Oligocene fossil plants of the John Day Formation, Fossil, Oregon

by Steven R. Manchester, Department of Geology, Indiana University, Bloomington, Indiana 47405, and Herbert W. Meyer, Museum of Paleontology, University of California, Berkeley, California 94720

ABSTRACT

Fossil plants from an exposure of John Day Formation in Fossil, Oregon, are identified and discussed in relation to vegetational and climatic interpretations of the Bridge Creek flora. The assemblage includes about 35 species, most of which belong to genera that are no longer native to the Pacific Northwest. Some of the genera are extinct, but most survive today in eastern Asia and/or eastern North America. The flora is dominated by broad-leaved deciduous elements such as alder, maple, beech, and an extinct hornbeam but also includes conifers such as dawn redwood and pine. The flora appears to represent a deciduous hardwood forest comparable in stature to the Mixed Northern Hardwood forest living today in eastern Asia. This suggests a climate somewhat cooler than that proposed for other localities of the Bridge Creek flora.

INTRODUCTION

One of the most readily accessible and well-collected fossil-plant localities in Oregon is located within the John Day Formation in the town of Fossil (Figure 1). The fossil beds were exposed during the construction of Wheeler High School in 1949 and are still accessible at the north end of the athletic field (SW¼NW¼ sec. 33, T. 6 S., R. 21 E., Wheeler County). Although the locality has been collected by amateurs and professionals on a continuing basis for more than 35 years, relatively little information has been published on the types of fossils that are preserved and on the nature of the forest that left this record. Brown (1959) illustrated and briefly discussed the remains of an unidentified bat from this site along with plants from this and other sites in the lower part of the John Day Formation. Naylor (1979) described a species of salamander (*Taricha lindoei*) from Fossil. The present paper reviews the geologic setting and approximate age of the locality and focuses on the taxonomic identity of plant specimens from the locality at Fossil in order to provide insight into the kind of forest represented and its relationship to other paleofloras of the John Day region.

The fossil flora and fauna of the John Day Formation have attracted interest for more than a century. The town of Fossil received its name in reference to fossil remains found on what is now Hoover Creek, where the original Fossil post office was established in 1876, prior to the incorporation of the community at its present location in 1891 (Steiwer, 1975). The first descriptions of fossil plants from the John Day Formation were published by Newberry (1883, 1898), based upon specimens collected by Rev. Thomas Condon in thc 1860's from the classic locality on Bridge Creek (also referred to as Wade's Ranch and Allen's Ranch; Chaney, 1948a). The Bridge Creek locality, which also provided specimens described by Knowlton (1902), is located about 25 miles south of Fossil and is now protected as part of the John Day Fossil Beds National Monument (Painted Hills Unit; Figure 1).

Fossil leaf beds have been discovered at widely scattered locations in the lower part of the John Day Formation in north-central Oregon and have been broadly referred to as the Bridge Creek flora (Chaney, 1952; Wolfe and Tanai, 1987), although the extent of their similarity in age and species composition to the classic Bridge Creek locality remains to be documented. Chaney (1927) published the most complete analysis of the flora, focusing on localities in the Crooked River basin. More recently, Ashwill (1983) called attention to related fossil plant localities on Gray Butte in the lower part of the Crooked River basin.

In the years that have elapsed since the most recent overall treatment of the Bridge Creek flora (Chaney, 1927), approaches to the identification of fossil plants have changed considerably, resulting in more reliable determinations based on detailed studies of leaf, fruit, and flower morphology. Individual species of the Bridge Creek flora have been periodically revised (Brown, 1939, 1946, 1959; Tanai and Wolfe, 1977; Wolfe, 1977; Manchester and Crane, 1987; Wolfe and Tanai, 1987), but a complete revision of the flora has not been done. To the extent possible in a paper of this length, we attempt to provide an update on the identity of Bridge Creek taxa through critical evaluation of the systematic affinities of the species known from the locality at Fossil. An interpretation of the type of vegetation and climate represented by the flora as well as theories regarding its origin are also presented.

Although the classic Bridge Creek locality is now closed to casual collecting, new specimens are continually collected at Fossil, and we expect that this account of the flora may appear incomplete as the investigation of newly recovered material proceeds and as private collectors share some of their finds with the scientific community. By illustrating the common elements of the flora, we hope to aid casual collectors in determining when they may have found something new or unusual.

GEOLOGIC SETTING

The fossil locality occurs in bedded lacustrine tuffs (i.e., lake-deposited volcanic ash) of the John Day Formation. The John Day Formation is exposed over an extensive area in north-central Oregon and generally lies above the Clarno Formation of Eocene age and below the Miocene Columbia River Basalt Group. It ranges in age from Oligocene to early Miocene with radiometric dates from 37 to 19 million years (m.y.). In general, the fossil-leaf-bearing horizons of the formation are early Oligocene in age (as per the chronology of Berggren and others, 1985) and occur stratigraphically below the succession of late Oligocene to Miocene beds that produce the well-known John Day vertebrate faunas (Woodburne and Robinson, 1977).

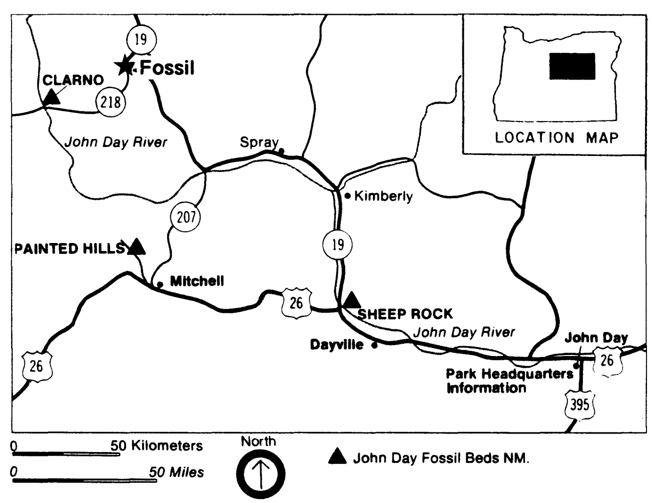

Figure 1. Index map showing location of Fossil in relation to John Day Fossil Beds National Monument.

Rocks comprising the John Day Formation were derived from at least three separate source areas, each producing lithologies of a particular composition (Robinson and Brem, 1981). Rhyolitic ash-flow tuffs and lava flows were erupted from volcanic vents east of the present-day Cascade Range, along the western margin of the John Day Formation outcrop area. Basalt and trachyandesite flows were derived from local sources near their outcrop areas. Dacitic to andesitic air-fall material is abundant and widespread throughout the formation and is believed to have originated from volcanism in the area of the Western Cascade Range during the early formation of these mountains. This air-fall material includes volcanic ash that was important in the preservation of plant and animal remains. The most informative paleobotanical localities, such as the one at Fossil, represent lake basins into which ash was redeposited along with plant debris from the surrounding forest.

Based on differences in thickness and upon the distribution of ash-flow sheets, the John Day Formation has been divided into three geographically separate but lithologically similar facies (Robinson and others, 1984), which suggest that the Blue Mountains formed a topographic barrier that separated different basins of deposition. Each of these facies contains important fossil plant horizons in its lower part. The western facies includes the locality at Fossil and those of Cove Creek and Dugout Gulch (data for these localities in Chaney, 1927), Knox Ranch (Arnold, 1952), and Gray Butte (Ashwill, 1983; McFadden, 1986). The eastern facies includes the fossil plant localities at Bridge Creek, Cant Ranch, and Twickenham (Chaney, 1948a). The southern facies, situated south of the Ochoco Mountains, includes localities along the Crooked River referred to as Gray Ranch and Post (Chaney, 1927).

The vicinity surrounding the John Day locality in Fossil is mapped as Clarno Formation (Robinson, 1975), but the stratigraphic relationship of the fossil outcrop to other units of the John Day Formation needs further study. Although radiometric dates are not available from the immediate vicinity of Fossil, the floral assemblage is similar to, and may be approximately contemporaneous with, the classic locality at Bridge Creek, which is radiometrically dated at 31.8 and 32.3 m.y. (Evernden and others, 1964; corrected to new constant). Other localities of similar lithologic and floral character (Pentecost Ranch, Cove Creek, Knox Ranch, and Dugout Gulch) occur between the basalts of members b and f (Robinson, 1975) of the John Day Formation northeast of Clarno, and a radiometric date for the base of the overlying member g is 30.4 m.y. (Woodburne and Robinson, 1977; new constant).

FOSSIL PLANTS

The fossils are preserved as impressions and carbonaceous compressions in laminated to massive tuff. In addition to the remains of leaves, the deposit contains abundant fruits, cones, seeds, and occasional flowers. Specimens are recovered either by examining surface material or by breaking the rock parallel to the bedding plane with hammer and chisel. Because the rock has many vertical fracture planes, some of the larger leaves can be collected only by carefully removing and gluing together adjacent pieces of rock as they are exposed in the bedding plane. The matrix is often soft, and the delicate impressions are easily damaged; therefore it is important to wrap the specimens carefully before transporting them.

