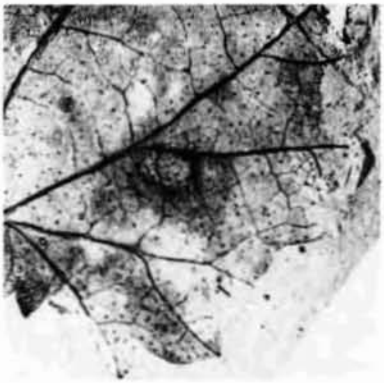

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PLATE 46

1–3. *Amelanchier covea* (Chaney) Chaney and Axelrod (p. 118).
   1. UCMP 89, holotype, Cove Creek (loc. 125).
   2. Detail from fig. 1, ×4.
   3. UCMP 12698, Cove Creek (Pentecost Ranch, loc. PA-2).

4–8. *Amelanchier grayi* Chaney (p. 117).
   4. UF 10325, Crooked River (loc. 258a).
   5. Detail from fig. 4, ×4.
   6. UF 10285a, Crooked River (loc. 258a).
   7. Detail from fig. 6, ×4.
   8. UF 10391a, Iron Mountain (loc. 241).

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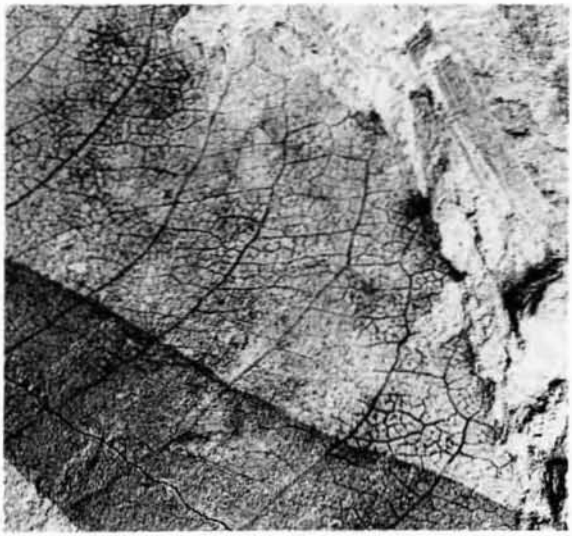

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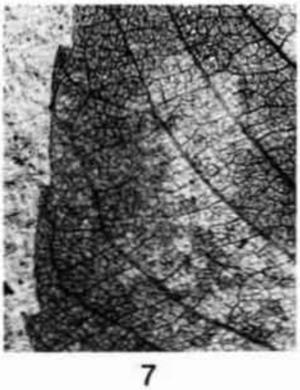

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PLATE 47

1–4, 7–9. *Crataegus merriamii* (Knowlton) new comb. (p. 117).
1. UCMP 2506, holotype, Painted Hills.
2. UCMP 12699, Iron Mountain (loc. P-4210).
3. UCMP 79, Crooked River (loc. 3748).
4. Detail from fig. 3, ×3.
7. UF 10272, Crooked River (loc. 258a).
8. UF 10273, Crooked River (loc. 258a).
9. UF 10397, Fossil (loc. 250).

5, 6, 10, 11. cf. *Malus* or *Pyrus* (p. 119).
5. UCMP 12730, Butler Basin (loc. 3931).
6. Detail from fig. 5, ×4.
10. UF 10395, Fossil (loc. 250).
11. Detail from fig. 10, ×4.

12, 13. cf. *Pyracantha* (p. 119).
12. UF 10396, Fossil (loc. 250).
13. Detail from fig. 12, ×6.


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PLATE 48

1–8. *Rosa hilliae* Lesquereux (p. 120).
    1. USNM 458402, Painted Hills (loc. 8641).
    2. UF 10461, Crooked River (loc. 258a).
    3. UF 10462, Crooked River (loc. 258a).
    4. UF 10271, Crooked River (loc. 258a), ×3.
    5. UF 10284b, Crooked River (loc. 258a).
    6. Detail from fig. 5, ×3.
    7. USNM 458400, Crooked River (loc. 8778a).
    8. Detail from fig. 7, ×3.
9–12. *Rosa* sp. fruit (p. 120).
    9. UCMP 12716, Painted Hills (loc. 3741), ×2.
    10. UF 10458, Iron Mountain (loc. 240), ×2.
    11. UF 10459a, Lost Creek (loc. 243), ×2.
    12. UF 10457, Lost Creek (loc. 244), ×2.
13–14. Rosaceous prickly stems (p. 123).
    13. UF 10277, Crooked River (loc. 258a), ×2.
    14. UF 10278a, Crooked River (loc. 258a), ×2.

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PLATE 49

1, 3. *Rubus ameyeri* new species (p. 121).
    1. UF 10475a, holotype, Iron Mountain (loc. 241).
    3. Detail from fig. 1, ×3.

2, 4. *Rubus fremdii* new species (p. 122).
    2. UF 10460, holotype, Crooked River (loc. 258a).
    4. Detail from fig. 4, ×3.

5. *Rubus* sp. fruit (p. 123).
    UF 10861, Crooked River (loc. 258a).

6. *Cladrastis oregonensis* Brown (p. 124).
    USNM 40008, holotype, Painted Hills.

7. *Cladrastis* sp. (p. 125)
    UF 7024, Fossil (loc. 250).

