Miocene Floras from Fingerrock Wash Southwestern Nevada

By JACK A. WOLFE

SHORTER CONTRIBUTIONS TO GENERAL GEOLOGY

GEOLOGICAL SURVEY PROFESSIONAL PAPER 454-N

Description of fossil plants from the southern Great Basin, with emphasis on their significance to phytogeography and floristic evolution

U.S. DEPARTMENT OF THE INTERIOR
March 3, 1849

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1964

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

CONTENTS

ILLUSTRATIONS

[Plates 1-12 follow index]

TABLES

MIOCENE FLORAS FROM FINGERROCK WASH, SOUTHWESTERN NEVADA

By JACK A. WOLFE

ABSTRACT

Two floras of Miocene age, the Fingerrock and Stewart Spring, are found in a stratigraphic section that also contains fossil mammals. The Fingerrock flora occurs in beds below the Stewart Spring local fauna of transitional Hemingfordian-Barstovian (middle-late Miocene) age, and the Stewart Spring flora occurs above that fauna but below the Cedar Mountain local fauna of Cerrotejonian (earliest Pliocene) age.

The late Hemingfordian Fingerrock flora was dominated by the live oak, *Quercus chrysolepis*, but most of the flora is composed of species found in contemporaneous floras of the Columbia Plateau. These species include lobed *Quercus, Carya, Ulmus, Zelkova, Platanus*, and *Acer*. The lack here of certain other species found in this association to the north indicates that the Fingerrock flora lived in a drier climate than prevailed at the same time on the Columbia Plateau. Nevertheless the Fingerrock flora was a warm-temperate mesophytic flora. Twenty-four species are described from the Fingerrock flora, none of which are new.

The early, or more probably middle, Barstovian Stewart Spring flora is, besides the expected lacustrine element, dominated by *Quercus chrysolepis, Picea breweriana*, and *Chamaecyparis nootkatensis*. This assemblage is typically found only in western Nevada and is further restricted to floras of Barstovian and Clarendonian age. Most of the species in the Stewart Spring flora appear to be descended from northern mesophytic forms, although the flora has a subhumid aspect different from the northern floras. Only a small element in the Stewart Spring flora may contain species of southern origin. Several phylads in the Stewart Spring flora are now found on the margins of and in the Great Basin. The Stewart Spring flora contains 42 described species, 9 of which are new.

INTRODUCTION

The Miocene floras of the southern Great Basin are of interest because it was in this region during the Miocene epoch that the subhumid flora first became dominant (Axelrod, 1958). Axelrod (1956, 1958) described and discussed some of the "Mio-Pliocene" floras of the southern Great Basin. With the exception of the middle Miocene Tehachapi flora (Axelrod, 1939), however, knowledge of middle and early late Miocene floras from this area is singularly lacking.

In 1960, vertebrate paleontologists from the University of California discovered several new plant localities in the Stewart Valley of southwestern Nevada. This region is already well known for numerous vertebrate fossils, and the plant localities can be related stratigraphically to the mammalian geochronology. One locality occurs several hundred feet lower than an early Barstovian fauna and is therefore considered to be Hemingfordian (middle Miocene) at the youngest. The other localities occur in paper shales between the beds containing early Barstovian and Clarendonian mammals, and thus this flora can be considered of middle or late Barstovian age.

The paper shales mentioned above are not only notable for the abundant and well-preserved leaves, seeds, and flowers but also for numerous fossils of insects and fishes. Exhaustive collecting in the future will probably bring these paper shales the same prominence as the famed paper shales near Florissant, Colo.

The paper-shale locality was first found by Mr. S. D. Webb of the University of California (Berkeley). Other vertebrate paleontologists have assisted in the collection of the fossil plants and in the discussion of mutual problems, and I particularly wish to thank Prof. D. E. Savage and Mr. J. R. Mawby, both of the University of California (Berkeley). Dr. H. D. MacGinitie has contributed in the discussion of paleobotanical problems.

GEOLOGIC OCCURRENCE

The fossil plants occur in a sequence of volcanic rocks lying in a north-south basin on the west flank of the Cedar Mountains (fig. 1). The lower part of the sequence is composed primarily of basaltic and rhyolitic flows with interbeds of tuffaceous sediments. There is no evidence in the lower part of widespread lacustrine conditions, and the sediments appear to have been deposited in rivers and ponds.

The Fingerrock flora (USGS paleobotancial loc. 9882) occurs in the lower part of this section, in a buff-colored water laid tuff that crops out for a lateral extent of about 150 yards. On weathering the tuff is white. To the south, the sedimentary rocks dip under a series of rhyolitic flows. About one-quarter of a mile to the south of locality 9882, tuffaceous rocks containing mammals (the Stewart Spring local fauna) rest on top of

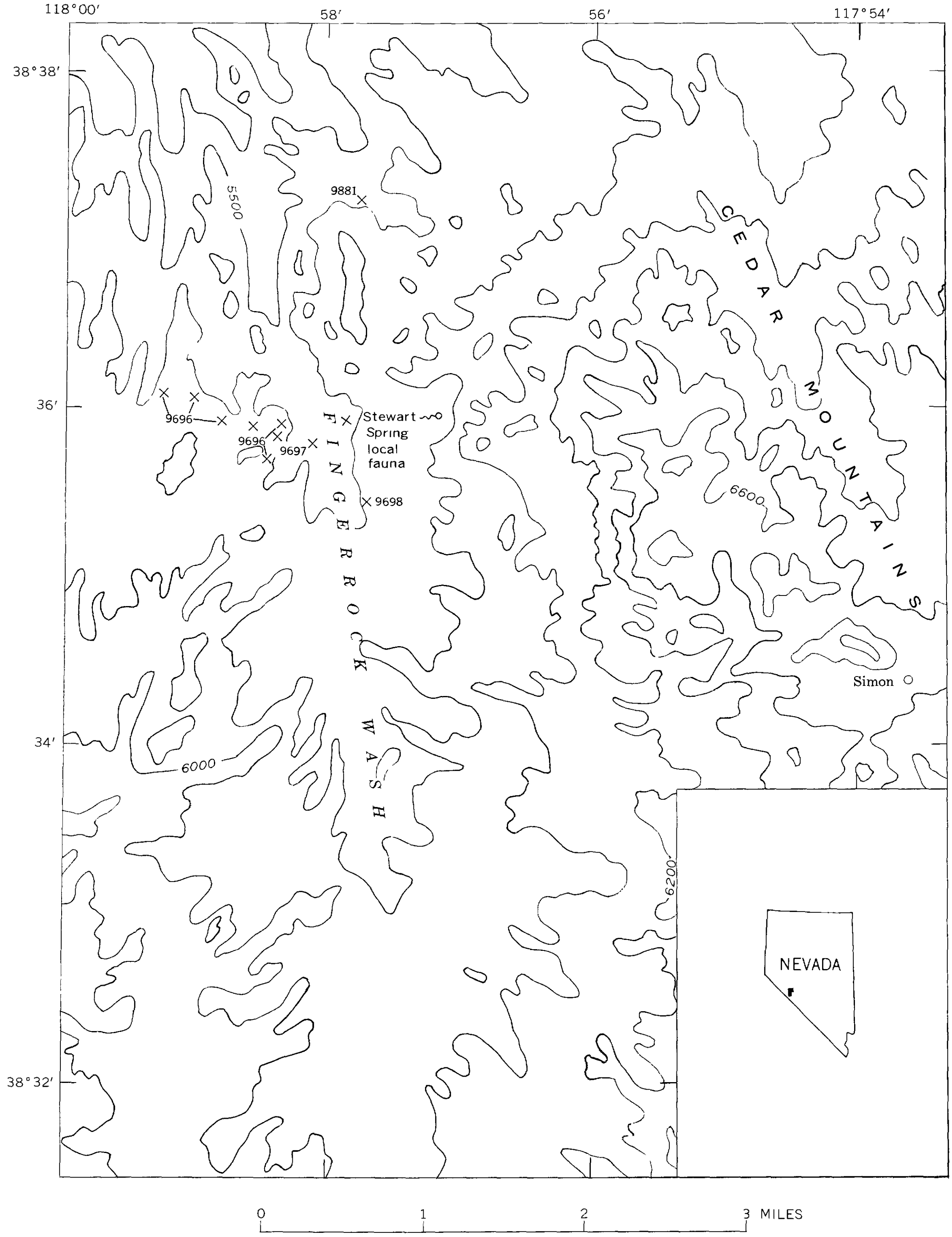


Figure 1.—Index map of the Fingerrock Wash area showing fossil localities.

the rhyolites. There appears to be at least one fault in the rocks in the strata that separate the mammals and plants, but the displacement along the fault is probably only a few feet.

Above the mammal beds, the section is composed of thin-bedded fine-grained shales, so-called paper shales (fig. 2). Plants from these shales have been collected from 75 feet (locs. 9697, 9698) and 200 feet (loc. 9696) above the mammals. The floras from the individual localities do not appear to differ and hence all are included in the Stewart Spring flora. Locality 9696 has furnished the most abundant flora. Collections were made for about a mile along the outcrop of this bed which was traced for at least an additional 2 miles. The extent of the shales indicates that the lake in which they formed had dimensions of at least 7 by 4 miles.

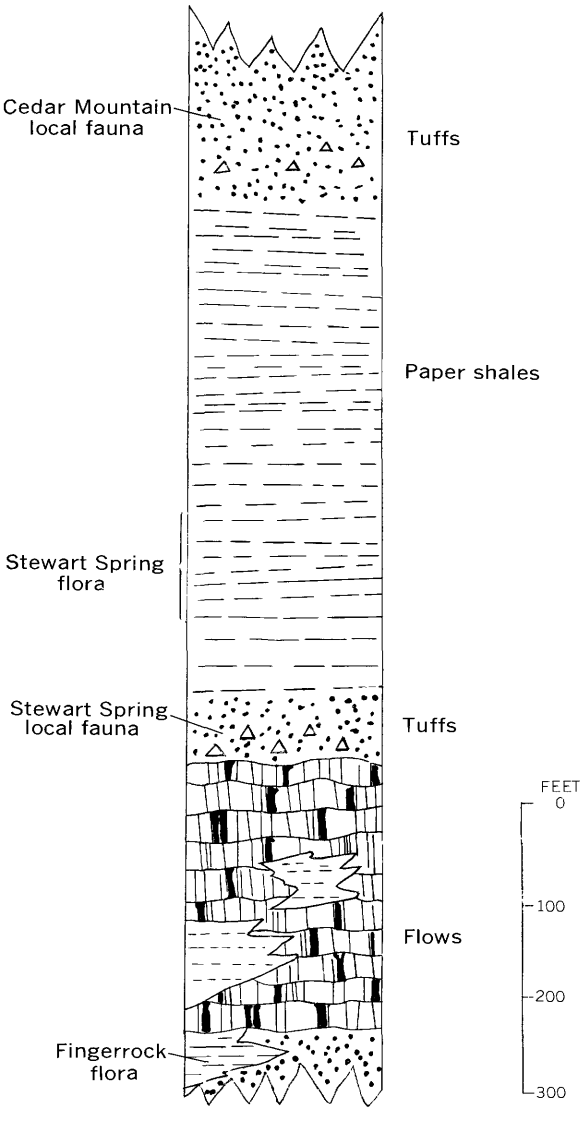


FIGURE 2.—Composite stratigraphic section of part of Tertiary rocks on west flank of Cedar Mountains.

Above locality 9696, the shales are sparingly fossiliferous and grade into a sequence of sandy tuffs. About 400 feet above locality 9696 is the horizon that 16 miles to the southeast contains Clarendonian mammals (D. E. Savage, oral communication, 1960).

Rocks lithologically similar to those in the upper part of the Stewart Valley section have been called the Esmeralda Formation (Turner, 1900). The type Esmeralda is more than 50 miles south of Stewart Valley, however, and no continuity can be demonstrated at this time. Axelrod (1956) designated a similar lacustrine sequence 50 miles east of Stewart Valley, the Aldrich Station Formation. In addition, the paleontologic evidence indicates that the upper part of the Stewart Valley section is correlative with Axelrod's Aldrich Station Formation. The lithologic similarities appear, however, to be due more to a similar environment of deposition in isolated basins than to remnants of a once continuous and large basin. Naming of rock units in the Stewart Valley should await the availability of large-scale topographic maps so that meaningful detailed geologic maps can be made and the relations of the various rock units worked out.