Our analysis of the flora is based upon collections at the University of California Museum of Paleontology (UCMP) and upon collections at Indiana University (IU) that we made during the summer of 1986. Based on these collections, the assemblage from Fossil includes about 35 species, including a fern, three conifers, a monocotyledon, and about 30 dicotyledons; a few of which remain unidentified. The specimens in Figures 2 to 6 are all from the locality at Fossil and are illustrated actual size (1 X) unless otherwise indicated. Captions for Figures 2 to 6 include the UCMP and IU specimen numbers. The most abundant fossils at the locality are leaves of *Metasequoia* (Figure 2D), *Alnus* (Figures 5A,B), and *Paracarpinus* (Figure 5E) and fruits of *Acer* (Figures 6F,G) and *Pteleaecarpum* (Figures 6L,M). Authors of species are presented in Table 1, and the following discussion is arranged according to the sequence of genera also presented in Table 1.

Lower vascular plants are uncommon in the flora. Only one fern has been recognized, based upon a single specimen (Figure 2A) of a fertile entire-margined pinnule showing two rows of circular sori and a strong midvein. Sporangia and spores are not preserved, but the arrangement of the sori is similar to that in some living species of *Polypodium.* This species has not been observed in other localities of the John Day Formation, although one other fern was described as *Pteris silvicola* from Gray Ranch (Chaney, 1927).

Conifers in the Fossil assemblage include *Abies* (fir), *Pinus* (pine), and *Metasequoia* (dawn redwood). Foliage of *Metasequoia* is common at this locality (Figure 2D), especially as isolated needles, and both seed (Figure 2B) and pollen cones (Figure 2C) also occur. From a historical standpoint, *Metasequoia* is one of the most interesting plants found at this locality. *Metasequoia* differs from *Sequoia* (the redwood of the California coast) by having deciduous rather than evergreen foliage and in having needles that arise opposite one another rather than alternate along the axis. For many years, however, these differences were not recognized, and most specimens from the Bridge Creek flora were identified as *Sequoia. Metasequoia* was first described by Miki (1941), based upon fossils from Japan. Subsequent to Miki's description, living trees of *Metasequoia* were found surviving in central China (Hu and Cheng, 1948). Chaney (1951) reexamined the fossils from Bridge Creek and other western American Tertiary floras and reassigned many to *Metasequoia occidentalis.*

Abies is represented by a cone scale (Figure 2E). *Pinus* is represented by leaves with five needles per fascicle (Figure 2I), occasional seed cones (Figure 2J), pollen cones (Figure 2F), and isolated seeds showing the disarticulation between the seed body and wing (Figures 2G,H). This is the same species that Mason (1927) recorded from Cove Creek and attributed to *P. torreyana.* However, *P. torreyana* is a living species with large, edible seeds unlike those of the fossil. The precise position of this fossil species with respect to living pines remains to be determined.

Only one definite monocotyledonous leaf has been recovered from Fossil (Figure 3A). Although incomplete, it shows parallel venation similar to that of *Canna,* with thick veins alternating with two orders of thinner parallel veins. Most of the other leaves in the assemblage have net-venation typical of dicotyledons.

Mahonia simplex, which belongs to the same genus as Oregon grape, is uncommon in the assemblage but is easily recognized by its asymmetrical, spiny leaflets (Figure 3G). The palmate venation of the leaflets of this fossil species is shared by living Asian species of *Mahonia* and by a single living American species (*M. nervosa;* Schorn, 1966). This species occurs at most localities of the Bridge Creek flora.

Cercidiphyllum (katsura tree), which is presently native to eastern Asia, was first recorded from the Bridge Creek flora by Brown (1935). The leaves, *Cercidiphyllum crenatum* (Figure 3C), are elliptical to ovate with palmate venation and fine glandular teeth. *Cercidiphyllum* fruits (Figure 3D), which appear as clusters of small, slender "pods," are also present at the locality and probably represent the same species as the leaves. However, because a positive link between the fruits and foliage has not been proven by actual attachment, the fruits have been assigned to a separate species for fruits, *C. helveticum* (Jähnichen and others, 1980). These leaves and fruits are essentially identical to those recorded from the Oligocene to Pliocene of Europe (Jähnichen and others, 1980) and are very similar to those of the two modern species. Specimens from the Bridge Creek flora are among the earliest known that correspond precisely to the modern genus. Most of the Paleocene and Eocene remains formerly attributed to *Cercidiphyllum* (Brown, 1939) are now considered to represent related extinct genera (Crane and Stockey, 1985).

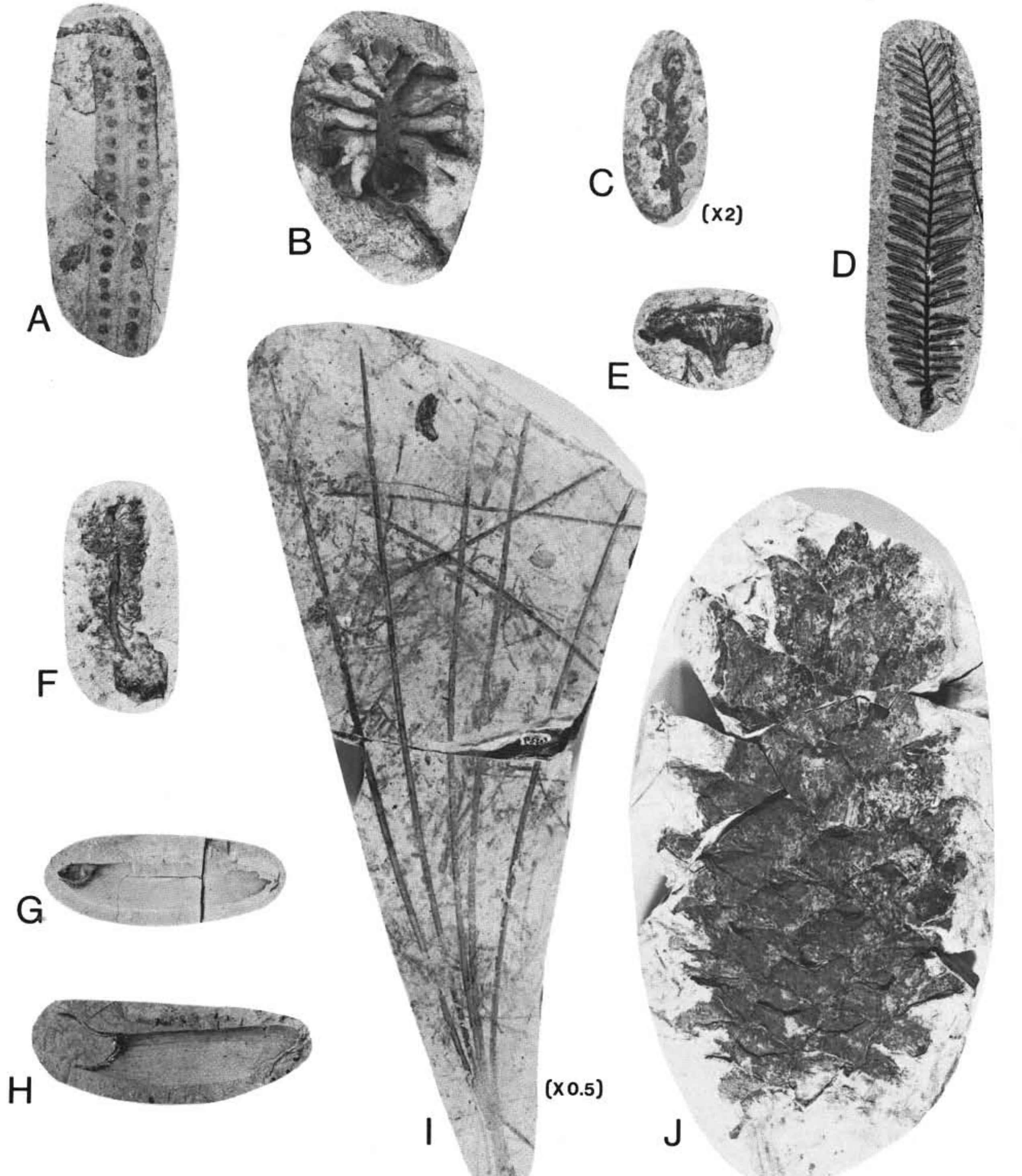

Figure 2. A. Fern pinnule similar to that of Polypodium, *UCMP9310. B.-D.* Metasequoia occidentalis *(dawn redwood). B. Seed cone, IU6988. C. Pollen cone, UCMP9311. D. Branchlet showing opposite arrangement of needles, IU6990. E. Cone scale of* Abies *(fir), IU6991. F.-J.* Pinus *sp. (pine). F. Pollen cone, UCMP9312. G. Winged seed, IU6993. H. Seed showing disarticulation of seed body from wing, IU6994. I. Fascicle of five needles, UCMP9316. J. Seed cone, IU6996.*

The Platanaceae (sycamore family) are represented by two distinct kinds of leaves in the assemblage. Leaves of *Platanus aspera* are common at Fossil and have three broad lobes with numerous prominent teeth, giving the margin a scalloped appearance (Figure 3B). *Platanus aspera* was first recognized from the Bridge Creek locality (Newberry, 1898). Although La Motte (1936) transferred the species to *Tilia,* our specimens show that the species has an inflated petiole base. This and characters of the teeth and venation support Newberry's original assignment. *Platanus condoni* (Figure 3H) includes the largest leaves known from the locality, some measuring up to 40 cm in length. The leaves of this species are fan shaped with five lobes; teeth are infrequent or absent. These leaves are similar in general plan to the leaves of the extinct genus *Macginitiea* (Manchester, 1986; Wolfe and Wehr, 1987), and more detailed study of a larger number of specimens is needed to determine the more appropriate generic position of this species. The Platanaceae are also represented by globose fruiting heads (Figure 3E) and numerous isolated fruitlets (Figure 3F).