8–10. *Cercis maurerae* new species (p. 123).
    8. UCMP 12811, paratype, Painted Hills (loc. 3741).
    9. UF 10477b, holotype, Iron Mountain (loc. 241).
    10. USNM 458405, paratype, Crooked River (loc. 8788a).

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PLATE 50

1, 2. *Micropodium ovatum* (Lesquereux) Brown (p. 126).
- 1. UCMP 1766, lectotype, Painted Hills, ×2.
- 2. UCMP 12812, Painted Hills (loc. 3741), ×2.

3–5, 8, 9, 10. Leguminosae leaflet gen. et sp. indet. (p. 126).
- 3. UCMP 12813, Painted Hills (loc. 3741).
- 4. UCMP 12814, Painted Hills (loc. 3741).
- 5. USNM 7090, Painted Hills.
- 8. UCMP 12815, Cove Creek (Pentecost Ranch, loc. PA-2).
- 9. UCMP 12816, Painted Hills (loc. 3741).
- 10. Detail from fig. 9, ×3.

6, 7. cf. *Cladrastis* (p. 125).
- 6. UF 10683, composite image from both counterpart specimens, Fossil (loc. 250).
- 7. Detail from fig. 6, ×3.

11–13. *Decodon brownii* new species (p. 127).
- 11. UF 10386, holotype, Iron Mountain (loc. 241).
- 12. Detail from fig. 11, ×3.
- 13. UF 10564a, paratype, Fossil (loc. 250).

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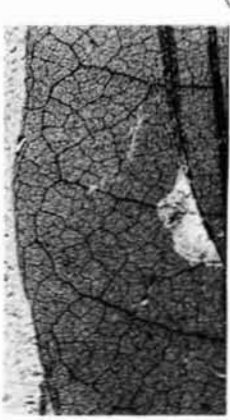

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PLATE 51

1–4. *Terminalia oregona* (Lakhanpal) new comb. (p. 128).
  ✓1. UF 10497a, Fossil (loc. 250).
  ✓2. UF 7032, Fossil (loc. 250).
  3. USNM 42355, Fossil (loc. 9420).
  4. Detail from fig. 2, ×3.

5, 6. *Rhus lesquereuxii* new species (p. 129).
  ✓5. UF 10473a, holotype, Iron Mountain (loc. 241).
  6. Detail from fig. 5, ×3.

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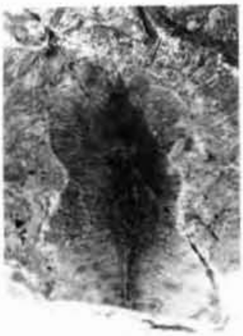

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PLATE 52

1–5. *Rhus lesquereuxii* new species (p. 129).
   1. USNM 42341, Painted Hills (loc. 8641).
   2. Detail from fig. 1, ×3.
   3. UF 10393, paratype, Fossil (loc. 250).
   4. UF 10382, paratype, Fossil (loc. 250).
   5. UF 10383, paratype, Fossil (loc. 250).

6. *Rhus* sp. fruit (p. 129).
   UF 10681, Fossil (loc. 250), ×5.

7. *Toxicodendron wolfei* new species (p. 130).
   UF 10379, holotype, Iron Mountain (loc. 240).

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PLATE 53

1–4. *Toxicodendron wolfei* new species (p. 130).
  1. UF 10385, paratype, Iron Mountain (loc. 241).
  2. Detail from fig. 1, ×3.
  3. UCMP 12702a, paratype, Cove Creek (Pentecost Ranch, loc. PA-2).
  4. Detail from fig. 3, ×3.

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PLATE 54

1, 2, 10. *Cedrela merrillii* (Chaney) Brown, leaves (p. 131).
- 1. UF 10472a, b, composite image from both counterpart specimens, Crooked River (loc. 258a).
- 2. UCMP 94, holotype, Crooked River (loc. 3748).
- 10. Detail from fig. 1, ×3.

3–9, 11, 12. *Cedrela merrillii* (Chaney) Brown, seeds (p. 131).
- 3. UF 7028, Fossil (loc. 250). previously figured Manch. Meyer 1987
- 4. UF 10869, Crooked River (loc. 258a).
- 5. UF 10870, Crooked River (loc. 258a).
- 6. UF 10873, Lost Creek (loc. 243).
- 7. UF 10871, Lost Creek (loc. 243).
- 8. UF 10875, Fossil (loc. 250).
- 9. UF 7029, Fossil (loc. 250). previously figured as above.
- 11. UF 10279, Crooked River (loc. 258a), ×2
- 12. UF 10280, Crooked River (loc. 258a), ×2.