FLORAL COMPOSITION AND INTERPRETATION

The floristic relationships of a fossil flora depend largely on the taxonomic, that is morphologic, relationships of the member species. In early Tertiary floras, the taxonomic relationships of the species to extant species are generally so obscure that the floristic relationships are of a general nature. For late Tertiary floras, the resemblance to extant floras is more apparent, and inferences deal with geographically more restricted modern floras. Early Tertiary communities bear little, if any, resemblance to extant communities; the Miocene warm-temperate mesophytic flora has more specific relationships to floras of eastern Asia and eastern North America, although the communities are not closely comparable.

It is difficult, at best, to attempt a reconstruction of the communities represented in fossil floras. Even modern communities are variable in content; for example, the redwood community has only one plant on which the concept is based, *Sequoia sempervirens*. Throughout much of its range, the redwood is associated regularly with species such as *Acer macrophyllum*, *Alnus rubra*, *Umbellularia californica*, and *Corylus californica*. But in some parts of the redwood's range one or more of its "typical associates" are lacking; the community in these parts is no less a redwood community. Similarly, in southern Oregon, most of the redwood's associates may be present but the redwood is not, and this community cannot therefore be called a redwood community. Extant plant communities are of only limited use in the interpretation of fossil floras.

At an early date, Chaney (1936) attempted to trace the redwood community through time. This attempt was a failure because of the misidentification of *Metasequoia* as *Sequoia* (Chaney, 1952), but even the substituted concept of a *Metasequoia* community is meaningless unless the age and geographic area are also defined. *Metasequoia glyptostroboides* [= *M. occidentalis* (Newberry) Chaney] occurs in definitely tropical early Tertiary floras with Menispermaceae, Icacinaceae, Lauraceae, Sapindaceae, and Dilleniaceae; this species is also found in the late Miocene Hidden Lake flora with *Abies*, *Picea*, *Liriodendron*, *Amelanchier*, and *Acer*. As Mason (1947, p. 204) has written:

> It therefore becomes necessary, in tracing floristic records through time, to re-define the flora repeatedly in terms of the changed associates of some of the more persistent characteristics.

Mason (1934, 1944) has also shown that in the short period of time from the Pleistocene to Recent, such apparently well defined communities as the closed cone pines have undergone considerable change in composition. In a region that has had a relatively stable climate, soil, and topography, communities may have remained similar over considerable periods of time, but in a region such as western North America all three factors have been rapidly changing. Hence, we cannot expect plant communities in this region to remain unchanged. The only reasonable method for inferring communities in fossil floras is on the basis of the fossil flora itself. The communities based on the extant flora should have little value in floristic interpretations of the fossil flora. Mason (1947, p. 204) considered the problems of the duration of communities:

> Because of the differences in genetic constitution and in physiological capacity between the various species of the community and because of the operation of different genetic mechanisms, it is hardly to be expected that any two or more species of such a community will follow precisely the same historical pattern even for a relatively short time.

Through careful taxonomic work in both fossil and extant plants, it is possible to infer how the plant associations, both fossil and extant, have come about. These inferences ultimately rest on the morphologic relationships of the plants themselves. For example, if most of the species in two distant floras are conspecific or closely related (vicarids), we infer that the organisms in these floras are descended from common ancestors in a relatively recent epoch. Whether we think that the ancestors migrated from one region to the other or migrated into both regions from another is another inference for which we need sequences of floras in the intervening area. If the morphologic relationships are more distant, or only compose a small part of the flora, then the floral connection may have been in the distant past or may have involved only a few members of the flora. In addition, it is possible that similar floras may be the result of parallel evolution in regions with similar environmental histories.

FINGERROCK FLORA

SYSTEMATIC LIST OF THE FINGERROCK FLORA

- Tracheophyta
  - Pteropsida
    - Gymnospermae
      - Coniferales
        - Pinaceae
          - *Abies concolor* Lindley
          - *Picea magna* MacGinitie
          - *Pinus monticola* Douglas
          - *Pinus ponderosa* Douglas
        - Cupressaceae
          - *Chamaecyparis nootkatensis* (Lambert) Spach
        - Taxodiaceae
          - *Glyptostrobus* sp.
    - Angiospermae
      - Monocotyledones
        - Glumiflorae
          - Cyperaceae
            - *Cyperacites* sp.
      - Dicotyledones
        - Salicales
          - Salicaceae
            - *Populus lindgreni* Knowlton
        - Juglandales
          - Juglandaceae
            - *Carya bendirei* (Lesquereux) Chaney and Axelrod
        - Fagales
          - Betulaceae
            - *Alnus relata* (Knowlton) Brown
            - *Betula thor* Knowlton
          - Fagaceae
            - *Quercus chrysolepis* Liebmann
            - *Quercus simulata* Knowlton
            - *Quercus pseudolyrata* Lesquereux
        - Urticales
          - Ulmaceae
            - *Ulmus newberryi* Knowlton
            - *Zelkova oregoniana* (Knowlton) Brown
        - Ranales
          - Berberidaceae
            - *Mahonia reticulata* (MacGinitie) Brown
        - Rosales
          - Platanaceae
            - *Platanus bendirei* (Lesquereux) Wolfe, n. comb.
          - Rosaceae
            - *Amelanchier subserrata* Smith
            - *Cercocarpus antiquus* Lesquereux
            - *Sorbus harneyensis* Axelrod
        - Sapindales
          - Aceraceae
            - *Acer bolanderi* Lesquereux
            - *Acer macrophyllum* Pursh
          - Ericales
          - Ericaceae
            - *Arbutus traini* MacGinitie

TABLE 1.—*Numerical abundance of Fingerrock fossils*

Species	*Number of specimens*	*Per-cent*
Quercus chrysolepis	119	43
Picea magna	26	9
Quercus simulata	25	9
Acer macrophyllum	16	6
Glyptostrobus sp	13	5
Ulmus newberryi	11	4
Zelkova oregoniana	11	4
Pinus monticola	9	3
Platanus bendirei	9	3
Carya bendirei	8	3
Quercus pseudolyrata	8	3
Mahonia reticulata	4	1
Abies concolor	3	1
Arbutus traini	3	1
Acer bolanderi	2	1
Pinus monticola	2	1
All others	8	3
Total	277	100

COMPOSITION

The numerical abundance of the various fossils are listed in table 1. From this table, it is apparent that the dominant trees near the site of deposition were the three oaks, *Acer macrophyllum*, *Zelkova*, *Ulmus*, *Picea magna*, *Pinus*, *Glyptostrobus*, *Platanus*, and *Carya*. It is assumed that all these plants grew in proximity to one another and hence can be thought of as a natural association. It is possible that some of the rarer fossils, for example the *Cercocarpus*, may have been part of another association, but it is equally probable that the *Cercocarpus* was just a rare shrub in the forest.

The general similarity of the Fingerrock association to that in contemporaneous Miocene floras in Oregon is apparent. All these floras have an association of *Quercus pseudolyrata*, *Carya bendirei*, *Zelkova oregoniana*, *Ulmus* spp., *Quercus simulata*, *Platanus bendirei*, and *Arbutus traini*. One noticeable difference in the Fingerrock *Quercus pseudolyrata* assemblage is the lack of *Fagus*, *Liquidambar*, and *Pterocarya*, all of which are of common occurrence in the northern parts of the association.

An unusual feature of the Fingerrock flora is the rarity or lack of what are considered typical fluviatile or lacustrine species. Fossils of *Populus*, *Alnus*, and *Betula* are present but are rare, and *Salix* is completely lacking. This indicates that the fossil assemblage may be the result of some depositional selectivity, with the more delicate leaves of plants such as *Populus* and *Salix* being destroyed. Most of the preserved leaves are relatively thick and resistant, for example, *Quercus chrysolepis*, *Mahonia*, *Cercocarpus*, and *Arbutus*. On the other hand, large twigs of *Glyptostrobus* and a complete leaf of *Sorbus* would be unusual in this context.

The coniferous element of *Abies*, *Picea*, and *Pinus* was apparently a part of the *Quercus pseudolyrata* association. This element is only present in floras of at least moderate altitude (above 2,000 ft) as in the Hidden Lake (Oregon Cascades), Blue Mountains, Stinking Water, and Thorn Creek floras. The in-place stumps in the Stinking Water basin (Chaney, 1959, p. 92) indicate that a spruce was directly associated with the oaks. Hence, the occurrence in the Fingerrock flora of Pinaceae indicates a moderate altitude for this region.

The lack of *Liquidambar*, *Fagus*, lobed white oaks, and *Pterocarya* is probably significant in regard to the climate. In addition, the Fingerrock lacks any of the plants of subtropical affinities (*Cinnamomum*, *Persea*, *Lindera*, and *Magnolia*) that are found in contemporaneous floras to the north. These differences are in my opinion too numerous to be due only to local habitat differences. It is more reasonable to suggest that the Fingerrock flora lived under greater temperature extremes and less precipitation than Chaney (1959, p. 56–60) postulated for the Mascall flora.

FLORISTIC RELATIONSHIPS

Nearly all the Fingerrock species are known in older and contemporaneous floras to the north in Oregon. The two exceptions are *Cercocarpus antiquus* and *Sorbus harneyensis*. The recorded occurrence of *S. harneyensis* from the Fingerrock is the oldest known and hence for present considerations this species is valueless. *Cercocarpus antiquus*, however, appears to be descended from a new species in the early Miocene of Oregon. Thus the obvious relationship of the Fingerrock flora is to the northern floras. What type of flora preceded the Fingerrock in southwestern Nevada is unknown. The bulk of the northwest Miocene flora is derived from the subtropical Oligocene flora of the northwest and from warm-temperate Oligocene flora of the Cordilleran region. It is likely that the Fingerrock flora was developed simultaneously from the same or similar sources.

Of direct concern here is the concept of the Arcto-Tertiary Geoflora, which is used to explain the floristic relationships between eastern North America, northwestern North America during the Miocene, eastern Asia, and western Europe during the Miocene. The Arcto-Tertiary concept infers the existence of a warm-temperate Eocene (perhaps even Cretaceous) boreal flora virtually similar to the extant east Asian and east North American floras. In response to cooling climate, this flora migrated southward into middle latitudes during the Oligocene and Miocene. In the western parts of Eurasia and North America, most of the species of this flora became extinct, but the flora has maintained its composition or identity in the eastern parts.

The Arcto-Tertiary theory has much to recommend it in its simplicity of explaining the floristic similarities mentioned above. On the other hand, the theory does not explain: (1) the floral sequence in Alaska, or (2) the floral dissimilarities between eastern Asia and western North America. Concerning the first point, I have elsewhere briefly discussed (MacNeil and others, 1961) the Alaskan floras. The mesophytic warm-temperate flora is first recorded in Alaska in the middle and late Oligocene rocks; the earlier floras known in Alsaka contain abundant cycads, palms, Lauraceae, Menispermaceae, *Alangium*, and other taxa indicative of subtropical if not tropical climates. Peculiarly, the early Tertiary Puget flora of Washington (Wolfe and others, 1961) contains more "warm-temperate" genera than are known from our admittedly meager Alaskan Eocene; among these are: *Carya*, *Pterocarya*, *Juglans*, *Alnus*, *Betula*, *Quercus*, *Ulmus*, *Zelkova*, *Cercidiphyllum*, *Tetracentron*, *Liquidambar*, and *Platanus*. Lacking are some of the more characteristic temperate taxa such as the lobed black and white oaks, Rosaceae, Aceraceae, and Salicaceae, but these are lacking or rare in Paleocene and Eocene floras throughout the Northern Hemisphere.

At apparently the same time, in the later half of the Oligocene, recognizably warm-temperate floras composed of Juglandaceae, Fagaceae, Rosaceae, Aceraceae, Salicaceae, and Betulaceae first appear, not only in Alaska but also at middle latitudes in North America (MacGinitie, 1953; Becker, 1961) and Eurasia (Krystofovich, 1956). Some plant migration is probably involved, for this is the most reasonable explanation for the spread of *Cercidiphyllum crenatum*. This species first appeared in the Oligocene of Washington (Wolfe, 1961) (probably descended from *C. elongatum* and by late Oligocene was present throughout most of Eurasia. Nevertheless, extensive migrations as demanded by the Arcto-Tertiary concept appear to be unreasonable.

The species of this Oligocene warm-temperate flora do not appear to show any greater relationships between North America and Eurasia than now prevail, although more work is needed to fully validate this conclusion. The Kazakhstan flora has a few identical or closely related species to the Kenai flora of Alaska, but there are even fewer closely related species in the Ruby Valley flora of Montana.