Leaves resembling those of *Morus* and *Broussonetia* in the Moraceae (mulberry family) are occasionally recovered (Figure 4A). They are broad and asymmetrical with a finely serrate margin. A pair of strong ascending secondary veins arises from the base of the lamina and gives off evenly spaced tertiary veins that form regular loops near the margin. This kind of leaf has not been reported previously from the Bridge Creek flora.

Two species of the Ulmaceae (elm family) are present, one belonging to a living genus *(Ulmus)* and the other to an extinct genus *(Tremophyllum).* The leaves of *Ulmus pseudo-americana* (elm) are distinguished from other leaves at Fossil by the combination of straight, parallel secondary veins, compound teeth, an asymmetrical base, and a stout petiole (Figure 4B). This species is described in detail from other localities of the Bridge Creek flora by Tanai and Wolfe (1977). Oddly, the distinctive winged fruits of *Ulmus* are not known from Fossil; the only John Day locality from which an elm fruit is known is Gray Ranch. Reexamination of specimens illustrated by Chaney (1927) as fruits of *Ulmus speciosa* and *U. brownellii* indicate that they represent *Pteleaecarpum oregonensis* and an unidentified winged seed, respectively.

Leaves of the extinct genus *Tremophyllum,* formerly described from the Tertiary of Europe (Rüffle, 1963), are relatively narrow and have a stout petiole, an asymmetrical leaf base, and blunt teeth that are distributed one per secondary vein (Figure 4C). These leaves, for which we propose the new name combination *Tremophyllum hesperium* (Brown) comb. nov., are also present at Gray Ranch and were formerly referred to *Ulmus brownellii* (Chaney, 1927) and *Zelkova hesperia* (Brown, 1946). Although correctly placed in the Ulmaceae, this species does not belong to any modern genus (Tanai and Wolfe, 1977, p. 1). Specimens from the Green River and Florissant floras show leaves of this kind attached to twigs bearing fruits of the extinct genus *Cedrelospermum* (Manchester, 1987a). Although such fruits have not been recovered from Fossil, they have been reported from Gray Ranch ("*Banksites lineatus*," Brown, 1940).

At least three genera of the Juglandaceae (walnut family) are present, although they are not abundant. *Juglans* (walnut) is represented by occasional leaflets and compressed nuts (Figure 4E). Leaflets resembling those of *Pterocarya* (Figure 4D) are also present. Although the distinctive biwinged fruits of *Pterocarya* have not been found at this locality, they are known from the John Day locality at Cant Ranch (Wolfe, 1959). Trilobed winged fruits related to *Engelhardia* occur at several localities of the Bridge Creek flora including Fossil (Figure 4F). Formerly misidentified as *Carpinus* (Chaney, 1927), the species corresponds most closely to *E. olsoni* from the Miocene Latah Formation of Idaho (Brown, 1940; Manchester, 1987b). Similar triwinged fruits occur today in two genera of the Juglandaceae: *Engelhardia* of Asia and *Oreomunnea* of tropical America. In some characters, this fossil species is more similar to *Oreomunnea,* but other characters of the fruits and foliage need to be determined for this fossil species before a positive modern generic assignment can be made (Manchester, 1987b).

Table 1. *Fossil plant list*

Fern:
- cf. *Polypodium* [fertile leaf]

Conifers:

PINACEAE
- *Pinus* sp. [leaves, seed cones, pollen cones]
- *Abies* sp. [cone scales]

TAXODIACEAE
- *Metasequoia occidentalis* (Newberry) Chaney [leaves, seed cones, pollen cones]

Flowering plants:

MONOCOTYLEDONS
- Monocotyledonous leaf

DICOTYLEDONS
- BERBERIDACEAE
  - *Mahonia simplex* (Newberry) Arnold [leaflets]
- CERCIDIPHYLLACEAE
  - *Cercidiphyllum crenatum* (Heer) Brown [leaf and associated fruits of *Cercidiphyllum helveticum* (Heer) Jähnichen, Mai, and Walther]
- PLATANACEAE
  - *Platanus aspera* Newberry [leaves]
  - *Platanus condoni* (Newberry) Knowlton [leaves]
  - Platanaceous fruits
- MORACEAE
  - *Morus*-like leaves
- ULMACEAE
  - *Ulmus pseudo-americana* Lesquereux [leaves]
  - *Tremophyllum hesperium* (Brown) comb. nov. [leaves]
- JUGLANDACEA
  - *Juglans* sp. [leaflets and fruits]
  - *Pterocarya* sp. [leaflets]
  - cf. *Engelhardia olsoni* Brown [fruit]
- FAGACEAE
  - *Quercus consimilis* Newberry [leaves]
  - *Fagus pacifica* Chaney [leaves and fruits]
- BETULACEAE
  - *Alnus hollandiana* Jennings emend. Klucking [leaves, catkins]
  - *Asterocarpinus perplexans* (Cockerell) Manchester and Crane [fruits and associated leaves of *Paracarpinus chaneyi* Manchester and Crane]
- TILIACEAE
  - *"Tilia" circularis* (Chaney) comb. nov. [fruits]
  - *Plafkeria obliquifolia* (Chaney) Wolfe [leaves]
- ROSACEAE
  - *Crataegus newberryi* Cockerell [leaves]
  - cf. *Sorbus* [leaflet]
- HYDRANGEACEAE
  - *Hydrangea florissantia* Cockerell [flowers]
- LEGUMINOSAE
  - *Cladrastis* sp. [fruits]
  - *Cercis* sp. [fruits]
- ACERACEAE
  - *Acer ashwilli* Wolfe and Tanai [leaves and fruits]
  - *Acer cranei* Wolfe and Tanai [fruits]
  - *Acer manchesteri* Wolfe and Tanai [leaves and fruits]
  - *Acer osmonti* Knowlton [leaves and fruits]
- MELIACEAE
  - *Cedrela merilli* (Chaney) Brown [leaf and seed]
- INCERTAE SEDIS
  - *Florissantia physalis* Knowlton [flower]
  - *Pteleaecarpum oregonensis* (Arnold) comb. nov. [fruit]
  - *"Albizzia" ovalicarpa* Becker [seed]
  - cf. *Terminalia* [fruit]
  - 2 unidentified species with serrate leaves
  - 1 unidentified species with entire-margined leaves

The Fagaceae (beech family) are represented by two genera, *Fagus* and *Quercus,* each apparently with one species. *Fagus* (beech) is known from both leaves and nuts at Fossil. The leaves, *Fagus pacifica*