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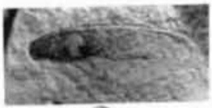

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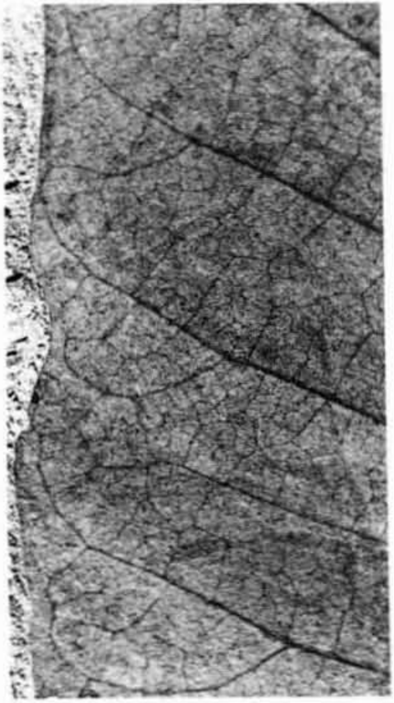

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PLATE 55

1–4. *Acer ashwillii* Wolfe and Tanai (p. 134).
    1. UCMP 9036, holotype, Fossil (loc. PA-15).
    ✓2. UF 10422, Fossil (loc. 250).
    ✓3. UF 10790, Fossil (loc. 250).
    ✓4. UF 10791, Fossil (loc. 250).
5–7. *Acer glabroides* Brown *emend* Wolfe and Tanai (p. 136).
    5. UCMP 108, lectotype, Crooked River (loc. 3748).
    ✓6. UF 10423a Fossil (loc. 250).
    ✓7. UF 10424, Fossil (loc. 250).

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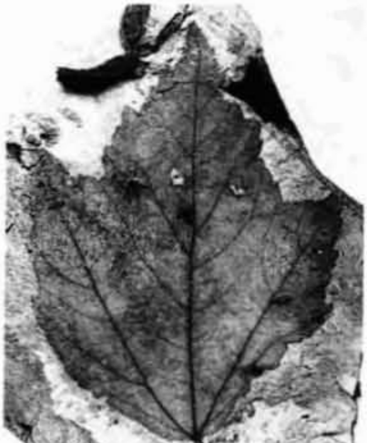

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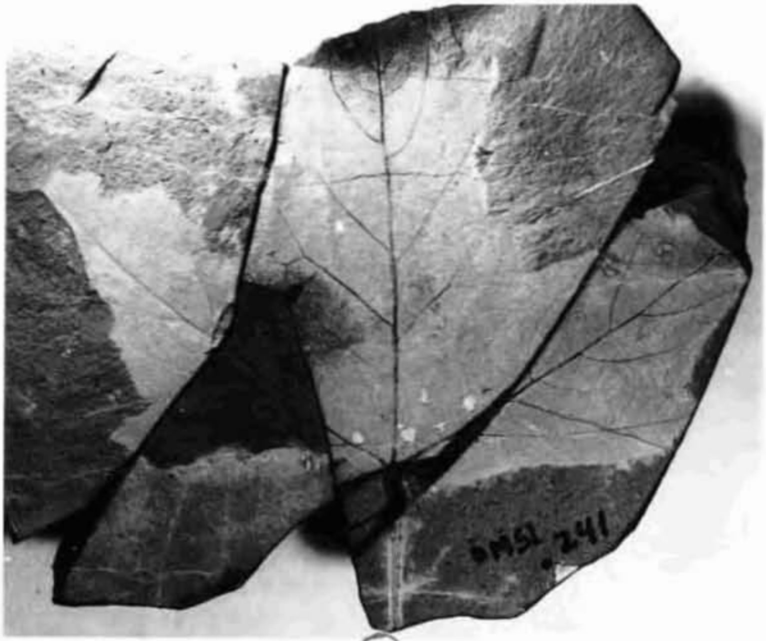
PLATE 56

1–3, 5. *Acer manchesteri* Wolfe and Tanai (p. 137).
  1. UF 10815, Iron Mountain (loc. 241).
  2. UCMP 9210, Iron Mountain (loc. 241).
  3. UCMP 9209, Crooked River (loc. 3927).
  5. UF 10812, Iron Mountain (loc. 241).

4. *Acer kluckingii* Wolfe and Tanai (p. 136).
  UCMP 9109, holotype, Cove Creek (Pentecost Ranch, loc. PA-2).



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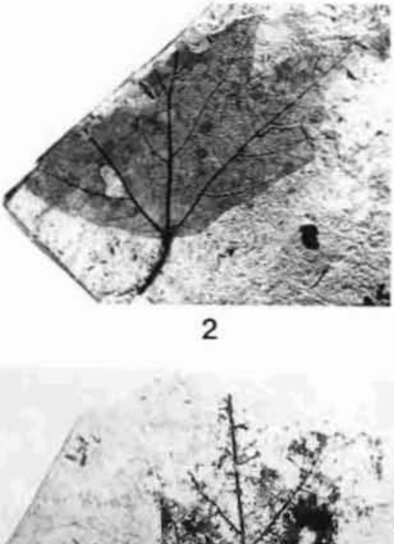

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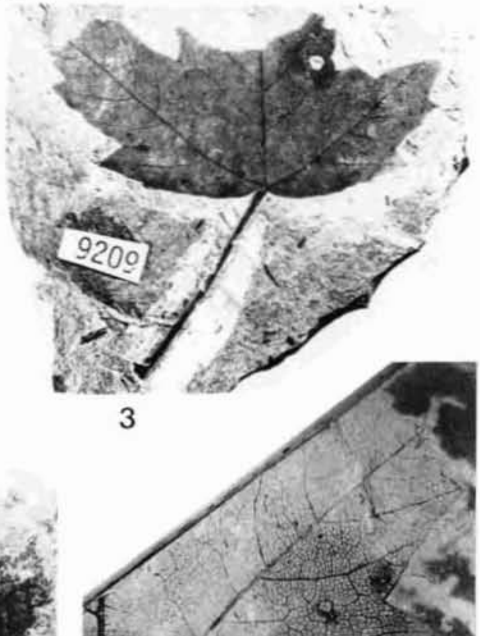