The Miocene flora of the northwestern conterminous United States, although similar to the extant east Asian flora, has significant differences. From the early Miocene flora of the Oregon Cascades, more than 150 species of presumably woody plants are known. Some of these species are closely similar to extant east Asian species and indicate some floral continuity. On the other hand, there is a large group of species in the following genera, that show no correspondence to the Asian flora: *Colubrina*, *Lyonothamnus*, *Cercocarpus*, *Arbutus*, *Juglans* (*Rhysocaryon*), *Quercus* (*Erythrobalanus*), *Platanus*, *Securidaca*, and *Acer*. Other species belong to genera that today survive only in east Asia, but their morphologic relationships to east Asian species are as distant as, for example, the relationship between *Acer macrophyllum* and the extant east Asian maples.

Some of the close comparisons that can be drawn between the west American Miocene and extant east Asian flora are in *Carya* and *Pterocarya*. The American Miocene species in these genera, however, can generally be placed in phylads that extend back into the tropical Eocene floras. Probably most of the strong floristic similarity between the Miocene of western North America and the Recent of east Asia is due to parallel evolution in related phylads in response to similar environments. These genera do not appear to have formed their own characteristic association in the Eocene and older epochs; rather, they probably were members of the tropical and subtropical floras in both North America and Eurasia.

The Fingerrock association of species of *Carya*, *Zelkova*, *Ulmus*, lobed *Quercus*, *Populus*, *Platanus*, *Acer*, and *Glyptostrobus* is due to the coincidence of tolerances of these species. That these tolerances have changed, or rather that phylads have undergone significant physiologic evolution in conjunction with migration and morphologic evolution is evident. The Puget individuals of *Alnus*, *Carya*, *Ulmus*, and *Glyptostrobus*, although possibly ancestral, almost certainly had tolerances different from those of the Fingerrock individuals of the same phylads.

The evolution of the warm-temperate mesophytic floras of the Northern Hemisphere still needs much more elucidation. From the preceding discussion it is evident that the concept of the Arcto-Tertiary Geoflora does not fully explain and is partly contradicted by the fossil record. On the basis of a consideration of the salient features of living plants, Mason (1947, p. 205) came to the same conclusion:

> It is difficult * * * to envisage such floristics as an Arcto-Tertiary flora (Chaney 1936) in contrast to a Madro-Tertiary flora (Axelrod, Mss.) as accounting for floristic sources and centers of origin during Tertiary time. Such concepts of floristic organization and development demand unity and stability of communities in time and space beyond what is possible in the light of the nature of floristic dynamics such as are bound up with the genetics of the population, the physiology of the individual, and the diversity and fluctuation of the environment.

STEWART SPRING FLORA

SYSTEMATIC LIST OF THE STEWART SPRING FLORA

- Tracheophyta
  - Pteropsida
    - Gymnospermae
      - Coniferales
        - Pinaceae
          - *Abies concolor* Lindley
          - *Abies* sp.
          - *Larix occidentalis* Nuttall
          - *Picea breweriana* S. Watson
          - *Picea magna* MacGinitie
          - *Pinus ponderosa* Douglas
          - *Tsuga heterophylla* Sargent
        - Cupressaceae
          - *Chamaecyparis nootkatensis* (Lambert) Spach
          - *Juniperus nevadensis* Axelrod
    - Angiospermae
      - Monocotyledones
        - Glumiflorae
          - Gramineae
            - *Poacites* sp.
          - Cyperaceae
            - *Cyperacites* sp.
      - Dicotyledones
        - Salicales
          - Salicaceae
            - *Populus cedrusensis* Wolfe, n. sp.
            - *Populus tremuloides* Michaux
            - *Populus trichocarpa* Torrey and Gray
            - *Populus washoensis* Brown
            - *Populus* sp.
            - *Salix pelviga* Wolfe, n. sp.
        - Garryales
          - Garryaceae
            - *Garrya axelrodi* Wolfe, n. sp.
        - Juglandales
          - Juglandaceae
            - *Juglans major* Torrey
        - Fagales
          - Betulaceae
            - *Betula* sp.
          - Fagaceae
            - *Quercus cedrusensis* Wolfe, n. sp.
            - *Quercus chrysolepis* Liebmann
        - Ranales
          - Berberidaceae
            - *Mahonia reticulata* (MacGinitie) Brown
        - Rosales
          - Saxifragaceae
            - *Philadelphus nevadensis* Condit
            - *Ribes webbi* Wolfe, n. sp.
            - *Ribes* sp.
          - Rosaceae
            - *Amelanchier cusicki* Fernald
            - *Cercocarpus antiquus* Lesquereux
            - *Holodiscus fryi* Wolfe, n. sp.
            - *Lyonothamnus parvifolius* (Axelrod) Wolfe, n. comb.
            - *Peraphyllum vaccinifolium* (Knowlton) Wolfe, n. comb.
            - *Prunus* sp.
            - *Rosa* sp.
            - *Sorbus* sp.

- Tracheophyta—Continued
  - Pteropsida—Continued
    - Angiospermae—Continued
      - Dicotyledones—Continued
        - Sapindales
          - Anacardiaceae
            - *Astronium mawbyi* Wolfe, n. sp.
            - *Rhus integrifolia* Bentham and Hooker
            - *Schinus savagei* Wolfe, n. sp.
          - Sapindaceae
            - *Sapindus* sp.
        - Rhamnales
          - Rhamnaceae
            - *Colubrina* sp.
        - Myrtiflorae
          - Elaeagnaceae
            - *Elaeagnus cedrusensis* Wolfe, n. sp.
        - Ericales
          - Ericaceae
            - *Arbutus traini* MacGinitie
            - *Arctostaphylos masoni* Wolfe, n. sp.

TABLE 2.—*Numerical abundance of Stewart Spring fossils*

Species or genus	*Number of specimens*	*Percent*
Picea	49	15
Quercus chrysolepis	47	14
Lyonothamnus parvifolius	43	12
Grass	28	8
Populus	22	7
Chamaecyparis nootkatensis	22	7
Tsuga heterophylla	13	4
Pinus ponderosa	9	3
Arbutus traini	8	2
Abies concolor	8	2
Ribes webbi	7	2
Salix pelviga	7	2
Peraphyllum vaccinifolium	6	2
Mahonia reticulata	6	2
Larix occidentalis	6	2
Cercocarpus antiquus	6	2
All others	47	14
Totals	334	100

COMPOSITION

The mixture of Pinaceae with dicotyledons is more pronounced in the Stewart Spring flora than in the Fingerrock flora. Pinaceae form a conspicuous element of the Stewart Spring flora, both in variety and numerical abundance, indicating that they were common forest trees. The dicotyledon flora is also rich, with a large lacustrine and (or) fluviatile element. The abundant remains of *Populus* and *Salix* are consonant with the present habitats of species of these genera.

The abundance of complete leaves of the *Lyonothamnus* is indicative of a lacustrine habitat for this species. However, as with *Quercus chrysolepis* and the gymnosperms, *Lyonothamnus* was probably a common forest tree. Other species that, judged from their numerical abundance, were numbers of the forest association are *Ribes webbi*, *Mahonia reticulata*, *Cercocarpus antiquus*, *Elaeagnus cerdrusensis*, and *Arctostaphylos masoni*. Fossils of all these species were collected for more than a mile along the outcrop of the main leaf-bearing bed. Nearly all extant species of these genera are shrubs, rather than trees, and it is reasonable to assume a similar habit for the fossil species.

Although remains of grass are abundant in the shales, the affinites of the grass or grasses are unknown. The common remains of grass could be interpreted as indicating a lacustrine habitat or a very great abundance in the forest.

The Stewart Spring flora shows considerable similarity to the Aldrich Hill and Horsethief Canyon floras (Axelrod, 1956) about 60 miles to the west. There are somewhat lesser similarities between the Stewart Spring and the Middlegate, Fallon, and Chloropagus floras (Axelrod, 1956) to the north and the Esmeralda flora to the south. As discussed later, most of these other floras are younger than the Stewart Spring. All these floras in western Nevada have a large number of species in common in two or more floras. A group of three species, *Picea breweriana*, *Quercus chrysolepis*, and *Chamaecyparis nootkatensis* is, however, the only group that all the floras have in common. This association of spruce, live oak, and cedar is the most characteristic feature of these floras. The oak and spruce fossils are everywhere abundant, but the cedar is typically rare. In table 3 the abundance of these three forms in the various floras is compared. In both the Horsethief Canyon and Stewart Spring floras, the representation of these species is conspicuously lower, but this can be correlated with the comparatively high representation of *Populus*, *Salix*, and other probable lacustrine genera. Other genera that are frequently found in the spruce-live oak-cedar association are *Lyonothamnus*, *Fraxinus*, *Amelanchier*, *Cercocarpus*, *Arbutus*, *Mahonia*, *Sequoiadendron*, and *Juniperus*.

TABLE 3.—*Comparison of relative abundance in percentage of spruce, live oak, and cedar in the Nevada Barstovian and Clarendonian floras*

Species	Stewart Spring	Horsethief Canyon	Aldrich Hill	Chloropagus	Fallon	Middlegate
Picea breweriana	15	3.6	25.4	64.3	83.5	84.3
Quercus chrysolepis	14	9.6	28.2	2.2	.7	.6
Chamaecyparis nootkatensis	7	.9	.4	2.8	.1	.1
Total	36	14.1	54.0	69.3	84.3	85.0

Floras with the dominant association of spruce, live oak, and cedar are restricted to western Nevada (fig. 3). The Barstovian, Upper Cedarville flora (LaMotte, 1936), the Trout Creek (MacGinitie, 1933), and the Clarendonian Goose Creek floras from the northern Great Basin are typical northwest mesophytic assemblages. No Neogene flora is known from the eastern Great Basin.

The climate under which the spruce-live oak-cedar association lived is best described as subhumid and warm temperature. A pronounced climatic change may have taken place in the late Hemingfordian-early Barstovian interval if the differences between the Fingerrock and Stewart Spring floras are indicative. Axelrod's (1956, fig. 13) suggestion of 20–35 inches of annual rainfall is a reasonable estimate, although it is unlikely that the lower figure was approached until well into the Claredonian. In the northern Great Basin, the persistence of species such as *Quercus deflexiloba* and *Zelkova oregoniana* into the the Hemphillian indicates a considerably greater amount of precipitation.

The occurrence of *Picea*, *Quercus*, and *Chamaecyparis* in the same floras is contrary to their Recent distribution (fig. 3). Although *Picea breweriana* and *Quercus chrysolepis* do have an overlap in ranges, the overlap is small. *P. breweriana* is restricted to the southern Oregon Coast Ranges and the Trinity, Siskiyou, and Klamath Mountains of northern California. In Oregon, the individuals of *P. breweriana* occur as low as 4,000 feet, but in California they occur at altitudes of 5,500–8,000 feet. *Q. chrysolepis* apparently overlaps the lower range of *P. breweriana* in the Trinity Mountains, but typically the canyon live oak is found at lower altitudes. Along the west slope of the Sierra Nevada, *Q. chrysolepis* is typically found up to 6,000 feet.

Chamaecyparis nootkatensis is, compared with the other two species, of northern distribution. From coastal southeastern Alaska, individuals of *C. nootkatensis* are found at increasingly higher altitudes to the south. Isolated southern outliers are found at altitudes of 2,500–6,100 feet in the central Oregon Cascades. Thus, at no place today is *C. nootkatensis* found in association with *Picea breweriana* or *Quercus chrysolepis*.

The comparatively large area of overlap in ranges of the three species in the Neogene (fig. 3) indicates that the tolerances of the extinct individuals were considerably different from those now living. Moreover, all three species occupied a greater area in the past. The present range of *Chamaecyparis nootkatensis* indicates that it is adapted to a cool moist climate; the Nevada occurrences must have been adapted to a considerably different climate. This does not necessarily indicate that lineages of *C. nootkatensis* have adapted through time to a different climate, for specimens of the species are also known in the Neogene floras of the Oregon Cascades. The Nevada occurrences probably represent extinct physiologic races.

Quercus chrysolepis has also been restricted through time. Specimens are known from decidedly mesic floras in the late Miocene of the Puget lowland, as well as in a mesic early Barstovian flora from the MacKenzie River basin of the Oregon Cascades. The Oregon occurrence is interesting because of the association with *Liriodendron*, *Pterocarya*, *Sophora*, and *Liquidambar*.

The record of *Picea breweriana* is somewhat less certain because of the difficulty in determining seeds of *Picea*. Nevertheless, it is apparent that *P. breweriana* was widely distributed from the Oregon Cascades south into central California and east into Nevada.

In general aspect, the Stewart Spring flora does not appear to be closely related to the Fingerrock flora or the Miocene mesophytic floras of the northwest. As was pointed out previously, the live oak-spruce-cedar association is constant in western Nevada and has no closely comparable association prior to Barstovian or after Clarendonian.