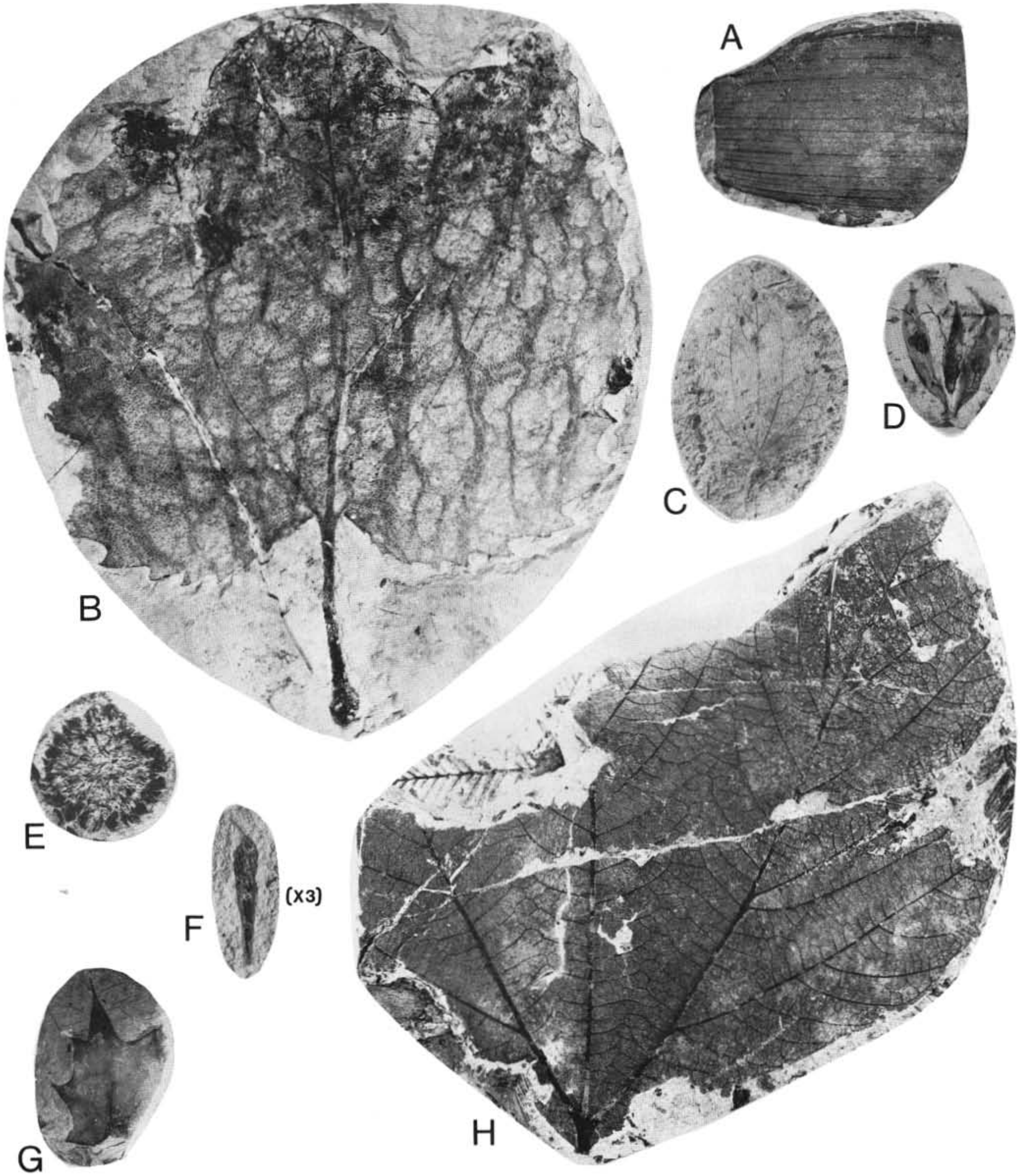

Figure 3. A. Section of a monocot leaf showing parallel venation, UCMP9313. B. Leaf of Platanus aspera *(sycamore), IU6997. C.-D.* Cercidiphyllum *(katsura tree). C. Leaf of* Cercidiphyllum crenatum, *IU7000. D. Three fruits of* Cercidiphyllum helveticum *in cluster, IU7001. E.* Platanus *fruiting head, IU6998. F. Isolated* Platanus *fruitlet, IU6999. G.* Mahonia simplex *(Oregon grape), IU7003. H.* Platanus condoni, *IU7002.*

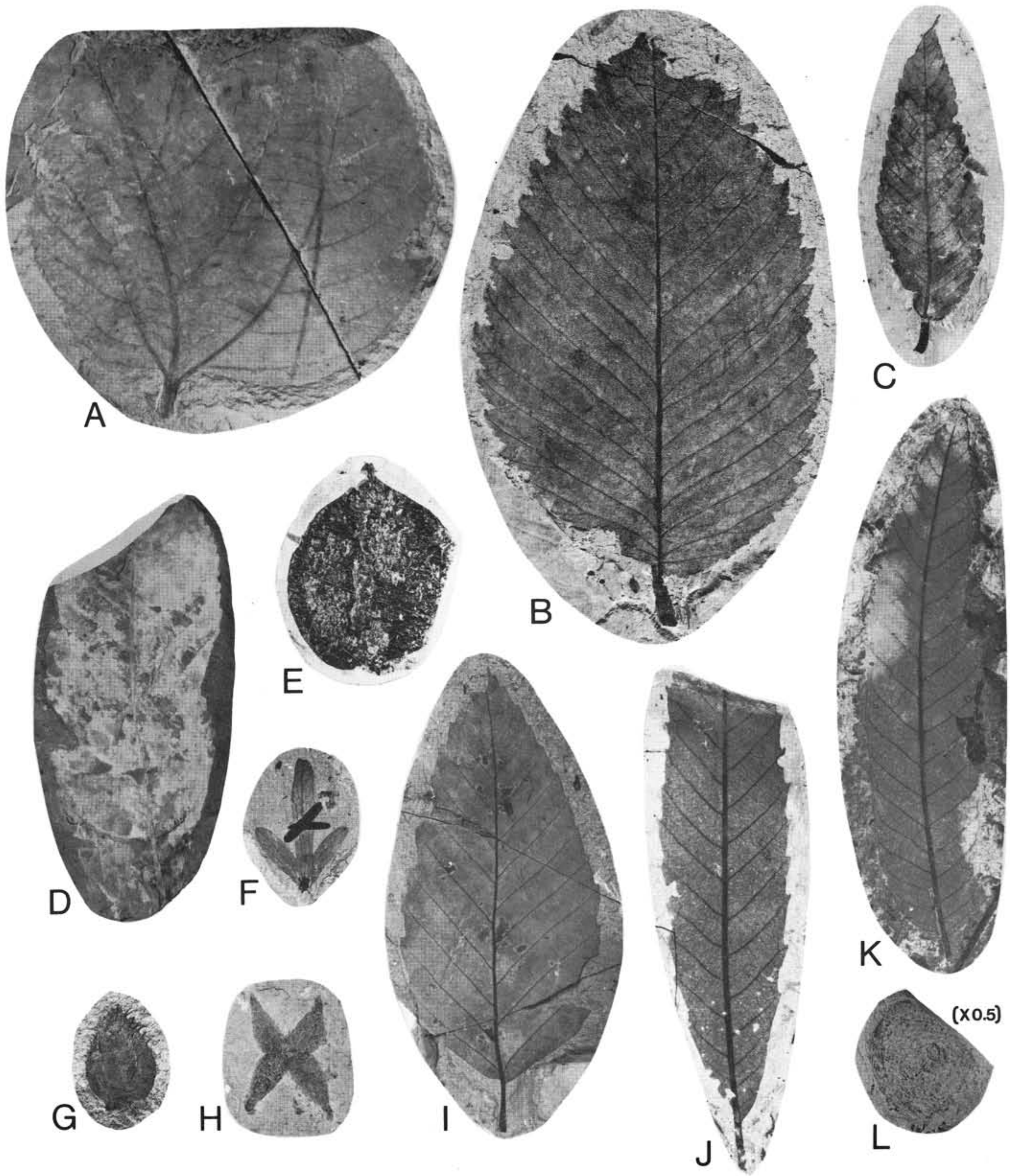

Figure 4. A. Leaf similar to Morus *(mulberry), UCMP9314. B.* Ulmus pseudo-americana *(elm), IU7004. C.* Tremophyllum, *IU7005. D.* Pterocarya, *IU7006. E.* Juglans *(walnut), IU7007. F. Cf.* Engelhardia olsoni, *IU7013. G.* Fagus pacifica *nut (beechnut), showing recurved spines of cupule, IU7008. H. Opened cupule of* Fagus pacifica *showing four valves, IU7009. I. Leaf of* Fagus pacifica *(beech), IU7010. J.* Quercus consimilis *leaf, IU7011. K.* Quercus consimilis *(oak) leaf showing fewer teeth, IU7012. L.* Quercus *cupule (acorn cap), UCMP9317.*

(Chaney, 1927), are ovate with straight parallel secondary veins, each vein entering a tooth at the margin (Figure 4I). The nuts are recognized by their spiny cupule, which may be opened into four valves (Figure 4H) or closed and laterally compressed (Figure 4G). In leaf form (Tanai, 1974), prominence of leaf serrations, and the character of spines on the cupules, this fossil species is very similar to the living species *F. grandifolia* of North America and less similar to the species living today in Europe and Asia.

Leaves of *Quercus consimilis* are long elliptical, with a margin that ranges from fully serrate with a spiny tooth at the terminus of each secondary vein (Figure 4J) to partially serrate with perhaps only a few teeth near the apex (Figure 4K). Based upon the presence of a prominent fimbrial vein along the margin (a character lacking in *Castanea;* Tanai, 1986), the leaves attributed to *Castanea orientalis* by Chaney (1927) from the Gray Ranch and Cant Ranch localities may also belong to *Q. consimilis.* Acorns, although common at Bridge Creek, are rare in the Fossil assemblage. Only two specimens of probable acorn cupules are known, and both are large (approximately 4.5 cm in diameter; Figure 4L).

Leaves of the Betulaceae (birch family) are especially common at Fossil and belong to two genera: *Alnus* and *Paracarpinus. Alnus* (alder) is one of the most abundantly preserved plants in the Bridge Creek flora. Of the three *Alnus* species that Klucking (1959) recognized from Fossil on the basis of leaves, *A. hollandiana* (Figures 5A,B) is particularly abundant at Fossil. The leaves are ovate to elliptical with numerous small blunt teeth and have nonparallel, slightly concave secondary veins. Seed catkins (Figure 5C) and pollen catkins (Figure 5D) are also common.

Leaves and fruits of an extinct genus related to the living *Carpinus* (hornbeam) are also abundant at Fossil. The leaves, *Paracarpinus chaneyi* (Figure 5E; Manchester and Crane, 1987), are elliptical, with numerous small, sharp marginal teeth and straight, parallel secondary veins. The associated fruits, *Asterocarpinus perplexans* (Figure 5F; Manchester and Crane, 1987) consist of a small nutlet surrounded by four, five, or six radiating wings with pinnate venation.

The Tiliaceae (linden tree family) are represented by extinct fruits and leaves at Fossil. Laminae of the kind formerly considered to be leaves of *Asarum* (Chaney, 1927) and *Nymphoides* (Brown, 1946) are abundant at Fossil (Figure 5I), but attached peduncles bearing globose fruits indicate that, rather than leaves, the laminae are fruiting bracts similar to those of modern *Tilia* (linden). Although circular rather than lanceolate, the bracts are remarkably similar in venation to those of modern lindens. The fruits have a basal perianth scar, are five-sided, and have a bumpy surface like those of living *T. petiolaris.* We suggest the new name combination *"Tilia" circularis* (Chaney) comb. nov., indicating the close affinity with this modern genus. However, it is likely that further study will confirm that a new generic name is necessary. Characteristic leaves and lanceolate bracts more similar to those of living species of *Tilia* have not been found at Fossil, although they are present at Cove Creek and Dugout Gulch.