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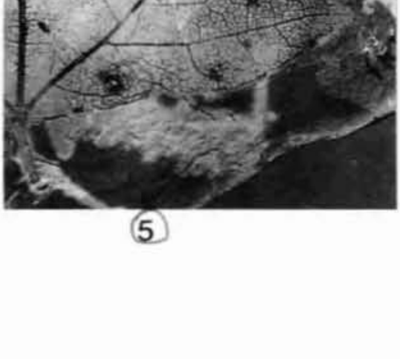

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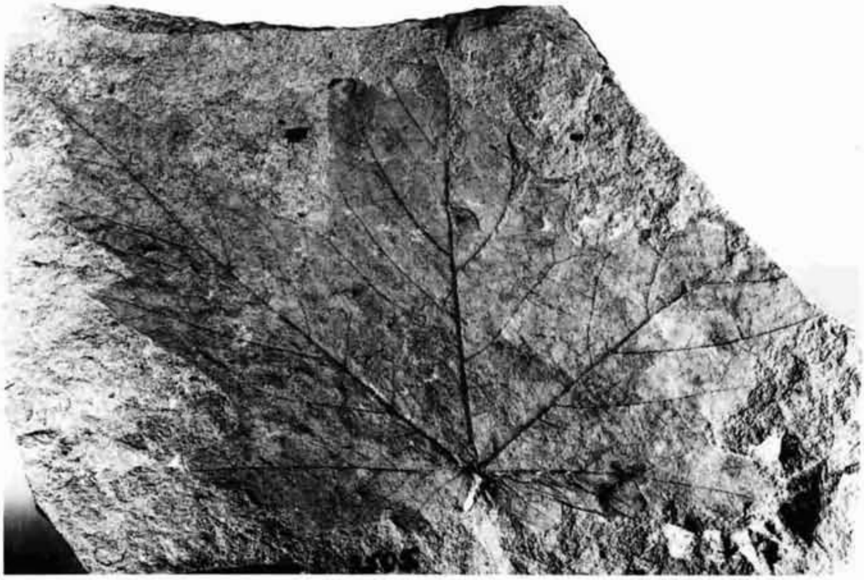
PLATE 57

1, 2. *Acer osmontii* Knowlton (p. 133).
   1. UCMP 2505, holotype, Painted Hills (loc. 3741).
   2. USNM 396154, Cove Creek (Knox Ranch, loc. 9440).



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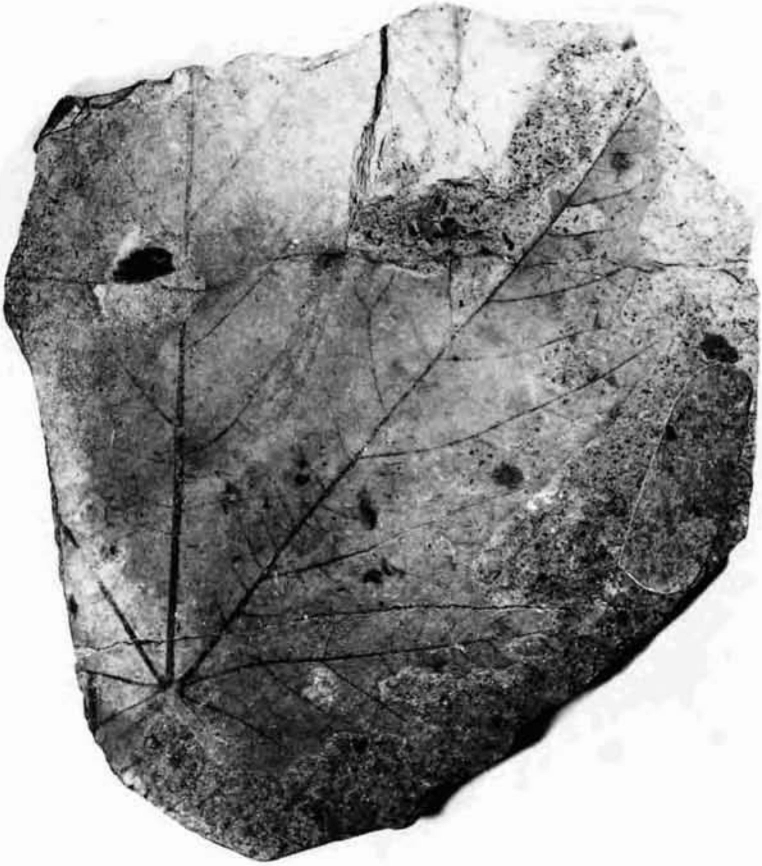

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PLATE 58

1–3. *Acer* sp. 1 (p. 137).
  1. UCMP 9070, Iron Mountain (loc. 132).
  2. UF 10310a, Crooked River (loc. 258a).
  3. UF 10311a, b, composite image from both counterpart specimens, Crooked River (loc. 258a).