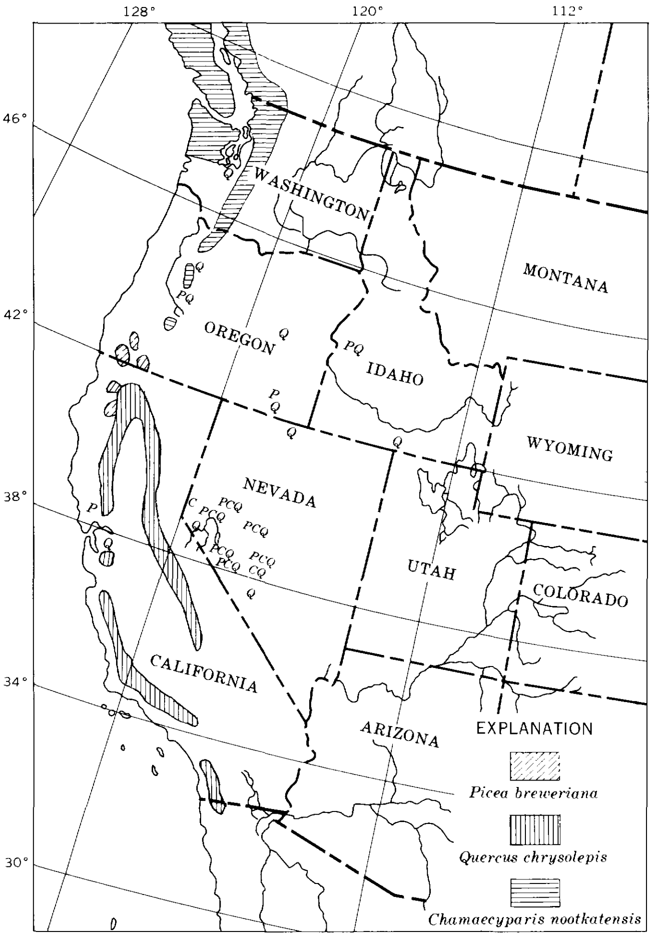


FIGURE 3.—Distribution map of *Picea breweriana*, *Quercus chrysolepis*, and *Chamaecyparis nootkatensis*. Patterned areas are Recent distribution; fossil occurrences denoted by P, Q, or C, respectively.

Nineteen of the Stewart Spring species are either poorly known or are not known to be related to any older species; the significance of these is of necessity minimized in the present discussion. Of the remaining 23 species, 3 groupings can be made: (1) species conspecific with or descended from species in the Fingerrock flora, (2) species conspecific with or descended from species in the northwest Miocene flora, and (3) species related to or possibly descended from species in the Oligocene flora of the Cordilleran region.

The first group, species, or phylads common to the Fingerrock and Stewart Spring floras contains:

Abies concolor
Picea magna
Pinus ponderosa
Chamaecyparis nootkatensis
Sorbus sp.
Quercus chrysolepis
Mahonia reticulata
Amelanchier cusicki
Cercocarpus antiquus
Arbutus traini

The second group, species, or phylads common to the northwest Miocene and Stewart Spring flora is:

Abies concolor
Picea breweriana
Picea magna
Pinus ponderosa
Tsuga heterophylla
Chamaecyparis nootkatensis
Populus tremuloides
Populus trichocarpa
Populus washoensis
Colubrina sp.
Salix pelviga
Juglans major
Betula sp.
Quercus chrysolepis
Mahonia reticulata
Ribes webbi
Amelanchier cusicki
Cercocarpus antiquus
Lyonothamnus parvifolius
Arbutus traini

The third group, Stewart Spring species with phylads in the Oligocene of the central and northern Rocky Mountain region, is:

Picea magna
Pinus ponderosa
Populus trichocarpa
Salix pelviga

Astronium mawbyi
Colubrina sp.
Quercus chrysolepis
Amelanchier cusicki
Cercocarpus antiquus
Sapindus sp.
Arctostaphylos masoni

These lists demonstrate that a large part of the Stewart Spring flora is of basically northwest mesophytic derivation. The only species that might be of more southerly origin are:

Populus cedrusensis
Garrya axelrodi
Rhus integrifolia
Elaeagnus cedrusensis
Quercus cedrusensis

The *Garrya* is particularly significant because the family is endemic to southwestern North America today and has never been recorded from the mesophytic floras of the Northwest or the Cordilleran region. Similarly, the *Quercus*, *Populus*, *Rhus*, and *Elaeagnus* may have come into southwestern Nevada from a southerly or southeasterly direction; however, only the *Rhus* has a close relative in the Tehachapi flora.

Garrya axelrodi and *Quercus cedrusensis* have strong similarities to species in both central California and northern Mexico. *Populus cedrusensis* shows about the same degree of differentiation from its Baja California relative as the *Garrya* and *Quercus* do from their Mexican relatives. *Juglans major* might be thought to indicate a Mexican derivation, but investigations of Tertiary Juglandaceae indicate that the immediate ancestor of *J. major* lived in the Northwest, where *Rhysocaryon* evolved from *Cardiocaryon*. It is possible that the southern Rocky Mountain region was analogous to the northern Rocky Mountain region in containing in the Oligocene ancestors of many of the warm-temperate subhumid species of the Neogene of the southwestern United States. Nevertheless, it is still evident that at least half of the Stewart Spring species are derivatives of mesophytic Oligocene and earlier Miocene species.

The Stewart Spring flora contains several species whose descendants have survived with little or no modification in the Great Basin or its western and northern margins. These species are:

Abies concolor
Picea breweriana
Pinus ponderosa
Juniperus nevadensis
Arctostaphylos masoni
Populus tremuloides
Populus trichocarpa
Amelanchier cusicki
Cercocarpus antiquus
Elaeagnus cedrusensis
Peraphyllum vaccinifolium

Some of these species adapted to the drier habitats of the Great Basin proper, but others are found only in the moister mountains bordering the region.

From the preceding discussions (see also p. N5–N6), certain basic conclusions can be drawn. The flora of a region at any particular time has the strongest relationship with the preceding flora of the same region. That is, through the processes of adaptation, lineages have continued in western North America through much of the Cenozoic. On the other hand, the communities, associations, and floras that we construct from these lineages are quite different through time. We cannot correctly say that the flora evolves; environmental, that is natural, selection operates only on a series of individuals. Through time these lineages of individuals have changing tolerances and (or) different areas of occupation, and in conjunction with extinction, the flora "changes." Concomitant with the changing environment, the plants have changed, both physiologically and morphologically. Mason (1953, p. 155) has aptly written: "Environmental elaboration over area and morphological elaboration occur together in time and in space and are the result of the same phylogenetic processes."

FLORAL PROVINCES IN THE BARSTOVIAN

The middle Miocene Fingerrock flora is in the same province as the northwest mesophytic flora, as shown by the large number of species in common. The floral continuity between the southern Great Basin and the Northwest during the Miocene is considerable, except for the lack in the south of probable highly mesophytic species. As interpreted here, the southern Great Basin and the Northwest were in the same floral province during the middle Miocene (Hemingfordian).

By late Miocene (Barstovian), the southern Great Basin floras, as represented by the Stewart Spring, have relatively few species in common with floras to the north. Not only is the Stewart Spring dissimilar to floras on the Columbia Plateau, but it is just as dissimilar to floras in the northern Great Basin. Early Barstovian floras such as the Payette and Succor Creek in Oregon and Idaho are dominated by the lobed black and white oaks, *Acer*, *Platanus*, and other clearly mesophytic groups that are lacking in the Stewart Spring. Later Barstovian northern floras (Upper Cedarville, Stinking Water, and Thorn Creek) still maintained the mesophytic aspect. Indeed, only recently have we come to realize that Clarendonian floras (Goose Creek) of the northern Great Basin are basically mesophytic. Even a Hemphillian flora from southern Idaho (Brown, 1940) contains wood of *Quercus*, *Carya*, *Acer*, and *Picea*. Of the Hemphillian and early Blancan floras, only the Alvord Creek and Cache Creek lack the typical mesophytic species (fig. 4).

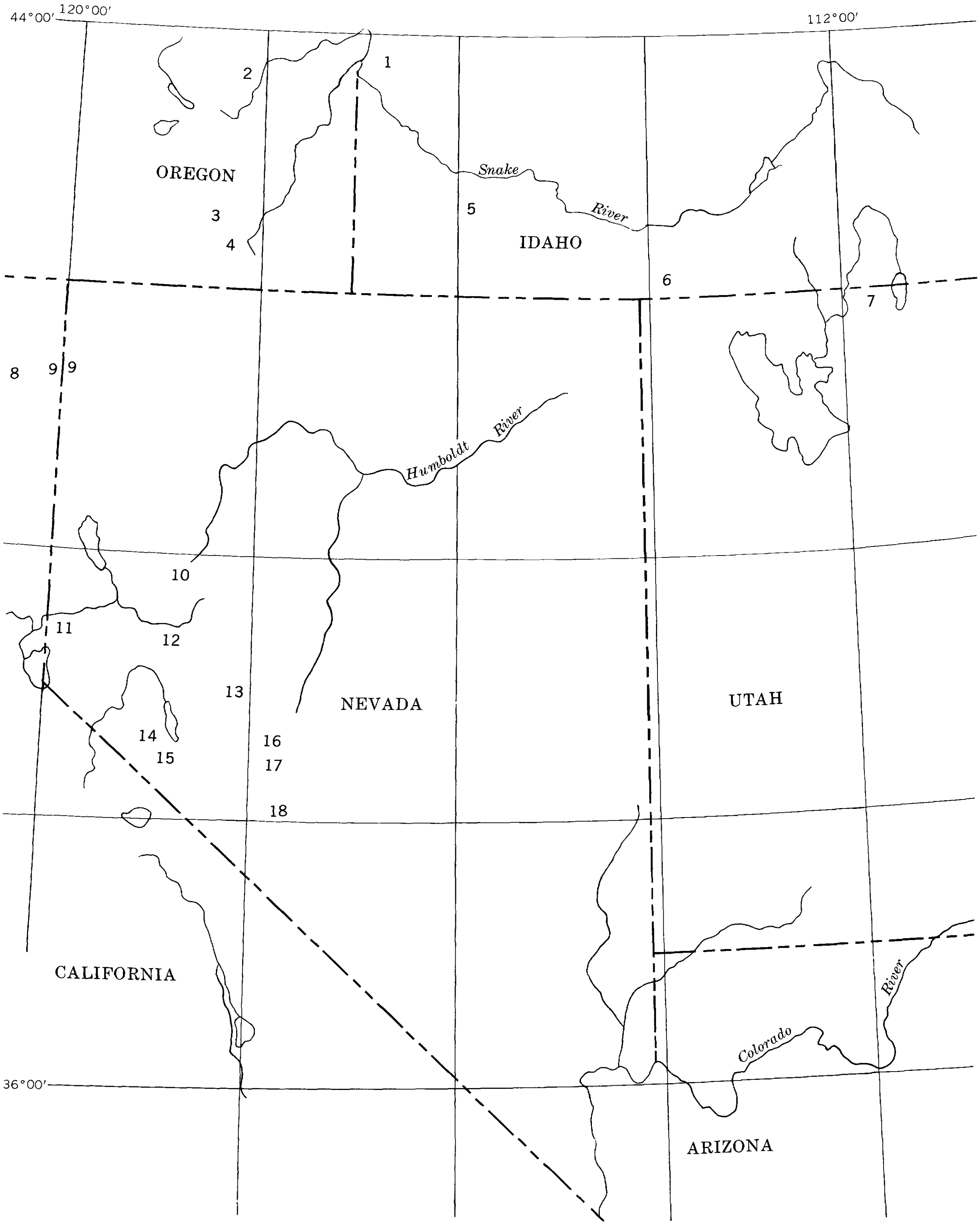


FIGURE 4.—Sketch map of Great Basin showing location of some Neogene floras. 1, Lower Idaho; 2, Stinking Water; 3, Alvord Creek; 4, Trout Creek; 5, Bruneau; 6, Goose Creek; 7, Cache Valley; 8, Alturas; 9, Upper Cedarville; 10, Chloropagus; 11, Verdi; 12, Fallon; 13, Middlegate; 14, Coal Valley; 15, Aldrich Hill and Horsethief Canyon; 16, Fingerrock; 17, Stewart Spring; and 18, Esmeralda.