Leaves of *Plafkeria obliquifolia* (Figure 6A) are asymmetrical with entire margins, palmate venation, and a stout petiole. The higher order venation forms a fine orthogonal meshwork. These characters suggest that the leaves may belong to the Tiliaceae (Wolfe, 1977) or Sterculiaceae, and it is possible that these leaves belong either to the plant that produced *"Tilia" circularis* bracts or to that which produced *Florissantia* flowers.

The Rosaceae (rose family) are represented primarily by occasional leaves of *Crataegus* (hawthorn). *Crataegus newberryi* (Figure 5G) occurs at nearly all localities of the John Day and Crooked River basins and was described in detail by Chaney (1927). The leaves are pinnately lobed with small teeth along each lobe. Specimens of prickly stems (Figure 5H) may also belong in the Rosaceae, and a single leaflet resembling *Sorbus* has been observed (Figure 6H). Additional rosaceous genera such as *Rubus, Amelanchier,* and *Rosa* are known from other Bridge Creek localities but have not been identified from Fossil.

Hydrangea, in the Hydrangeaceae, is easily recognized by its flowers with four (rarely three) separate, broad, rounded petals (Figure 5J). It is rare at the Fossil locality and is also present but rare at Gray Ranch, Bridge Creek, and Dugout Gulch. A fruiting panicle of *Hydrangea* from Bridge Creek was illustrated by La Motte (1936, pl. 3, fig. 5; incorrectly identified as *Tilia*).

Two kinds of pods of Leguminosae (pea family) have been recovered from the locality. One of them (Figure 6B) resembles the living *Cercis* (redbud) in having a pod that is winged (having a flange of tissue extending slightly beyond the suture) and in having its seeds oriented perpendicular to the pod. Similar specimens are known from Gray Ranch, Bridge Creek (Chaney, 1927), and Dugout Gulch. The second type of pod (Figure 6C), similar to that of *Cladrastis* (yellow wood), is stipitate, has occasional constrictions between seeds, and has its seeds oriented parallel to its long axis. The specimen described as *Cladrastis oregonensis* by Brown (1937) from Bridge Creek differs from the one figured here in having only one seed and in lacking constrictions. Leaflets similar to *Cladrastis* occur occasionally in the Bridge Creek flora but have not been confirmed at Fossil.

Acer (maple) is common and diverse at most localities of the Bridge Creek flora. Chaney (1927) attributed several leaves and fruits from Gray Ranch to a single species. However, more critical study of the fruits and foliage indicates that eight species are present in the Bridge Creek flora (Wolfe and Tanai, 1987), including four that occur at Fossil: *Acer ashwilli* (Figure 6D), *A. osmonti* (Figure 6F), *A. cranei,* and *A. manchesteri* (Figure 6G).

Cedrela merilli is represented by winged seeds and leaves similar to those of the living *C. mexicana* (Brown, 1937). The characteristic seeds (Figures 6I,J) have thin lateral wings that often show a rounded crease near the distal margin. The leaves (Figure 6K) are recognized by their pronounced asymmetry and smooth margins. *Cedrela* grows today from Mexico to tropical South America. Asian species formerly included in this genus are now placed in a separate genus, *Toona.*

Flowers of *Florissantia physalis* (Knowlton, 1916) are occasionally found at Fossil and are present at most localities of the Bridge Creek flora. The flowers have a large, fused, five-lobed perianth (Figure 6N) and a five-carpeled ovary with a single style. Although previously called *Porana speirii* (Chaney, 1927; Brown, 1940) and more recently *Holskioldia speirii* (MacGinitie, 1953; Brown, 1959), a critical study of the specimens now available from Fossil and Dugout Gulch indicates that they are not related to either of these modern genera and instead are probably flowers of an extinct plant. Some rare specimens show the stamens with large globose anthers (Figure 6-O). The general aspects of this flower suggest that it may belong to the order Malvales.

Pteleaecarpum oregonensis (Figures 6L,M) belongs to an extinct genus of winged fruit that is also known from the Oligocene of Europe (Bůžek, 1971). The species is abundant at Fossil and other localities of the Bridge Creek flora and was formerly identified as *Ulmus speciosa* (Newberry, 1898; Chaney, 1927), *Ptelea miocenica* (Brown, 1937, p. 178, pl. 51, fig. 4), and *Koelreuteria oregonensis* (Arnold, 1952). Unlike *Ulmus* and *Ptelea,* these fruits bear four to six seeds in axile attachment, and unlike *Koelreuteria,* they have small seeds and two rather than three carpels. To our knowledge, *Pteleaecarpum* does not occur in North America except in the John Day Formation.

Unidentified small oval-winged seeds (Figure 6E) are abundant at Fossil and also occur at Dugout Gulch as well as Gray Ranch. These appear to be identical to specimens Becker (1960) described from the Oligocene Mormon Creek flora of southwestern Montana as *Albizzia ovalicarpa,* although the actual generic identity remains undetermined.

Fossil winged fruits resembling those of *Terminalia* are known

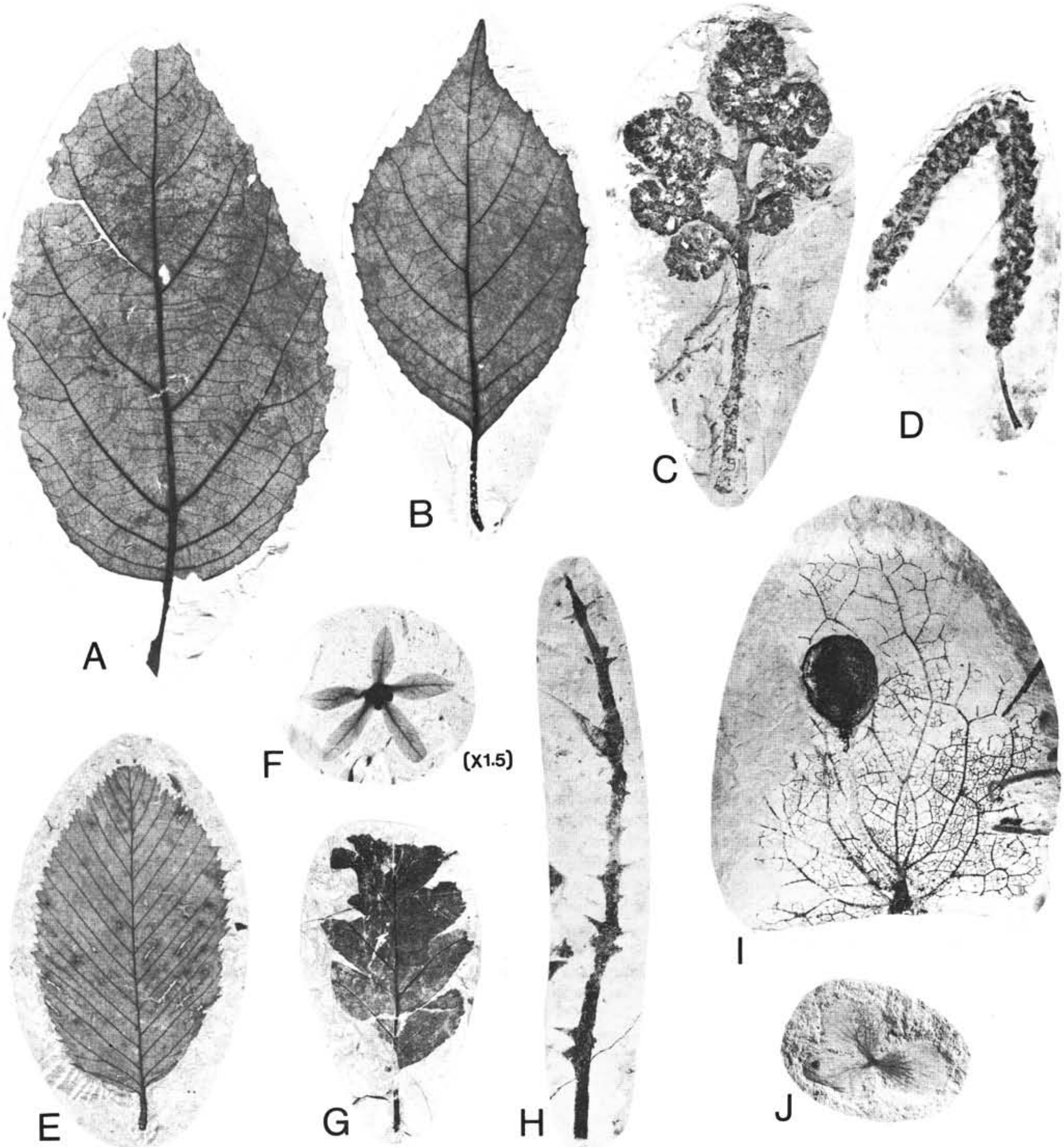

Figure 5. A.,B. Alnus hollandiana *(alder) leaves, IU7014, IU7015. C.* Alnus *seed catkin, IU7016. D.* Alnus *pollen catkin, IU7017. E.* Paracarpinus chaneyi *leaf, IU6098. F. Fruit of* Asterocarpinus perplexans *showing radiating wings, IU6091, 1.5 X. G.* Crataegus newberryi *(hawthorn) leaf, IU7019. H. Prickly stem, IU7020. I. Bract and attached fruit of* "Tilia" circularis *(extinct linden), UCMP9315. J.* Hydrangea *flower, IU7021.*

from two specimens from Fossil, one figured by Brown (1959) and the other here (Figure 6P). They are similar in general outline to the fruits of *Pteleaecarpum* but are distinguished by their larger size and a wing venation that is parallel but not reticulate. The species has not been recovered from other Bridge Creek localities. This kind of winged fruit occurs in several modern families, and the systematic position of this species remains to be confirmed.