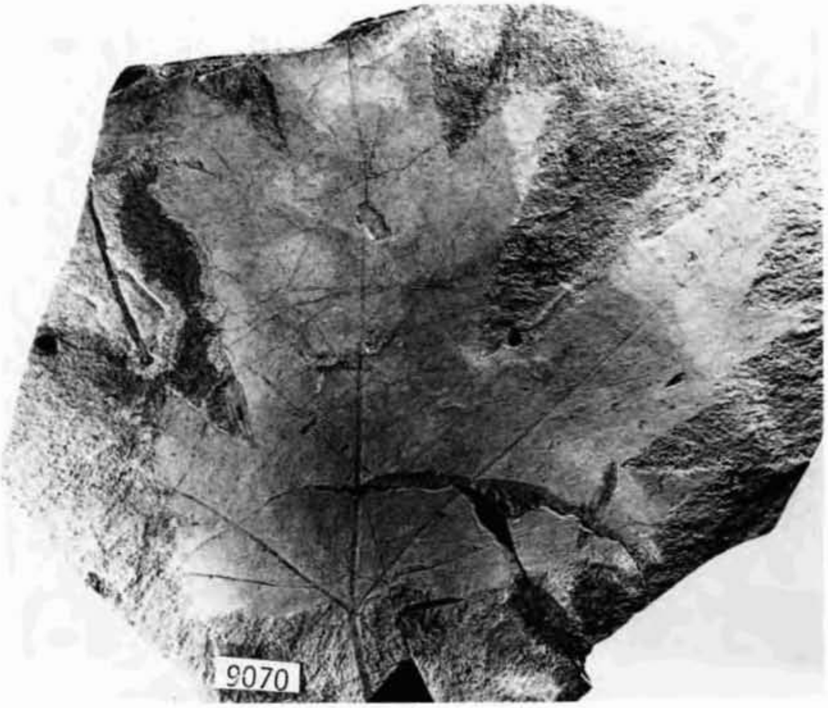

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PLATE 59

1–3. *Acer* sp. 2 (p. 138).
  1. UF 10792, Fossil (loc. 250).
  2. UF 10809, Fossil (loc. 250).
  3. UF 10292b, Crooked River (loc. 258a).

4. *Aesculus* sp. (p. 142).
  UF 10762, Cove Creek (Pentecost Ranch, 246).


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PLATE 60

1, 16. *Acer cranei* Wolfe and Tanai (p. 139).
    1. USNM 396058, Painted Hills (loc. 8641).
    16. UF 10288a, Crooked River (loc. 258a), ×2.

2, 3, 13. *Acer oligomedianum* Wolfe and Tanai (p. 139).
    2. UF 10301, Crooked River (loc. 258a).
    3. UF 10518, Crooked River (loc. 258a).
    13. USNM 396076, holotype, Crooked River (loc. 8778a), ×2.

4–6, 15. *Acer* sp. A (p. 140).
    4. UCMP 9035, Iron Mountain (loc. 241).
    5. UF 10610, Fossil (loc. 250).
    6. UCMP 9115, Cove Creek (Pentecost Ranch, loc. PA-2).
    15. UF 10609, Fossil (loc. 250), ×2.

7, 8, 17. *Acer* sp. B (p. 140).
    7. UF 10617, Iron Mountain (loc. 240).
    8. UF 10632, Crooked River (loc. 258a).
    17. UF 10287a, Crooked River (loc. 258a), ×2.

9, 14. *Acer* sp. C (p. 141).
    9. UF 10620, Lost Creek (loc. 243a).
    14. UF 7026, Fossil (loc. 250), ×2.

10–12. *Acer osmontii* Knowlton (p. 133).
    10. UCMP 9135, Cove Creek (Pentecost Ranch, loc. PA-2).
    11. UCMP 12720, Painted Hills (loc. 3741).
    12. UF 10627a, Cove Creek (Knox Ranch, loc. 245).

18. *Dipteronia* sp. (p. 142).
    USNM 42351, Painted Hills (loc. 8641).

19. *Dipteronia sinensis* Oliver, modern fruit (p. 143).
    Western Szechuan, China (Arnold Herbarium: E. H. Wilson 883).


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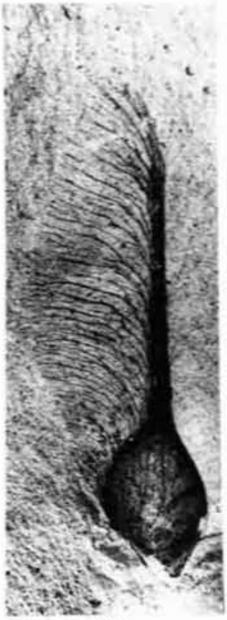
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PLATE 61

1, 4. *Cornus* sp. (p. 143).
    1. UCMP 12705a, Cove Creek (Pentecost Ranch, loc. PA-2).
    4. USNM 458406, Butler Basin (loc. 6881).

2, 3. *Aucuba smileyi* new species (p. 144).
    2. UF 10478, holotype, Iron Mountain (loc. 240).
    3. Detail from fig. 2, ×3.

5, 7, 8. *Paliurus blakei* (Chaney) new comb. (p. 145).
    5. USNM 458408, Crooked River (loc. 8778).
    7. UCMP 95, holotype, Crooked River (loc. 3929).
    8. Detail from fig. 7, ×3.

6. *Palaeophytocrene* sp. (p. 145).
    UF 10400a, Iron Mountain (loc. 240).