To the west in the Sierra Nevada region, the mesophytic flora dominated. Both the Table Mountain (Condit, 1944a) and the Remington Hill (Condit, 1944b) floras are evidence to this interpretation. The age of the Remington Hill is uncertain, but it appears to be Barstovian. Significant mesophytic elements are *Quercus columbiana*, *Q. deflexiloba* (=*Q. pseudolyrata* of Condit), *Ulmus newberryi* (=*U. californica* of Condit), *Liquidambar*, *Platanus dissecta* (=*P. paucidentata*, in part of Condit), *Crataegus*, and *Carya* (=*Aesculus preglabra* of Condit). This flora is highly similar to late Barstovian floras from northern Oregon. The Table Mountain flora is dated by mammals as early Clarendonian. Significant elements here are: *Platanus dissecta*, *Crataegus*, *Persea*, *Carya*, *Cercis*, *Ulmus*, *Berchemia*, *Cornus*, *Rhododendron*. Once again, similarities may be noted to more northerly floras, as well as to the contemporaneous but more subtropical Neroly flora on the coast. It is apparent that the Stewart Spring is distinct floristically from the known Barstovian and Clarendonian floras to the west in California.

The middle Pliocene (Hemphillian) floras of central California, however, do show relationship on the generic level to the Stewart Spring flora. The Mulholland (Axelrod, 1944a) and the Oakdale (Axelrod, 1944b) floras contain: nonlobed live oaks, *Mahonia*, *Ribes*, *Sapindus*, and *Lyonothamnus*. On the species level, however, the resemblance is small, and the derivation of these Hemphillian floras was probably distinct from the Nevada floras. This is further indicated by the presence of several species related to or conspecific with species in the "Madro-Tertiary Geoflora."

To the south, the Hemingfordian Tehachapi (Axelrod, 1939) and the Clarendonian Ricardo (Webber, 1933) floras have very little in common, particularly on the species level, with the Stewart Spring. Hence, it may be concluded that at least since the Hemingfordian the southern Great Basin was in a floral province distinct from the area to the south. To the west and north, no floral dissimilarity is apparent until the Barstovian. The almost complete lack of Neogene floras in Utah and eastern Colorado does not allow a statement as to the eastward extent of the southern Great Basin floral province.

BIOSTRATIGRAPHY

The presence of associated mammalian fossils facilitates the age determination of these floras. The Stewart Spring flora occurs in beds about 400 feet stratigraphically below Clarendonian (early Pliocene) mammals of the Cedar Mountain local fauna (Fish Lake Valley local fauna of Wood and others, 1941) and 200 feet stratigraphically above the Stewart Spring local fauna (Wood and others, 1941). Although the age of the latter fauna has been somewhat uncertain, recent work demonstrates an age equivalent to the Mascall fauna (S. D. Webb, oral communication, 1960), that is, early Barstovian (late middle or early late Miocene). The distance that the Fingerrock beds lie below the Stewart Spring fauna is uncertain, and, because of the possible intervening unconformity, this fauna only fixes the upper age limit of the Fingerrock flora.

Hence, the age of the Fingerrock flora must rest primarily on paleobotanical evidence. Two species agree with the mammalian evidence on an upper age limit. *Quercus pseudolyrata* and *Platanus bendirei* are not known in beds younger than early Barstovian, after which their descendant species, *Q. deflexiloba* and *P. dissecta*, are found. *Q. pseudolyrata* also determines a lower age limit of probable early Hemingfordian, that is, equivalent to the Latah flora. The problem then becomes the determination of whether the Fingerrock flora is of early (Latah) or late (Mascall) Hemingfordian age. Two species, *Cercocarpus antiquus* and *Arbutus traini*, are more typical of later Miocene floras and thus indicate that the Fingerrock flora is more likely of late Hemingfordian age.

Various other Nevada floras have been considered to be of "Mio-Pliocene" age (Axelrod, 1956), that is latest Barstovian and early Clarendonian (Cerrotejonian of Savage, 1955). Included in these floras are the Aldrich Hill and Horsethief Canyon floras which have been included together as the Aldrich Station flora (Axelrod, 1956). Considering the relatively great stratigraphic separation (875 ft; Axelrod, 1956, p. 24), the two floras combined may represent a considerable segment of time. The upper flora, the Aldrich Hill, occurs 2,625 feet below fossil mammals (Axelrod, 1956). According to Axelrod (p. 55), the mammals include *Nannipus tehonensis*, which dates them as Cerrotejonian. The occurrence of the Aldrich Hill and Horsethief Canyon floras a few thousand feet lower than the mammals in a section composed primarily of thin-bedded shale and diatomite indicates to me that both floras are no younger than middle Barstovian. That is, both floras would be approximate correlatives of the Stewart Spring, or perhaps slightly older. Certainly the three floras are similar, but the occurrence in the Aldrich Hill and Horsethief Canyon floras of *Zelkova* and *Ulmus* may indicate that they are older than the Stewart Spring.

The floras found in the Carson Sink region all appear to be younger than the Aldrich Hill, Horsethief Canyon, and Stewart Spring floras. The Chloropagus and Fallon floras typically lack the warm-temperate and presumably older forms such as *Lyonothamnus*, *Sapindus*, *Astronium*, *Zelkova*, and *Ulmus*. The methods of dating by climatic interpretations or floristic evolution (Axelrod, 1956) are fully as approximate as the method of generic analysis (Wolfe and Barghoorn, 1960). All these floras, on any method, are of Barstovian or Clarendonian age.

From stratigraphic evidence, it is known that the Chloropagus flora is older than the Fallon but how much older is problematic. The composition of the two floras does indicate that they are of nearly the same age (Axelrod, 1956, p. 155) and are either latest Barstovian or early Clarendonian. Unfortunately, neither the Clarendonian Esmeralda (Knowlton, 1901) nor Coal Valley (Berry, 1927) floras are well-enough known for purposes of correlation.

The age of the Middlegate flora rests, in part, on fragmentary mammals. The mammals from the Middlegate Formation of Axelrod (1956) came from a bed slightly higher than the flora (Axelrod, 1956, p. 204), but R. W. Wilson (in Axelrod, 1956, p. 204) stated that "* * * the material appears to represent *Aphelops*. It suggests a Late Barstovian or Early Clarendonian age * * *" The stratigraphic significance of even well-preserved Neogene rhinocerotids is not certainly known. Fragmentary mammals stratigraphically more than 3,000 feet above the Middlegate flora were "tentatively" regarded as Hemphillian (Tedford in Axelrod, 1956, p. 205). Thus, the mammals do not aid significantly in the age determination of the Middlegate flora.

From the paleobotanical standpoint, the Middlegate is probably older than the Fallon and Chloropagus floras. Because of the occurrence in the Middlegate flora of *Acer macrophyllum*, *Acer columbianum*, *Platanus dissecta*, typical forms of *Quercus simulata*, *Persea*, and *Betula vera*, I am inclined to regard this flora as at least as old as the Stewart Spring. The Middlegate flora may be even older, and in particular the maples and sycamore indicate this. None of the known Clarendonian or Barstovian floras from central Nevada have these species in them, although they are present in the Fingerrock flora. On the other hand, the Middlegate lacks *Carya* and *Quercus pseudolyrata* and hence is probably younger than the Fingerrock. Thus the Middlegate flora appears to be transitional between the Fingerrock and Stewart Spring, that is, transitional Hemingfordian-Barstovian.

The age relationships of several Great Basin Neogene floras are summarized in table 4.

TABLE 4.—*Correlation of some Neogene floras of the Great Basin*

Mammalian provincial age	Cedar Mountains Coaldale area	Wassuk Range	Reno-Carson Sink area	Warner Range	Steens Mountains	Snake River basin
Blancan						Cache Valley
Hemphillian			Verdi	Alturas	Alvord Creek	Bruneau
Montediablan						Goose Creek
Cerrotejonian	Esmeralda	Coal Valley	Fallon			Lower Idaho
Barstovian	Stewart Spring	Aldrich Hill Horsethief Canyon	Chlorapagus	Upper Cedarville		
Hemingfordian	Fingerrock					

SYSTEMATICS

In this paper the taxonomic treatment of numerous species differs from current practices in North American Tertiary paleobotanical work. This difference is the result of the concept of taxa based solely on morphologic not on age criteria. Although several European and Asian workers have not hesitated to use names applied to extant plants for fossils, most American workers have been reluctant to do this. Hence, in La Motte's catalog (1952) not one Recent species is found below the Quaternary.

The practice of setting up separate names for fossils, no matter how similar to Recent plants, is based largely on the idea that in the fossil record we are dealing with isolated organs; what assurance, therefore, do we have that in the case of identical fossil and extant leaves (or any other organ) that the rest of the organs were also identical? This is an admittedly important question. In fact, we have no such assurance, but we can demonstrate in extant plants that foliage is diagnostic to the generic level, and hence we use generic names of extant plants for fossils. It is equally valid, therefore, to extend epithets of Recent plants into the fossil record if foliage is diagnostic to the specific level. In many genera of extant plants, the seeds and (or) foliage are specifically diagnostic, and I have thus placed fossils not distinct from the same living organs in Recent species.

The practice of using names of extant species for fossils has the advantage of indicating the rates of modernization in several groups. For example, most of the middle Miocene conifers are still extant. Most middle Miocene species of dicotyledons, on the other hand, are extinct. By late Miocene (Barstovian), a large number of living species was present, even among the dicotyledons. Of the 22 specifically identified Stewart Spring dicotyledons, 7, or 32 percent, are extant. In the Clarendonian Goose Creek flora, this reaches 50 percent. It should be noted that the dicotyledons are almost certainly woody, and the percentages for herbaceous dicotyledons may be considerably different.

The application of the concept of "ecospecies" to taxonomy has been rejected here; size of foliage is not considered to be a valid taxonomic criterion. The drawings of marginal venation include the venation only to the level of tertiaries.

Specimens are deposited in the U.S. National Museum (USNM) or in the University of California Museum of Paleontology, Berkeley (UCMP).

Class GYMNOSPERMAE

Order CONIFERALES

Family PINACEAE

Genus ABIES (Tourn.) Linnaeus

Abies concolor Lindley

Plate 1, figure 10; plate 6, figures 1–3, 6, 10, 11

Abies concolor Lindley, 1850, Jour. Hort. Soc. London, v. 5, p. 210.

Discussion.—The seeds, needle, and bract from the Stewart Spring localities figured here can be matched by the respective organs of the extant *Abies concolor*. Probably some specimens assigned to *A. concoloroides* Brown by various authors also represent *A. concolor*, but the former species contains a variety of types, most of which are closer to extant species other than *A. concolor*.

The Fingerrock specimen here assigned to *Abies concolor* appears to have a less rectangular wing than is typical of seeds of that species. More specimens may indicate that this difference is consistent and would hence form the basis for a new species. *Abies concolor* has not yet been certainly recorded from the middle Miocene.

Hypotypes: USNM 42025, 42032–42037, UCMP 8600–8603.
Occurrence: Fingerrock, Stewart Spring.

Abies sp.

Figure 5

Discussion.—This fragmentary seed, with the sharply expanded and relatively large wing, is similar to seeds of the extant *Abies magnifica* var. *shastensis* Lemmon. More fossil material, however, is needed in order to establish the specific relationship.

Specimen: USNM 42031.
Occurrence: Stewart Spring.

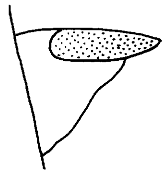


FIGURE 5.—*Abies* sp. USNM 42031, × 1.

Genus LARIX Tourn. ex Adanson

Larix occidentalis Nuttall

Plate 6, figures 23, 28, 29

Larix occidentalis Nuttall, 1849, Sylva North Am., v. 3, p. 143.

Discussion.—The twigs and seed figured here represent the first validated record of *Larix* in the Tertiary of North America. The whorled decurrent and sparsely spaced needles are characteristic of foliage of the genus; as well, the elongated winged seed with the round seed is typical of *L. occidentalis*. The general lack of *Larix* in western Tertiary rocks is surprising in view of the large representation of other of the larch's living associates. The only other possible record is on the basis of wood of unknown age (Beck, 1945).

Hypotypes: USNM 42040, 42041, UCMP 8604.
Occurrence: Stewart Spring.

Genus PICEA Link

Picea breweriana S. Watson

Plate 6, figures 4, 5, 8, 9, 13, 14, 19

Picea breweriana S. Watson, 1885, Proc. Am. Acad., v. 20, p. 378.