EXOTIC AND EXTINCT GENERA OF THE FLORA

Many of the species found at Fossil represent genera that are no longer native to the Pacific Northwest, and some belong to extinct genera. Genera exotic to the present-day flora of the region include *Metasequoia, Cercidiphyllum, Platanus, Ulmus, Pterocarya, Juglans, Engelhardia, Fagus, Hydrangea, Cladrastis, Cercis,* and *Cedrela.* Many occur today in Asia; in particular, *Metasequoia* and

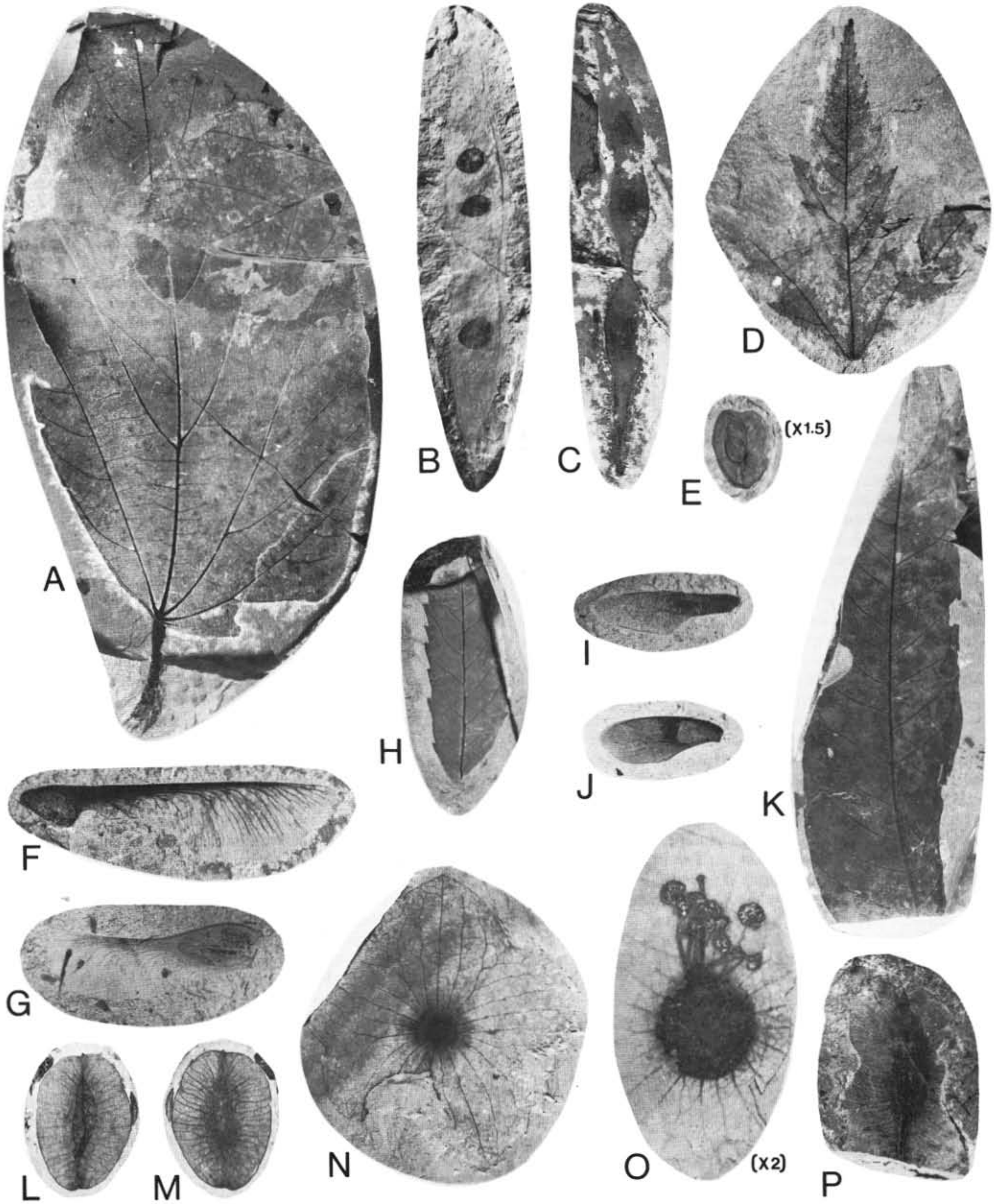

Figure 6. A. Leaf of Plafkeria obliquifolia, *IU7022. B. Pod similar to that of* Cercis *(redbud), IU7023. C. Pod similar to that of* Cladrastis *(yellow wood), IU7024. D. Leaf of* Acer ashwilli *(maple), UCMP 9029. E. Unidentified winged seed, IU7034. F. Winged fruit of* Acer osmonti, *IU7025. G. Winged fruit of* Acer manchesteri, *IU7026. H. Cf.* Sorbus, *IU7027. I.,J. Winged seeds of* Cedrela merilli, *IU7028, IU7029. K. Leaf of* Cedrela merilli, *IU7030. L.,M. Counterpart impressions of a winged fruit* Pteleaecarpum, *IU7033. N.* Florissantia physalis *flower, IU7031. O.* Florissantia physalis *flower with intact stamens, IU7036. P. Winged fruit similar to* Terminalia, *IU7032.*

Cercidiphyllum are presently restricted to eastern Asia, and *Pterocarya* occurs only in eastern Asia and the Caucasus region. The fossil species of *Cedrela* and *Engelhardia* are most similar to those living in Mexico and Central America. *Fagus* is widespread in the Northern Hemisphere today, but the Bridge Creek species is most similar in fruits and foliage to the eastern North American species. Likewise, *Platanus aspera* seems to compare most favorably with the living American species. Most of these genera also occur in Miocene floras of the Pacific Northwest, and their disappearance from this region was probably due to climatic change during the later Tertiary and the Pleistocene.

Previous investigations of the Bridge Creek flora have treated nearly all of the taxa as living genera. However, we estimate that about 15 to 20 percent of the species represent extinct genera. Examples include *Asterocarpinus/Paracarpinus, Tremophyllum, Pteleaecarpum, "Tilia," Plafkeria,* and *Florissantia.* The previous misidentification of these taxa to living genera has resulted in a misleading impression that the Bridge Creek flora was completely modern in its generic composition. The recognition of extinct genera has been aided by more critical study of leaf architecture and by increased attention to associated fruits and flowers.

VEGETATION

One of the most striking aspects noticeable when collecting at this locality is the contrast between the fossil plants and the modern flora and vegetation of this region. The lower elevations around the town of Fossil consist of shrub-steppe and savanna vegetation dominated by grasses, sagebrush *(Artemisia tridentata),* and western juniper *(Juniperus occidentalis),* while the higher, moister elevations in surrounding mountains support coniferous forests with ponderosa pine *(Pinus ponderosa),* Douglas fir *(Pseudotsuga menziesii),* and grand fir *(Abies grandis).* More detailed descriptions of the modern vegetation are provided by Franklin and Dyrness (1973).

Most of the fossil species represent broad-leaved deciduous plants. Conifers are not diverse, although the deciduous foliage of *Metasequoia* is common. Broad-leaved evergreen species also lack diversity and are not common. Most of the species represent tree genera, although *Hydrangea, Mahonia, Crataegus,* and *Sorbus* may have been shrubs. The strong representation of deciduous plants relative to evergreen plants may in part reflect a depositional bias whereby deciduous taxa are overrepresented due to their production of a greater number of leaves that are shed annually. Deciduous taxa are also more common than evergreen taxa as constituents of lakeside and streamside vegetation, resulting in a loss of their leaves directly into or alongside the depositional environment. Nevertheless, evergreen taxa, if present within proximity of the depositional site, should be present in a large collection such as the one from the locality at Fossil, although the abundance of specimens of evergreen taxa may be greatly underrepresented relative to that of deciduous taxa. Similarly low proportions of broad-leaved evergreen taxa are observed at other localities of the John Day Formation, including Knox Ranch, Twickenham, Bridge Creek (Wolfe, 1981), and Dugout Gulch (Manchester and Meyer, unpublished data), although Wolfe (1981) calculated a higher percentage for Post (Gray Ranch).

The assemblage from Fossil, like others of the John Day Formation, indicates vegetation similar to that of temperate hardwood deciduous forests of eastern Asia (Wang, 1961) and eastern North America (Braun, 1950; Vankat, 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 *Metasequoia,* Chaney (1925) compared fossils from the Bridge Creek flora with the living redwood forest of California and incorrectly identified many elements of the flora based upon gross morphology and his preconception that the floras were essentially identical. Later, Chaney (1948a,b, 1952) recognized the similarity of the Bridge Creek flora to modern forests of eastern Asia.