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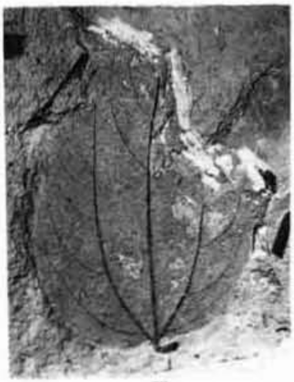
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PLATE 62

1–4. *Hovenia oregonensis* new species (p. 146).
    1. UCMP 97, paratype, Crooked River (loc. 3748).
    2. UF 10371b, paratype, Lost Creek (loc. 243a).
    3. UF 10359, holotype, Fossil (loc. 250).
    4. Detail from fig. 3, ×4.

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PLATE 63

1. *Vitis* sp. seed (p. 147).
    USNM 42356, Crooked River (loc. 8778a), ×3.

2, 6, 7. *Diplodipelta reniptera* (Becker) Manchester and Donoghue (p. 148).
    2. UF 10464, Crooked River (loc. 258a), ×2.
    6. UF 10465, Crooked River (loc. 258a), ×2.
    7. UCMP 12717b, Crooked River (loc. 3748), ×2.

3. *Dipelta ventricosa* Hemsley, modern fruit (p. 149).
    W. P. Fang 17307, Mt. Omei, Szechuan, China.

4, 5. *Fraxinus* sp. (p. 149).
    4. UF 10545, Fossil (loc. 250), ×2.
    5. UF 10546, Fossil (loc. 250), ×2.

8–10. *Pinckneya dilcheri* new species (p. 149).
    8. UF 10642a, paratype, Crooked River (loc. 258), ×6.
    9. UF 10643, paratype, Crooked River (loc. 258), ×6.
    10. UF 10644, holotype, Crooked River (loc. 258), ×6.

11. *Pinckneya pubens* Michx., modern seed (p. 149).
    Engelmann s.n., Georgia, U.S.A., ×6.

12–14. *Catalpa* sp. (p. 150).
    12. USNM 458378, Crooked River (loc. 8778), ×4.
    13. USNM 458379, Crooked River (loc. 8778a), ×4.
    14. UF 10570, Crooked River (loc. 258a), ×6.

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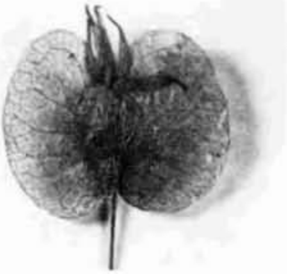

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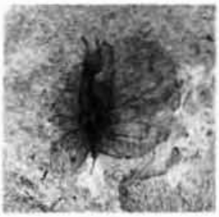

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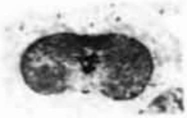

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PLATE 64

1, 2. Unknown dicot species 1 (p. 150).
  1. UCMP 12818, Crooked River (loc. 3748).
  2. Detail from fig. 1, ×3.

3, 4. Unknown dicot species 2 (p. 151).
  3. UF 7027, Fossil (loc. 250).
  4. Detail from fig. 3, ×3.

5. Unknown dicot species 3 (p. 151).
  UF 10826, Fossil (loc. 250).

6. Unknown dicot species 4 (p. 151).
  UCMP 12819, Painted Hills (loc. 3741-1).

7. Unknown dicot species 5 (p. 151).
  UF 10427a, Iron Mountain (loc. 241).

8, 9. Unknown dicot species 6 (p. 151).
  8. UCMP 12820, Painted Hills (loc. PA-417).
  9. Detail from fig. 8, ×3.


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PLATE 65

1, 2. Unknown dicot species 7 (p. 152).
  1. UF 10368, Fossil (loc. 250).
  2. Detail from fig. 1, ×4.

3. Unknown dicot species 8 (p. 152).
  UF 10827, Fossil (loc. 250).

4, 5. Unknown dicot species 9 (p. 152).
  4. USNM 42377, Crooked River (loc. 8778a).
  5. Detail from fig. 4, ×3.

6. Unknown dicot species 10 (p. 152).
  UCMP 12822, Lost Creek (loc. 3750).

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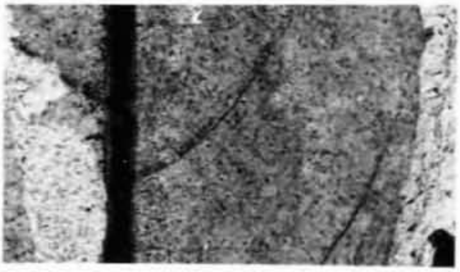

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PLATE 66

1–4. Unknown dicot species 11 (p. 152).
  1. USNM 8486, Painted Hills.
  2. Detail from fig. 1, ×3.
  3. UCMP 12823, Painted Hills (loc. 3741).
  4. UCMP 12824, Iron Mountain (loc. P-4210).

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PLATE 67

1, 2. Unknown dicot species 12 (p. 153).
  1. UF 10322, Crooked River (loc. 258a).
  2. Detail from fig. 1, ×3.

3. Unknown dicot species 13 (p. 153).
  UF 10773, Cove Creek (loc. 247).

4. Unknown dicot species 14 (p. 153).
  UF 10825, Iron Mountain (loc. 241).

5, 6. Unknown dicot species 15 (p. 153).
  5. UF 10527, Fossil (loc. 250).
  6. UF 10526, Fossil (loc. 250).