Discussion.—Representatives of *Picea breweriana* that occur as fossils have been given the name of *P. sonomensis* Axelrod, although the fossils are indistinguishable from seeds from extant plants of *P. breweriana*. As noted above, the former distribution of *P. breweriana* was much wider than at present; *P. breweriana* is truly relictual today. Mason (1947, p. 209) noted the close relationship between *P. breweriana* and *P. engelmanni* of the Rocky Mountains and suggested a common ancestry. Of interest in this connection is a small collection of probable Neogene age from the Camelo Hills of Arizona; the only two species present are *P. engelmanni* and *Chamaecyparis nootkatensis*. This association is, of course, apparently analogous to that of *P. breweriana* and *C. nootkatensis* in Nevada.

Hypotypes: USNM 42042–42048, UCMP 8605, 8606.
Occurrence: Stewart Spring.

Picea magna MacGinitie

Plate 1, figures 3 and 5; plate 6, figures 7, 12, 17, 18, and 22

Picea magna MacGinitie, 1953, Carnegie Inst. Washington Pub. 599, p. 83, pl. 18, figs. 5–7.

Discussion.—MacGinitie (1953, p. 83) noted that *Picea magna* is a large-coned spruce unrelated to the extant American species but related to species in eastern Asia. *P. magna* is one of the oldest known megafossil species of spruce in North America; it is first known in the Oligocene but apparently became extinct during the Clarendonian.

Hypotypes: USNM 42027, 42028, 42049–42053, UCMP 8607, 8608.
Occurrence: Fingerrock, Stewart Spring.

Genus PINUS Linnaeus

Pinus monticola Douglas ex Lamb

Plate 1, figures 2, 9

Pinus monticola Douglas ex Lamb, 1832, Gen. Pin., v. 3, p. 87.
Pinus latahensis Berry, 1929, U.S. Geol. Survey Prof. Paper 154, p. 238, pl. 49, fig. 7.
Pinus monticolensis Berry, 1929, U.S. Geol. Survey Prof. Paper 154, p. 238, pl. 49, figs. 5, 8.
1934, U.S. Geol. Survey Prof. Paper 185, p. 104.
Pinus tetrafolia Berry, 1929, U.S. Geol, Survey Prof. Paper 154, p. 238, pl. 49, fig. 6.
Pinus quinifolia Smith, 1941, Am. Midland Naturalist, v. 25, p. 490, pl. 2, figs. 2, 8.
Pinus wheeleri auct. non Cockerell. Chaney and Axelrod, 1959, Carnegie Inst. Washington Pub. 617, p. 143.
Axelrod, 1956, California Univ. Pubs. Geol. Sci., v. 33, p. 277, pl. 4, fig. 23; pl. 12, figs. 17, 18.

Discussion.—All western Tertiary fossils related to the extant *Pinus monticola* have been considered to represent the same fossil species only because of this relationship (Chaney and Axelrod, 1959, p. 143). MacGinitie (1953, p. 79), however, pointed out that just because two fossils have the same living equivalent, the fossils do not necessarily belong to the same species. All the specimens on which the above citations are based are indistinguishable from the respective organs of the extant *P. monticola*.

Hypotypes: USNM 42016, UCMP 8609.
Occurrence: Fingerrock.

Pinus ponderosa Douglas

Plate 1, figures 1, 4; plate 8, figures 32, 33

Pinus ponderosa Douglas ex Lawson, 1836, Agr. Manual, p. 354.
Pinus florissanti Lesquereux, 1883, U.S. Geol. Survey Terr. Rept., v. 8, p. 138, pl. 21, fig. 13.
MacGinitie, 1953, Carnegie Inst. Washington Pub. 599, p. 84, pl. 19, fig. 2; pl. 20, figs. 1, 3, 4.
Axelrod, 1956, California Univ. Pubs. Geol. Sci., v. 33, p. 276, pl. 4, figs. 19, 20; pl. 17, figs. 10, 11.
Axelrod, 1958, California Univ. Pubs. Geol. Sci., v. 34, p. 126, pl. 17, fig. 3.
Pinus macrophylla Berry, 1929, U.S. Geol. Survey Prof. Paper 154, p. 238, pl. 49, fig. 9.

Discussion.—The correspondence of fossil seeds, needles, and cones often found in the same beds to the comparable organs of *Pinus ponderosa* is so close that the fossils should be assigned to the extant species.

Hypotypes: USNM 42017, 42026, 42038, 42039, UCMP 8610.
Occurrence: Stewart Spring, Fingerrock.

Genus TSUGA Carriere

Tsuga heterophylla Sargent

Plate 6, figures 15, 16, 20, 21, 24

Tsuga heterophylla Sargent, 1895, Silva North Am., v. 7, p. 73.

Discussion.—Numerous seeds found in the paper shales are referrable to the extant *Tsuga heterophylla*, This species is today a mesophyte; in the Cascade Range it increases in abundance relative to *Pseudotsuga* to the north.

Hypotypes: USNM 42053–42057, UCMP 8611.
Occurrence: Stewart Spring.

Family CUPRESSACEAE

Genus CHAMAECYPARIS Spach

Chamaecyparis nootkatensis (Lambert) Spach

Plate 6, figures 27, 30, 31, 34–37

Chamaecyparis nootkatensis (Lambert) Spach, 1842, Hist. Veg., v. 11, p. 333.
Thuja dimorpha auct., non (Oliver) Chaney and Axelrod. Axelrod, 1956, California Univ. Pubs. Geol. Sci., v. 33, p. 279. pl. 4, fig. 24; pl. 12, figs. 1–4; pl. 18, figs. 1, 2; pl. 25, figs. 2, 3.

Discussion.—Numerous cupressaceous shoots and cones can be matched by those of the extant *Chamaecyparis nootkatensis*. The foliage of the long shoots can be confused with that of *Thuja dimorpha* (fig. *6B*), but in the latter species the scales of the short shoots have the same shape and pattern of insertion as the long shoots. The short shoots of *C. nootkatensis* (fig. *6A*) are distinct, with short and unflattened scales. The specimen figured as plate 6, figure 36, has attached cones which are clearly those of *Chamaecyparis*.

Today *Chamaecyparis nootkatensis* is confined to the area west of the crest of the Cascades. Although southwest Nevada was probably more mesic in the Miocene than today, it is apparent that it was not as mesic as the area currently inhabited by *C. nootkatensis*.

Hence, it is reasonable to consider that the Nevada individuals of this species represent a distinct ecotype.

Hypotypes: USNM 42019–42024, UCMP 8613, 8614.
Occurrence: Fingerrock, Stewart Spring.

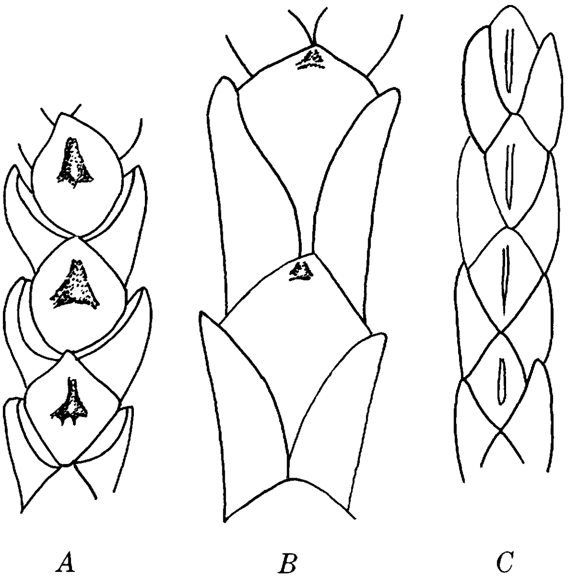


FIGURE 6.—Cupressaceae. *A, Chamaecyparis nootkatensis* (Lambert) Spach, hypotype USNM 42024. *B, Thuja dimorpha* (Oliver) Chaney and Axelrod, USNM 42059. *C, Juniperus nevadensis* Axelrod, hypotype UCMP, × 10.

Genus JUNIPERUS

Juniperus nevadensis Axelrod

Plate 6, figure 26

Juniperus nevadensis Axelrod, 1940, Washington Acad. Sci. Jour., v. 30, p. 170.
1956, California Univ. Pubs. Geol. Sci., v. 33, p. 278, pl. 12, figs. 9–12; pl. 18, figs. 3, 4.
Sabina linguaefolia auct. non (Lesquereux) Cockrell. Knowlton, 1923, U.S. Geol. Survey Prof. Paper 131, p. 187.

Discussion.—*Juniperus nevadensis* specimens can be matched by at least two species of extant juniper. Hence, Axelrod's species is retained for fossil shoots indistinguishable from those of *J. californica* Carr. and *J. utahensis* (Engelm.) Lemm.

Hypotype: UCMP 8612.
Occurrence: Stewart Spring.

Genus GLYPTOSTROBUS Endlicher

Glyptostrobus sp.

Plate 1, figures 8, 11

Discussion.—Several shoots bearing axially arranged triangular leaves occur in the Fingerrock flora; these shoots are identical to those of *Glyptostrobus oregonensis* from the Miocene of Oregon. Until associated or attached cones are found, however, no certain specific assignment can be made.

Specimens: USNM 41933, 41934.
Occurrence: Fingerrock.

Class ANGIOSPERMAE

Subclass MONOCOTYLEDONES

Order GLUMIFLORAE

Family GRAMINEAE

Genus POACITES Brongniart

Poacites sp.

Plate 7, figure 1

Discussion.—Remains of the vegetative parts of grass are abundant in the paper shales. It is possible that several types of grass are present, but the lack of attached reproductive structures precludes assignment to other than a form genus.

Specimens: USNM 41973–41975, UCMP 8618, 8619.
Occurrence: Stewart Spring.

Family CYPERACEAE

Genus CYPERACITES Schimper

Cyperacites sp.

Plate 1, figure 6

Discussion.—This specimen represents either a sedge or grass but is otherwise indeterminate.

Specimen: USNM 41976.
Occurrence: Fingerrock.

Cyperacites sp.

Plate 7, figure 2

Discussion.—The specimen figured represents a clump of a sedgelike plant, complete with roots in the original soil.

Specimen: USNM 41972.
Occurrence: Stewart Spring.

Subclass DICOTYLEDONES

Order SALICALES

Family SALICACEAE

Genus POPULUS Linnaeus

Populus cedrusensis Wolfe, n. sp.

Plate 7, figures 4, 5, 8, plate 8, figure 4; figure 7

Populus sonorensis Axelrod. Axelrod, 1956, California Univ. Pubs. Geol. Sci., v. 33, p. 284, pl. 5, figs. 5, 9–11.

Description.—Leaves simple, palmate; shape broadly to narrowly ovate; length 3.5–5.0 cm, width 1.5–4.0 cm; base narrowly to broadly rounded, apex acute to acuminate; three primary veins, but one or both laterals often weakly developed and extending ⅓–¼ the length of lamina; three to five pairs of central secondaries departing at an angle of 35°–60°, undulatory and looping at the margin but sending strong craspedodrome tertiaries into teeth; three to five lateral secondaries; nervilles irregularly forking; areoles irregularly polygonal, typically 2 mm across, intruded by dendroid compound freely ending veinlets; margin irregularly serrate, with one to seven sharp triangular teeth; petiole 2.0–2.7 cm long.

Discussion.—Several leaves in the Aldrich Station and Stewart Spring floras most closely resemble those produced by the extant *Populus brandegeei* Schneid. of Baja California. Similarities between leaves of the latter species and *P. cedrusensis* are the frequently aparallel and undulatory secondaries and the irregularly spaced sharp triangular teeth. Differences are in shape, which is typically only broadly ovate in *P. brandegeei*, and in more numerous teeth of the extent species. Along the margin below the end of the lateral primaries, *P. brandegeei* has five to nine teeth, but in *P. cedrusensis* the maximum number is seven and often there are none.

There are even fewer resemblances between leaves of *Populus sonorensis* and *P. cedrusensis*. The former species has leaves with relatively straight subparallel secondaries, blunt teeth, and a blunt rounded apex. It is questionable if *P. sonorensis* is closely related to either *P. cedrusensis* or *P. brandegeei*.

Holotype: USNM 41876
Paratypes: USNM 41877–41879; UCMP 4050, 4052, 4053.
Occurrences: Stewart Spring.