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, based on modern vegetation that has been modified by centuries of human activity (Wang, 1961). Based upon physiognomic characters (i.e., those that express the structure and physical appearance of vegetation), such as the relatively low diversity, the proportions of coniferous, broad-leaved deciduous, and broad-leaved evergreen components, the low percentage of entire-margined dicotyledonous leaves (17 percent), and the presence of about 20 percent of species with palmately lobed leaves, the flora from Fossil corresponds most closely to the Mixed Northern Hardwood forest. Wolfe (1981) considered the Bridge Creek flora to represent Mixed Mesophytic forest, although he emphasized (p. 88) that the "reduced broad-leaved evergreen element in these fossil assemblages is anomalous relative to extant vegetation." Physiognomically, the flora is less anomalous in comparison with the Mixed Northern Hardwood forest. With the exception of some species with small leaves, broad-leaved evergreens are generally absent in this modern community (Wang, 1961; Wolfe, 1979). Floristically, the assemblage is more similar to the Mixed Mesophytic forest in the presence of *Cedrela, Cercidiphyllum,* and *Pterocarya.* Most other extant genera of the fossil assemblage occur today in both forest types.

CLIMATIC IMPLICATIONS

It is possible to infer paleoclimatic conditions from fossil floras based upon the climatic distribution of modern vegetation types, which is influenced by temperature, precipitation, and seasonality. Wolfe (1979) plotted the temperature parameters for different vegetation types in eastern Asia and showed that the Mixed Northern Hardwood forest occurs in mesic areas where the mean annual temperature ranges from 3 to 10 °C, the mean cold month temperature ranges up to -2 °C, the mean warm month temperature ranges from 20 to 28 °C, and the mean annual range of temperature (i.e., a measure of equability, given as the difference between mean warm month temperature and mean cold month temperature) ranges from 23 to 45 °C. The Mixed Mesophytic forest of China, however, occupies a narrower range of temperature parameters, with the mean annual temperature ranging from 9 to 13 °C, the mean cold month temperature from -2 to 1 °C, the mean warm month temperature from 20 to 27 °C, and the mean annual range of temperature from 20 to 29 °C.

Wolfe (1981) pointed out that the occurrence of large-leaved (greater than 20 cm^2) broad-leaved evergreen species is significant in assessing paleoclimate, because these species are generally limited to vegetation of climates where the mean cold month temperature is greater than -2 °C. The apparent lack of such species in the assemblage from Fossil indicates that the mean cold month temperature may have been less than -2 °C. Although *Mahonia* is an evergreen, its leaflets are small, and some living species of this genus extend into cold vegetation where large-leaved broad-leaved evergreens are absent. *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; however, the leaves of *Cedrela* were apparently deciduous, judging from their thin textures.

Leaf-margin percentages provide another criterion for comparison of floras of different climates. Bailey and Sinnott (1915) observed a correlation in living vegetation between the percentage of species having entire-margined leaves (i.e., leaves that lack teeth or lobes) and climate, with successively higher percentages of entire-margined leaves in cool temperate, warm temperate, and lowland tropical floras. Further studies have shown that the percentage is influenced by mean annual temperature (Wolfe and Hopkins, 1967; Wolfe, 1971) as well as rainfall (Dilcher, 1973). Wolfe (1979) indicated a direct correlation between mean annual temperature and leaf-margin percentage in mesic climates, based upon undocumented data from eastern Asia, although a much less precise correlation was found in well-documented studies of the Carolinas (Dolph and Dilcher, 1979) and Costa Rica (Dolph, 1979). We estimate that the Fossil assemblage has 17 percent entire-margined leaves; this figure is based upon 28 dicot species and includes margins inferred for leaves of three extant genera presently represented only by fruits (*Hydrangea,* serrate; *Cladrastis* and *Cercis,* entire). Using the simple correlation between leaf margin and mean annual temperature as proposed by Wolfe (1979), this value corresponds to a mean annual temperature of about 5 °C. Our leaf-margin percentage is lower than that published previously for the Bridge Creek flora (25 percent, based upon 66 species from several localities; Wolfe and Hopkins, 1967; Wolfe, 1971) and that calculated for Gray Ranch (34 percent entire margins, based upon 37 species; Wolfe, 1981) and Dugout Gulch (24 percent entire margins, based upon 25 species; Manchester, unpublished data). It is possible that the assemblage from Fossil varies somewhat from other Bridge Creek localities (particularly Gray Ranch) due to differences in age, altitude, successional stage, or factors of local ecology.

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 (1981) considered these more coastal floras to represent Broad-leaved Evergreen and Coniferous forest, suggesting that the climate nearer the Oregon coast (then in the area of the present Willamette Valley) may have had a slightly warmer mean annual temperature and a slightly lower mean annual range of temperature (i.e., more equable) than the inland area occupied by the Bridge Creek flora. Compared with the present climate of western Oregon, the Lyons and Rujada floras indicate that the mean annual temperature has apparently not changed significantly, although the mean annual range of temperature has decreased about 5 to 10 °C (i.e., summers have become cooler, and winters are warmer) (Wolfe, 1981). The present climate of Oregon also differs in having reduced summer precipitation. Aridity is particularly pronounced today in central and eastern Oregon and can be attributed to the rain-shadow effects resulting from the late Cenozoic development of the High Cascades.

Vegetational analyses and leaf-margin data from a number of western Tertiary floras (Wolfe and Hopkins, 1967; Wolfe, 1978) reveal that the most striking climatic event of the Tertiary was a drastic (about 10 to 11 °C) decline in mean annual temperature along with an increase of about 15 to 16 °C in mean annual range of temperature (at middle latitudes) that occurred during the Oligocene between about 32 and 34 m.y. ago, just prior to the deposition of the Bridge Creek flora (Wolfe, 1978). In the John Day basin, the Eocene Clarno Formation contains fossil leaf assemblages that represent warmer, more equable climatic conditions than the Bridge Creek flora. The Clarno Nut Beds assemblage (Manchester, 1981) is much more diverse than the Bridge Creek flora, includes many broad-leaved evergreen taxa that are primarily restricted to tropical and subtropical areas, and, based on physiognomic criteria, probably had a mean annual temperature of more than 20 °C. Following the Oligocene climatic change, temperate climate persisted in lowland areas with only moderate fluctuations through the remainder of the Tertiary (Wolfe, 1978).

ORIGIN OF THE FLORA

A comparison of the Bridge Creek flora with older floras in the region such as the Clarno raises questions concerning the mechanism of floral change through which hardwood deciduous forests replaced near-tropical vegetation during the Oligocene. The Arcto-Tertiary geoflora concept, a theory that developed as early as the late 1800's and was later expounded upon by Chaney (1938, 1940, 1947, 1948a), sought to explain this change and became widely accepted as fact. Wolfe (1977) presented the most complete 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 as a response to gradual climatic cooling. Although Chaney (1948b, p. 21-22) noted that some species failed to survive while others were added during this "migration," he believed that the Arcto-Tertiary geoflora underwent little floristic change and maintained its general character 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 between population genetics, physiological tolerances of individual species, and the fluctuation of the environment. During an event of climatic or environmental change, each individual plant species will have its own unique genetic capability of coping with such a change; it is not conceivable that all species within a plant community will have the same response. To assume that the floristic composition of a plant community remains fundamentally unchanged over a long interval of time is inconsistent with evolutionary theory. Based upon 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 to early Oligocene floras of Alaska were subtropical to near-tropical, similar to middle-latitude floras of the same age from the Pacific Northwest, and lacked the floristic and vegetational character assumed by Chaney.

The Mixed Mesophytic and Mixed Northern Hardwood forests began developing during the Oligocene from lineages having origins in older floras of dissimilar character. Based upon the studies and ideas of Mason (1947) and Wolfe (1972, 1977), plant species can be envisioned as having had at least four possible responses to the Oligocene climatic cooling: (1) extinction, (2) survival through preadaptation, (3) survival through rapid evolution, and (4) dispersal from upland regions. Many species that inhabited the Eocene and early Oligocene near-tropical forests of the Pacific Northwest became extinct during the rapid Oligocene climatic deterioration, but some species may have had physiological 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 *Pterocarya, Plafkeria, Engelhardia, and Platanus* are known from the older, warmer floras from this region, but 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 were closely related to those from older upland floras (Wolfe, 1972), where temperatures were cooler than in the lowlands, and some lineages may have dispersed from these upland areas into lowland areas during the climatic change. Bridge Creek taxa such as *Abies, Acer, Crataegus, Mahonia,* and *Asterocarpinus* also occur in somewhat older upland floras from the Rocky Mountain region, such as the Florissant (MacGinitie, 1953), Ruby (Becker, 1961), and Red Rock Ranch and Marshall Pass (Meyer, 1986) floras, suggesting probable upland sources for these taxa. Some taxa (e.g., *Tremophyllum, Florissantia,* and *Hydrangea*) occur in both the temperate upland and near-tropical lowland floras of the Eocene to early Oligocene; their occurrence in the Bridge Creek flora may have resulted from either source.