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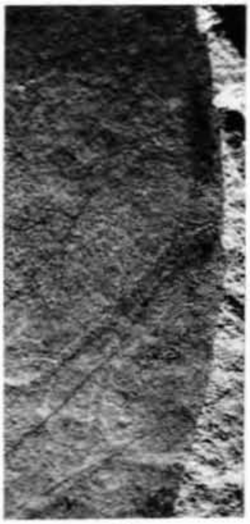

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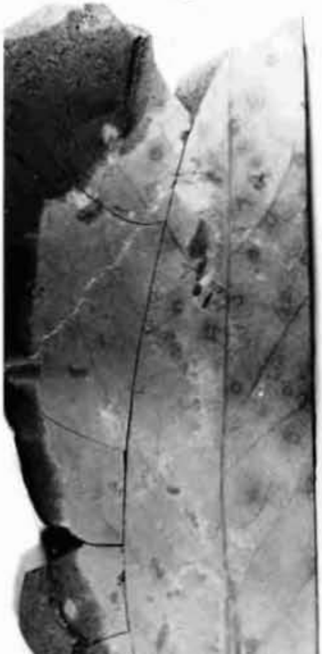

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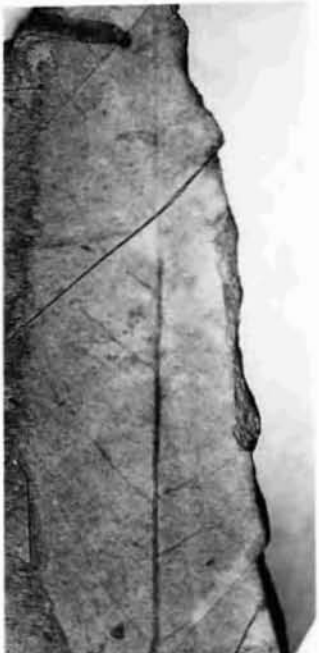

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PLATE 68

1, 2. Unknown dicot species 16 (p. 154).
  1. UF 10363a, Fossil (loc. 250).
  2. Detail from fig. 1, ×3.

3, 4. Unknown dicot species 17 (p. 154).
  3. UF 10467, Fossil (loc. 250).
  4. Detail from fig. 3, ×3.

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PLATE 69

1\. Unknown dicot species 18 (p. 154).
    UF 10579b, Fossil (loc. 250).
2, 3. Unknown dicot species 19 (p. 154).
    2. UF 10327, Crooked River (loc. 258a).
    3. Detail from fig. 2, ×3.
4\. Unknown dicot species 20 (p. 154).
    UF 10728, Iron Mountain (loc. 240).
5, 6. Unknown dicot species 21 (p. 156).
    5. USNM 458411, Crooked River (loc. 8778a).
    6. Detail from fig. 5, ×3.
7\. Unknown dicot species 22 (p. 155).
    UF 10265, Crooked River (loc. 258a).

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PLATE 70

1, 2. Unknown dicot species 23 (p. 155).
  1. UCMP 21, Crooked River (loc. 3728).
  2. Detail from fig. 1, ×3.

3. Unknown dicot species 24 (p. 155).
  UF 10578a, Lost Creek (loc. 243a).

4, 7. Unknown dicot species 25 (p. 155).
  4. UF 10372a, Fossil (loc. 250).
  7. Detail from fig. 4, ×3.

5, 6. Unknown dicot species 26 (p. 156).
  5. UF 10326, Crooked River (loc. 258a).
  6. Detail from fig. 5, ×3.


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PLATE 71

1, 2. Unknown dicot species 27 (p. 156).
    1. USNM 458403, Cove Creek (loc. 9440).
    2. UF 10828, Fossil (loc. 250).

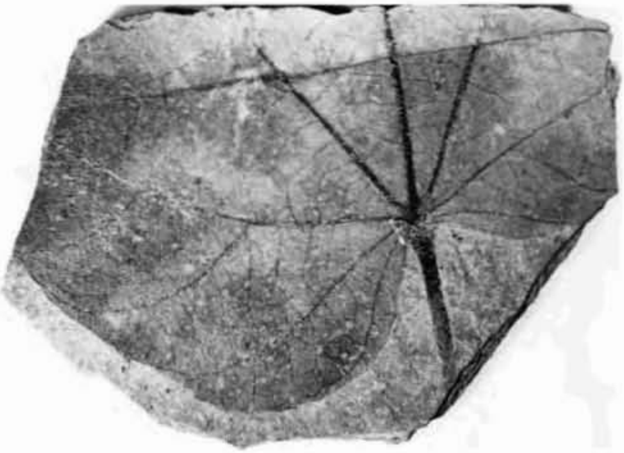

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PLATE 72

1, 2. Unknown dicot species 28 (p. 156).
    1. UCMP 12825, Butler Basin (loc. P-4211).
    2. Detail from fig. 1, ×3.

3. Unknown dicot species 29 (p. 156).
    UF 10394a, Fossil (loc. 250).

4. Unknown dicot species 30 (p. 156).
    UF 10525, Iron Mountain (loc. 241).

5. Unknown dicot species 31 (p. 157).
    UF 10823, Fossil (loc. 250).

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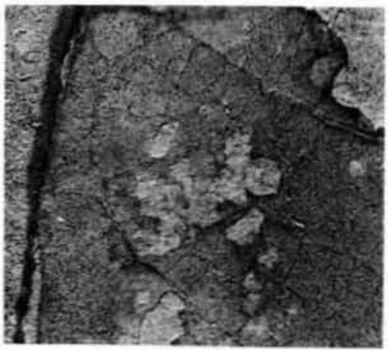

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PLATE 73

1–3. *Typhoides buzekii* new genus and species (p. 159).
  1. UF 10725, paratype, Lost Creek (loc. 243A).
  2. UF 10724, holotype, Iron Mountain (loc. 241).
  3. Detail from fig. 2, ×2.