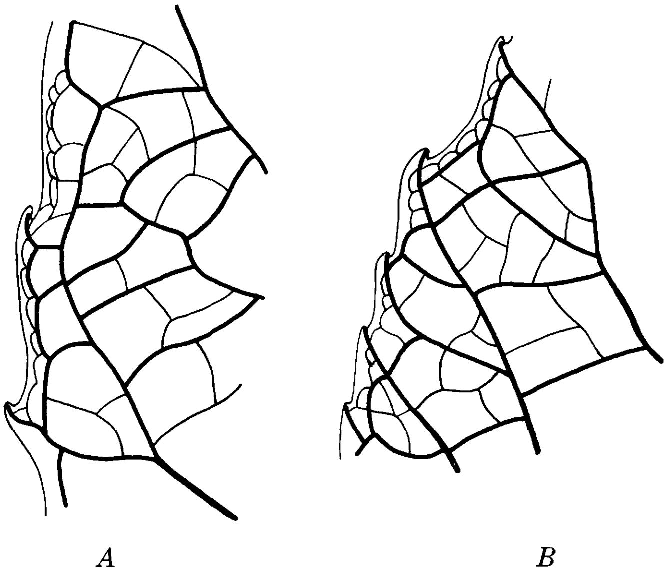


FIGURE 7.—Marginal venation of *Populus*. *A*, *P. cedrusensis* Wolfe, paratype USNM 41877. *B*, *P. brandegeei monticola* Wiggins, Recent, × 5.

Populus lindgreni Knowlton

Plate 1, figure 12

Populus lindgreni Knowlton, 1898, U.S. Geol. Survey 18th Ann. Rept., p. 725, pl. 100, fig. 3.
Chaney and Axelrod, 1959, Carnegie Inst. Washington Pub. 617, p. 151, pl. 17, figs. 1–3.

Discussion.—Chaney and Axelrod (1959) have shown that *Populus lindgreni* is not an aspen but is an extinct species related to *P. heterophylla* L. It should be noted, however, that even this relationship is distant.

Hypotype: USNM 41947.
Occurrence: Fingerrock.

Populus tremuloides Michaux

Plate 8, figures 5, 6, 7

Populus tremuloides Michaux, 1803, Flora Boreali-Americana, v. 2, p. 243.
Populus pliotremuloides Axelrod, 1937, Carnegie Inst. Washington Pub. 476, p. 169, pl. 4, figs. 1–3.
Condit, 1944, Carnegie Inst. Washington Pub. 553, p. 41.
Axelrod, 1950, Carnegie Inst. Washington Pub. 590, p. 53, pl. 3, fig. 4; p. 201.
Axelrod, 1956, California Univ. Pubs. Geol. Sci., v. 34, p. 128, pl. 22, figs. 5–8.
Populus lindgreni auct. non Knowlton. MacGinitie, 1933, Carnegie Inst. Washington Pub. 416, p. 49 [in part].

Discussion.—All the specimens on which the above citations are based are indistinguishable from leaves of the extant *Populus tremuloides*. There is a prevalent idea that leaves of *P. tremuloides* (or *pliotremuloides*) differ from those of *P. voyana* only by size; there are also several valid characters which separate these two species. In *P. voyana* the teeth are sharp, numerous, and glandular tipped, whereas in *P. tremuloides* they are crenate to simple rounded bumps, few, and glandular tipped only near the apex, if at all. There are seven primary veins in *P. voyana*, although the basal pair may be inconspicuous; in *P. tremuloides* there are five primaries although a rudimentary sixth is rarely present. The marginal areoles in *P. tremuloides* are intruded, always admedially, by the freely ending veinlets; marginal areoles are intruded both ab- and admedially by the veinlets in *P. voyana*.

The stratigraphic relationship between *Populus tremuloides* and *P. voyana* appears to be clearcut. The latter species is known only from rocks of Arikareean and Hemingfordian ages, and *P. tremuloides* first appears in the Barstovian.

Hypotypes: USNM 41880, 41881, UCMP 8620.
Occurrence: Stewart Spring.

Populus trichocarpa Torrey and Gray

Plate 8, figures 3, 11, 12

Populus trichocarpa Torrey and Gray ex Hooker, 1836, Icones Plantarum, p. 878.

Populus eotremuloides Knowlton, 1898, U.S. Geol. Survey 18th Ann. Rept., p. 725, pl. 100, figs. 1, 2; pl. 101, figs. 1, 2.

Brooks, 1935, Carnegie Mus. Annals, v. 24, p. 282.

LaMotte, 1936, Carnegie Inst. Washington Pub. 455, p. 114, pl. 5, figs. 7, 9.

Brown, 1937, U.S. Geol. Survey Prof. Paper 186, p. 169, pl. 47, fig. 1.

Smith, 1941, Am. Midland Naturalist, v. 24, p. 496, pl. 3, fig. 4; pl. 4, fig. 7.

Axelrod, 1956, California Univ. Pubs. Geol. Sci., v. 33, p. 282, pl. 18, figs. 7, 8; pl. 26, fig. 5.

Populus alexanderi Dorf, 1930, Carnegie Inst. Washington Pub. 412, p. 75, pl. 6, figs. 10, 11; pl. 7, figs. 2, 3.

Chaney, 1938, Carnegie Inst. Washington Pub. 476, p. 215, pl. 6, figs. 1, 5.

Axelrod, 1944, Carnegie Inst. Washington Pub. 553, p. 281, pl. 48, fig. 4.

Brown, 1949, Washington Acad. Sci. Jour., v. 39, p. 226, fig. 19.

Axelrod, 1950, Carnegie Inst. Washington Pub. 590, p. 199, pl. 4, fig. 6.

Axelrod, 1956, California Univ. Pubs. Geol. Sci., v. 33, p. 282, pl. 6, fig. 9, pl. 13, figs. 1, 2.

Axelrod, 1958, California Univ. Pubs. Geol. Sci., v. 34, p. 128, pl. 19, figs. 1–11.

Populus emersoni Condit, 1938, Carnegie Inst. Washington Pub. 476, p. 255, pl. 4, figs. 1, 2.

Populus lindgreni auct. non Knowlton. Oliver, 1934, Carnegie Inst. Washington Pub. 455, p. 17 [part].

MacGinitie, 1933, Carnegie Inst. Washington Pub. 416, p. 49.

Discussion.—All specimens of Barstovian or younger age previously referred to *Populus eotremuloides* and *P. alexanderi* prove to be identical with leaves of the extant *P. trichocarpa.* An undescribed species from the early and middle Miocene of the Oregon Cascades appears to be ancestral to *P. trichocarpa.*

Hypotypes: USNM 41882–41884, UCMP 8621, 8622.
Occurrence: Stewart Spring.

Populus washoensis Brown

Plate 7, figures 6, 7

Populus washoensis Brown, 1937, Washington Acad. Sci. Jour., v. 27, p. 516.

Smith, 1939, Torrey Bot. Club Bull., v. 66, p. 467, pl. 10, fig. 1.

Smith, 1941, Am. Midland Naturalist, v. 25, p. 496, pl. 3, figs. 1, 2, 6.

Axelrod, 1944, Carnegie Inst. Washington Pub. 553, p. 98, pl. 22, figs. 1, 2.

Chaney and Axelrod, 1959, Carnegie Inst. Washington Pub. 617, p. 152, pl. 18, figs. 6–8 only.

Populus booneana Smith, 1941, Am. Midland Naturalist, v. 25, p. 494, pl. 2, figs. 14, 15.

Populus subwashoensis Axelrod, 1956, California Univ. Pubs. Geol. Sci., v. 33, p. 284, pl. 6, figs. 1–4; pl. 13, figs. 13, 14 only.

1958, California Univ. Pubs. Geol. Sci., v. 34, p. 128, pl. 22, figs. 1–4.

Populus lindgreni auct. non Knowlton. Oliver, 1934, Carnegie Inst. Washington Pub. 455, p. 17.

LaMotte, 1936, Carnegie Inst. Washington Pub. 455, p. 115, pl. 4, fig. 1.

Cebatha heteromorpha auct. non (Knowlton) Berry. LaMotte, 1936, Carnegie Inst. Washington Pub. 455, p. 126, pl. 9, fig. 1.

Populus pliotremuloides auct. non Axelrod. Chaney, 1938, Carnegie Inst. Washington Pub. 476, p. 214, pl. 6, fig. 4; pl. 7, figs. 1c, 1d.

Brown, 1949, Washington Acad. Sci. Jour., v. 30, p. 226, figs. 20–22.

Discussion.—Not considering small-leafed "eco-species" valid taxonomic species, I have united *Populus subwashoensis* with *P. washoensis.* Examination of the *Populus* leaves in the Cache Creek flora (Brown, 1949) shows them to be conspecific with *P. washoensis,* as suggested by Axelrod (1956, p. 285).

The leaves of *Populus washoensis* have a highly variable number of teeth, from two per side to as many as ten. No other species, fossil or extant, has both leaves with a few large crude teeth and leaves with an evenly and moderately finely serrate margin. The latter variation is found in leaves of *P. grandidentata* Michaux, which also resemble leaves of *P. washoensis* in shape and general venation pattern. An even closer match can be noted in the leaves of the Asian *P. bonatti* Levl.

Populus washoensis has not been reported from any pre-Barstovian flora. The youngest occurrence is in the early Blancan Cache Creek flora.

Hypotypes: USNM 41885, 41886, UCMP 8623, 8624.
Occurrence: Stewart Spring.

Populus sp.

Plate 7, figure 3

Discussion.—This specimen is a catkin of some species of *Populus* although which of the four species known from leaves the catkin represents is problematic. Most of the capsules are three parted, although a few are two parted.

Specimen: USNM 41937.
Occurrence: Stewart Spring.

Genus SALIX Linnaeus

Salix pelviga Wolfe, new name

Plate 8, figures 1, 2, 8; figure 8

Myrica lanceolata Knowlton, 1898, U.S. Geol. Survey 18th Ann. Rept., pt. 3, p. 724, pl. 99, figs. 5,6.

Salix knowltoni Berry, 1927, U.S. Natl. Mus. Proc., v. 72, p. 9, pl. 2, fig. 1.

Salix hesperia auct. non (Knowlton) Condit. Axelrod, 1956, California Univ. Pubs. Geol. Sci., v. 33, p. 285, pl. 25, fig. 11.

Discussion.—By synonymizing *Myrica lanceolata* with *Salix knowltoni*, Berry (1927) automatically made his new species a junior synonym. A new combination, *S. lanceolata*, however, would be a homonym, and hence a new name must be given for this species.

Axelrod (1950, p. 254) is of the opinion that one of the types from the Payette is the same as his *Salix payettensis* from the Alvord Creek. Both types of *Myrica lanceolata*, however, represent a relatively broad-leafed willow with numerous teeth, whereas *S. payettensis* is a narrow-leafed form with few teeth. The specimens called *S. knowltoni* by Axelrod (1956, p. 285) are entire margined, short and often obvate leaves unlike the types of either *S. pelviga* or *S. knowltoni.* Neither Berry's description or figure of the latter species show that the type actually has distinct and sharp teeth, although they reveal that the specimen is a more linear leaf than any of Axelrod's specimens.

The closest species to *Salix pelviga* is *S. truckeana* Chaney from the Dalles Formation. This latter form appears to be a considerably more linear leaf, although there may be an overlap in this feature.

Hypotypes: USNM 41958, 41959, UCMP 8625, 8626.
Occurrence: Stewart Spring.

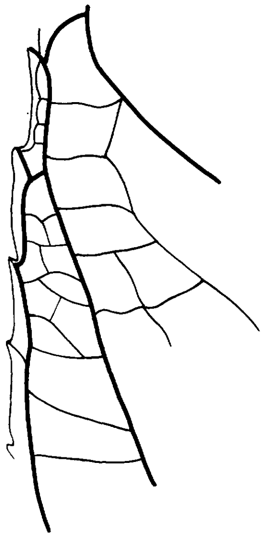
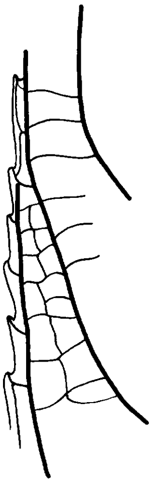



FIGURE 8.—Marginal venation of *Salix*. *A, Salix pelviga* Wolfe, hypotype USNM 41958. *B, S. nigra* Marsh, Recent, × 5.

Order GARRYALES

Family GARRYACEAE

Genus GARRYA Douglas

Garrya axelrodi Wolfe, n. sp.

Plate 12, figure 4, figure 9

Description.—Leaves simple, pinnate; shape oval; length 3.8–9 cm, width 2–4.5 cm; apex narrowly rounded, but spinetipped; base cuneate, decurrent along petiole; eight or nine pairs of secondaries, departing from midrib at an angle of 30°–40°, curving apically, undulatory, forking about two-thirds the distance to the margin, forming a series of irregularly shaped loops; tertiaries and quaternaries forming marginal loops; intersecondaries frequent and conspicuous; nervilles irregularly branching, departing from the basal sides of the secondaries perpendicular to midrib and from the apical sides perpendicular to the secondaries; areoles irregularly polygonal, less than 0.5 mm in diameter, intruded by once or twice branching freely ending veinlets; margin entire; petiole not complete, but at least 0.6 mm long.