ACKNOWLEDGMENTS

We thank students and associates of the 1986 Paleobotany Research Team of the Oregon Museum of Science and Industry, particularly Ron Ascher, Melvin Ashwill, Alex Atkins, Barb Campbell, Rob

Clapp, Katie Newsom, Lisa Rankin, Brian Ries, John Ries, Josie Spitzer, and Eric Weinstein for assistance in field work that produced most of the specimens figured in this paper. Howard Schorn kindly provided access to collections from Fossil and other John Day localities at the Museum of Paleontology of the University of California, Berkeley. Melvin Ashwill, Eric Bestland, David Blackwell, David Dilcher, Ted Fremd, Pat Herendeen, Howard Schorn, Gary Smith, and Jack Wolfe provided helpful discussion. Jack Steiwer provided historical information. This study was supported by a grant from the National Science Foundation (BSR 84-07841) to S. Manchester.

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USGS releases new-style topographic map index and catalog for Oregon

A new index and a companion catalog of the 3,764 topographic and related maps of Oregon available from the U.S. Geological Survey (USGS) have been published by the USGS, the nation's principal civilian mapping agency.

The "Oregon Index to Topographic and Other Map Coverage" and the "Oregon Catalog of Topographic and Other Published Maps" were designed to assist users in selecting and purchasing maps of the state.

Both index and catalog are in booklet form. They replace the old single-sheet index and are the first of their kind for Oregon. A program to issue similar publications for all 50 states will be completed soon.

"For the first time, all topographic and related USGS maps of Oregon are included in one easy-to-use index and catalog set, " said John R. Swinnerton, Menlo Park, Calif., chief of the Western Mapping Center of the Survey's National Mapping Division. "These include planimetric, topographic, and photo-image maps, as well as land-use and land-cover maps. The old-style index did not show or list all of the 37 different USGS map products currently available to the public."

The new Oregon index and catalog also list United States maps, county maps, national park maps, National Atlas maps, world maps, orthophotoquads, orthophotomaps, and special maps that include all or parts of Oregon.

"The new indexes do not have to be updated and published periodically, but the catalogs will be efficiently and economically updated by computer and reissued as needed," Swinnerton said. Previously, the updating and reprinting process took several years.

The Oregon catalog contains forms for ordering topographic and other maps from the USGS. The catalog also lists 54 private map dealers in Oregon who sell USGS maps and the 15 libraries in Oregon that have the maps for reference and inspection.

Single copies of the new Oregon index and catalog are available free of charge from the U.S. Geological Survey, Map Distribution, Box 25286, Federal Center, Denver, Colo., 80225, telephone (303) 236-7477. Copies also can be obtained from authorized USGS map dealers listed in the catalog or in local telephone yellow pages under "Maps." □

Oregon Agate and Mineral Society display featured at State Capitol

On September 15, 1987, Wally and Jean Hobson of the Mount Hood Rock Club of Gresham removed their display from the Oregon Council of Rock and Mineral Clubs display case at the Capitol Building in Salem. They plan to keep it intact to exhibit at their annual show and also at the Portland Regional Show, October 23-25th.

On the following day, the Oregon Agate and Mineral Society (OAMS) of Portland installed its colorful exhibit featuring sagenite, moss and plume agate and Oregon sunstones. Lighted frames at each end of the 11-ft case displayed sagenite agate, while transparent specimens were placed on the bottom shelf to take advantage of the fluorescent lighting underneath.

Featured in the display was the framed proclamation, signed by Governor Neil Goldschmidt, on August 4th, 1987, making the Oregon sunstone the official Oregon gemstone. Also displayed were faceted and tumbled sunstones, some colored rough specimens, and a 100-carat shaped and polished sunstone pendant.

Several OAMS members contributed the more than 40 items, representing 15 Oregon counties, shown in the display. Ray Schneider, charter member of OAMS, President Chuck Sweany, and Evelyn Sweany arranged the exhibit, assisted by Lyle Riggs, Agent for the Council.

The display will remain until January 15, 1988, and will be followed by an exhibit provided by the Roxy Ann Gem and Mineral Club of Medford, Oregon. □

OREGON GEOLOGY

published by the

Oregon Department of Geology and Mineral Industries

VOLUME 49, NUMBER 10

OCTOBER 1987

OREGON GEOLOGY
(ISSN 0164-3304)

VOLUME 49, NUMBER 10 OCTOBER 1987

Published monthly by the Oregon Department of Geology and Mineral Industries (Volumes 1 through 40 were entitled *The Ore Bin*).

Main Office: 910 State Office Building, 1400 SW Fifth Ave., Portland 97201, phone (503) 229-5580.

Baker Field Office: 1831 First Street, Baker 97814, phone (503) 523-3133 Howard C. Brooks, Resident Geologist

Grants Pass Field Office: 312 SE "H" Street, Grants Pass 97526, phone (503) 476-2496 Len Ramp, Resident Geologist

Mined Land Reclamation Program: 1534 Queen Ave. SE, Albany 97321, phone (503) 967-2039 Gary W. Lynch, Supervisor

Second class postage paid at Portland, Oregon. Subscription rates: 1 year $6; 3 years, $15. Single issues, $.75 at counter, $1 mailed. Available back issues of *Ore Bin*: $.50 at counter, $1 mailed. Address subscription orders, renewals, and changes of address to *Oregon Geology,* 910 State Office Building, Portland, OR 97201. Permission is granted to reprint information contained herein. Credit given to the Oregon Department of Geology and Mineral Industries for compiling this information will be appreciated. POSTMASTER: Send address changes to *Oregon Geology,* 910 State Office Building, Portland, OR 97201.

Information for contributors

Oregon Geology is designed to reach a wide spectrum of readers interested in the geology and mineral industry of Oregon. Manuscript contributions are invited on both technical and general-interest subjects relating to Oregon geology. Two copies of the manuscript should be submitted, typed double-spaced throughout (including references) and on one side of the paper only. Graphic illustrations should be camera-ready; photographs should be black-and-white glossies. All figures should be clearly marked, and all figure captions should be typed together on a separate sheet of paper.

The style to be followed is generally that of U.S. Geological Survey publications (see the USGS manual *Suggestions to Authors,* 6th ed., 1978). The bibliography should be limited to "References Cited." Authors are responsible for the accuracy of the bibligraphic references. Names of reviewers should be included in the "Acknowledgments."

Authors will receive 20 complimentary copies of the issue containing their contribution. Manuscripts, news, notices, and meeting announcements should be sent to Beverly F. Vogt, Publications Manager, at the Portland office of DOGAMI.

COVER PHOTO

Aerial view of Fossil, Oregon, looking to the north. Middle and upper parts of center show Wheeler High School and the outcrop of John Day Formation at the north end of the school's athletic field. Article discussing fossil plants from this outcrop begins on next page. Photo courtesy Douglas Watson.

OIL AND GAS NEWS

ARCO continues at Mist

Since successfully completing its first two 1987 wells at Mist, the Columbia County 11-34-65 and the Longview Fibre 11-34-64, ARCO is drilling a deep test at the Columbia County 31-27-65. This well, permitted to a 7,000-ft depth, is a relatively rare test to penetrate the deeper sediments at Mist.

Damon to deepen well

Damon Petroleum Corporation plans to reenter the Stauffer Farms 35-1 well. This well, located in sec. 35, T. 4 S., R. 1 W., Marion County, was drilled to a depth of 2,752 ft and was suspended in December 1986. Damon plans to reenter and deepen the well. Permit depth is 2,900 ft for this Willamette Valley test.

Recent permits

Permit no.	Operator, well, API number	Location	Status, proposed total depth (ft)
396	Interwest Exploration Cavenham 33-1 36-007-00018	SW¼ sec. 5 T. 6 N., R. 7 W. Clatsop County	Application; 8,000.
397	Damon Petroleum Corp. Stauffer Farms 35-1 D 36-047-00020-80	NW¼ sec. 35 T. 4 S., R. 1 W. Marion County	Location; 2,900.

□

New geologic map for Baker County gold mining district released

The Oregon Department of Geology and Mineral Industries (DOGAMI) has released a new geologic map of the Elkhorn Peak 7½-minute quadrangle. The area is part of the Rock Creek- Sumpter-Baker gold mining district. It also contains limestone deposits from which chemical-grade calcium carbonate has been produced in the past.

The new release, *Geology and Mineral Resources Map of the Elkhorn Peak Quadrangle, Baker County, Oregon,* is map GMS-41 in DOGAMI's Geological Map Series and was prepared by geologists M.L. Ferns and H.C. Brooks of DOGAMI, D.G. Avery of the USDA Forest Service, and C.D. Blome of the U.S. Geological Survey (USGS). It is part of an ongoing mapping program partially funded by the USDA Forest Service and also represents the first DOGAMI map published in part under the COGEOMAP program of the USGS.

The map area is located just west of Baker and includes the southeast portion of Elkhorn Ridge between Rock Creek and Phillips Lake. It is geographically rugged—with over a mile of relief—and geologically complex, containing rocks that represent fragments of ocean floor and island arcs rafted against the North American continent 100 to 160 million years ago.

The full-color map (scale 1:24,000) shows rock units and geologic structure on a topographic base and identifies zones of mineralization, mines and prospects, and locations of rock samples and fossils. It is accompanied by three geologic cross sections, a discussion of mineral deposits, and a table describing 67 known mines and prospects in the area. A separate sheet contains a detailed sample location map and descriptive and analytic tables for rock samples and fossils.

The new map, GMS-41, is now available at the Oregon Department of Geology and Mineral Industries, 910 State Office Building, 1400 SW Fifth Avenue, Portland, OR 97201. The purchase price is $6. Orders under $50 require prepayment. □