4, 6. *Zingiberopsis* sp. (p. 157).
  4. UF 10374, Iron Mountain (loc. 241).
  6. Detail from fig. 4, ×3.

5. Unknown monocot leaf (p. 159).
  UCMP 9313, Fossil (loc. P-5203).


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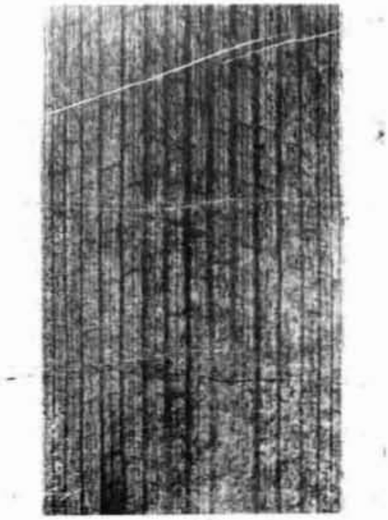
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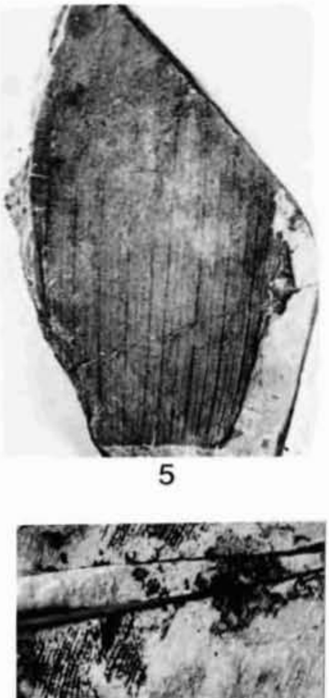
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PLATE 74

1–8. *Beckerosperma ovalicarpa* (Becker) new comb. (p. 160).
    1. UF 10669, Fossil (loc. 250).
    2. UF 10668a, Fossil (loc. 250).
    3. UF 10665, Fossil (loc. 250).
    4. UF 10676, Lost Creek (loc. 244).
    5. UF 7034, Fossil (loc. 250).
    6. UF 10654a, Fossil (loc. 250).
    7. UF 10655a, Fossil (loc. 250).
    8. Detail from fig. 6, ×3
9–13. *Potanospira fryi* new species (p. 161).
    9. UF 10572, paratype, Crooked River (loc. 258a).
    10. UF 10331a, paratype, Crooked River (loc. 258a).
    11. UF 10332, holotype, Crooked River (loc. 258a), ×3.
    12. Detail from fig. 10, ×3.
    13. UF 10574, paratype, Fossil (loc. 250)
14–20. *Saportaspermum occidentalis* new genus and species (p. 161).
    14. UF 10866a, paratype, Fossil (loc. 250).
    15. UF 10639, paratype, Fossil (loc. 250).
    16. UF 10868, paratype, Lost Creek (loc. 244).
    17. UF 10867, paratype, Crooked River (loc. 258a).
    18. UF 10640, paratype, Iron Mountain (loc. 241).
    19. UF 10638, holotype, Fossil (loc. 250).
    20. Detail from fig. 19, ×3
21, 22. Unknown fruit sp. A (p. 162).
    21. UCMP 12718a, Crooked River (loc. 3748), ×2.
    22. UCMP 12719, Crooked River (loc. 3748), ×3
23. Unknown fruit sp. B (p. 162).
    UF 10348a, Crooked River (loc. 258a), ×2.


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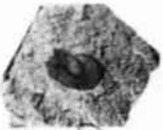
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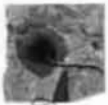
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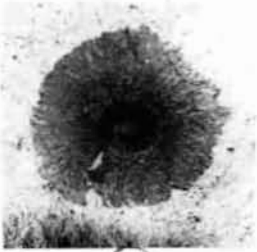
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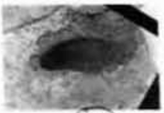
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PLATE 75

1–5. Unknown fruit sp. C (p. 162).
  1. UF 10864a, Crooked River (loc. 258a).
  2. UF 10863b, Crooked River (loc. 258a).
  3. UF 10645a, Crooked River (loc. 258a). Fruit attached to twig.
  4. UF 10645a, Crooked River (loc. 258a). Two fruits from same specimen as in fig. 3.
  5. Detail from fig. 4, ×2.

6. Unknown fruit sp. D (p. 163).
  UF 10347a, Crooked River (loc. 258a).

7. Unknown fruit sp. E (p. 163).
  UF 10641, Iron Mountain (loc. 240), ×2

8–10. cf. *Nuphar* (p. 70).
  8. UF 10885, Pentecost (loc. 246). Closely associated seeds.
  9. UF 10584, Fossil (loc. 250). Closely associated seeds and stigmatic disk.
  10. Detail from fig. 9, ×2.


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