Discussion.—The undulatory forking secondaries and the irregular series of marginal loops indicate that these fossils are referrable to *Garrya.* The closest extant species to *G. axelrodi* is *G. elliptica* Dougl. from northern and central California. The primary difference between leaves of the two species is in shape—in *G. axelrodi* the length to width ratio is 2:1 but in *G. elliptica* the ratio is typically 1.5:1. Axelrod (1944c, p. 204) noted that *Garrya elliptica* leaves are entire, rather than revolute or undulate, in the more mesic parts of this species' range, and only entire-margined leaves of *G. axelrodi* are known.

Three other records of fossil *Garrya* are known. *G. masoni* Dorf has been reported from the middle and late Pliocene of California (Dorf, 1930, p. 104; Axelrod, 1944c, p. 204). None of the leaves on which these records are based can be separated from leaves of *G. elliptica.*

Holotype: USNM 41935.
Paratype: USNM 41936, UCMP 8627 (counterpart).
Occurrence: Stewart Spring.

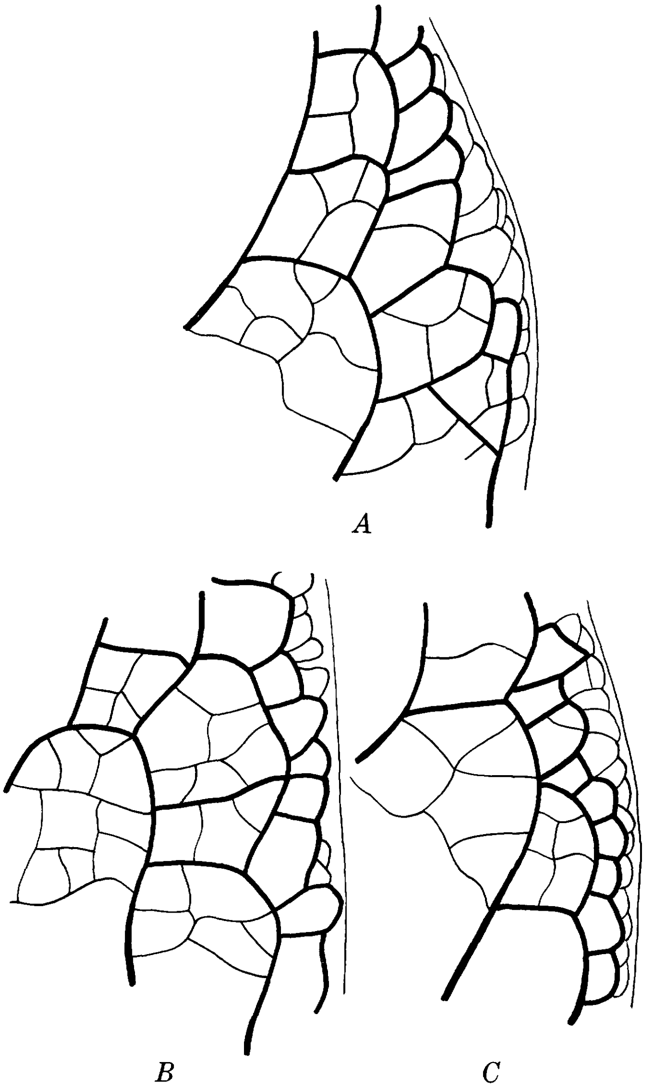


FIGURE 9.—Marginal venation of *Garrya*. *A, G. axelrodi* Wolfe, holotype USNM 41935. *B, G. laurifolia* Hartw., Recent. *C, G. elliptica* Dougl., Recent, × 5.

Order JUGLANDALES

Family JUGLANDACEAE

Genus CARYA Nuttall

Carya bendirei (Lesquereux) Chaney and Axelrod

Plate 1, figure 7

Carya bendirei (Lesquereux) Chaney and Axelrod, 1959, Carnegie Inst. Washington Pub. 617, p. 155, pl. 19, figs. 1–5.

Rhus bendirei Lesquereux, 1888, Proc. U.S. Natl. Mus., v. 11, p. 15, pl. 9, fig. 2.

Discussion.—*Carya bendirei* is the most widespread and abundant hickory in the Miocene of the northwestern United States. This occurrence is the most southerly for the species.

Although *Carya bendirei* has been thought to be related to the east American species of *Eucarya* (Chaney and Axelrod, 1959, p. 155), details of the ultimate and marginal venation and of the teeth indicate that this species and its relatives are most closely related to the subtropical Asian *C. tonkinensis* LeComte. The phylad to which *C. bendirei* belongs extends back into the Eocene of Washington and British Columbia.

Hypotype: USNM 41943.
Occurrence: Fingerrock.

Genus JUGLANS Linnaeus

Juglans major (Torrey) Heller

Plate 8, figures 9, 10

Juglns major (Torrey) Heller, 1900, Muhlenbergia, v. 1, p. 50. Manning, 1957, Arnold Arbor. Jour., v. 38, p. 136 (see synonymy).

Carpinus grandis auct. non Unger. Axelrod, 1944, Carnegie Inst. Washington Pub. 553, p. 254, pl. 43, fig. 6.

Discussion.—Both the Stewart Spring specimens and the one described from Alvord Creek as *Carpinus* can be matched by leaflets of the extant *Juglans major*. The Alvord Creek specimen has numerous camptodrome secondaries and cannot be *Carpinus*; the truncate base and short petiolule are features more frequently found in forma *stellata* Manning than in typical *J. major* (Manning, 1957, p. 139).

Hypotypes: USNM 41960, 41961, UCMP 8628.
Occurrence: Stewart Spring.

Order FAGALES

Family BETULACEAE

Genus ALNUS Linnaeus

Alnus relata (Knowlton) Brown

Plate 1, figure 13

Alnus relatus (Knowlton) Brown, 1937, U.S. Geol. Survey Prof. Paper 186, p. 49, figs. 1–6.

Phyllites relatus Knowlton, 1926, U.S. Geol. Survey Prof. Paper 140, p. 48, pl. 28, fig. 8.

Discussion.—E. P. Klucking (oral communication, 1959) stated that *Alnus relata*, as conceptualized by Brown (1937) and Chaney and Axelrod (1959), contains a heterogeneous assortment of species. Until the time that Klucking's revision of Tertiary Betulaceae of North America is published, little stratigraphic significance should be attributed to *A. relata*.

Hypotype: USNM 41969.
Occurrence: Fingerrock.

Genus BETULA Linnaeus

Betula thor Knowlton

Plate 1, figure 14

Betula thor Knowlton, 1926, U.S. Geol. Survey Prof. Paper 140, p. 35, pl. 17, fig. 3.

Betula fairii auct. non Knowlton. Chaney and Axelrod, 1959, Carnegie Inst. Washington Pub. 617, p. 160, in part, pl. 23, fig. 1 only.

Discussion.—The similarity of the Fingerrock specimen to the Mascall specimen called *Betula fairii* and to the type of *B. thor* is considerable, but without examining the specimens from the Blue Mountains flora I hesitate to place them in synonymy. Some of the latter appear to have basally pointing teeth and would therefore be *Alnus*. The types of *B. fairii* are all *Alnus* on the character of the teeth.

Hypotype: USNM 41971

Occurrence: Fingerrock.

Betula sp.

Plate 9, figure 1; figure 10

Discussion.—One incomplete specimen has secondary veins bending apically near the ends of the teeth; this is characteristic of leaves of *Betula* (E. P. Klucking, oral communication, 1959). Although the specimen appears to be conspecific with *Betula lacustris* MacG., specific determination should await a more complete specimen.

Specimen: USNM 42008, UCMP 8629.

Occurrence: Stewart Spring.

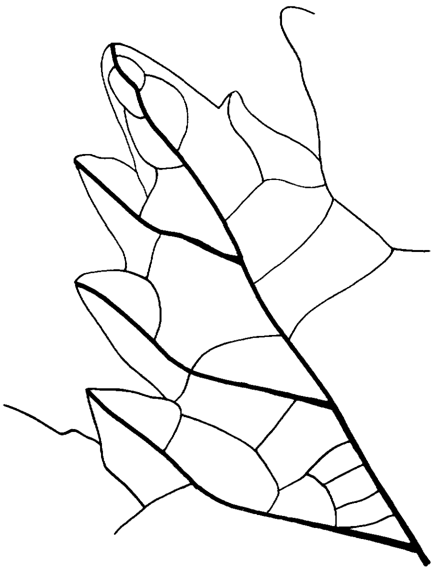


FIGURE 10.—Marginal venation of *Betula*. *B.* sp., USNM 42008, × 5.

Family FAGACEAE

Genus QUERCUS Linnaeus

Quercus chrysolepis Liebmann

Plate 2, figures 1–10, 14; plate 9, figures 2, 3, 5–7, 12, 16

Quercus chrysolepis Liebmann, 1854, Danske Vidensk selsk. Forh., p. 173.

Discussion.—Numerous leaves of oak clearly related to the extant *Quercus chrysolepis* have been reported from the Neogene of western North America under the names of *Q. convexa* Lesq., *Q. browni* Brooks, and *Q. hannibali* Dorf. The type specimens of *Q. convexa* are *Castanopsis*, which can be readily distinguished from *Quercus* on the basis of ultimate venation. It should be noted that the extant American species of *Castanopsis* are the only ones that can be so distinguished on ultimate venation. In addition, some of the Stinking Water specimens of *Quercus hannibali* (Chaney and Axelrod, 1959, p. 168) are also referable on the basis of ultimate venation to *Castanopsis*. Probably most specimens of *Q. hannibali* are *Q. chrysolepis*, but the solution to this problem will have to await a thorough study of west American fossil nonlobed oaks. The suites from both the Fingerrock and Stewart Spring floras can be matched in all characters by *Q. chrysolepis* leaves.

Leaves either identical with or closely resembling those of *Q. chrysolepis* are found in abundance in the Neogene of central British Columbia. This indicates that *Q. chrysolepis* or an ancestor was present in the northwest mesophytic flora, and that, when conditions approached aridity, the live oak assumed a more dominant role in the flora.

Hypotypes: USNM 41887–41904, UCMP 8630–8639.

Occurrences: Fingerrock, Stewart Spring.

Quercus cedrusensis Wolfe, n. sp.

Plate 9, figure 15

Description.—Leaf simple, pinnate; shape oval; length 6.9 cm, width 4.2 cm; base narrowly cordate, apex acute; 11 pairs of subparallel secondaries, departing at an angle of 50°–90°, straight until forking near margin, craspedodrome; no intersecondaries; nervilles irregularly percurrent, 1–2 mm apart; areoles 0.3–0.5 mm in diameter, irregularly polygonal, either lacking freely ending veinlets or with linear simple veinlets; margin with conspicuous marginal vein, and seven small dentate-spinose teeth; petiole more than 0.3 cm long.

Discussion.—In grosser aspects of venation and margin, as well as in ultimate venation, this fossil is similar to the leaves of the extant *Quercus agrifolia* Nees. This latter species, however, has leaves typically with six pairs of secondaries and a correspondingly greater number of intersecondaries; in addition, the intercostal venation is irregular with the nervilles about 4 mm apart. Another extant species, *Q. fulva* Liebm., has leaves that are more similar to *Q. cedrusensis* in intercostal venation and numbers of secondaries. *Q. fulva*, however, lacks teeth in the basal half of the lamina and the secondaries typically depart at an angle of 40°.

Holotype: USNM 41968.
Occurrence: Stewart Spring.

Quercus pseudolyrata Lesquereux

Plate 3, figure 1

Quercus pseudolyrata Lesquereux, 1878, Harvard Coll. Mus. Comp. Zoology Mem., v. 6, no. 2, p. 8, pl. 2, figs. 1, 2.
1888, U.S. Natl. Mus. Proc., v. 11, p. 17, pl. 10, fig. 1.
Knowlton, 1902, U.S. Geol. Survey Bull. 204, p. 48.
Berry, 1931, U.S. Geol. Survey Prof. Paper 170, p. 34.
Chaney and Axelrod, 1959, (in part). Carnegie Inst. Washington Pub. 617, p. 169, pl. 38, figs. 1–3 only.
Quercus pseudolyrata acutiloba Lesquereux, 1888, Harvard Coll. Mus. Comp. Zoology Mem., v. 6, No. 2, p. 17, pl. 11, fig. 2.
Quercus pseudolyrata brevifolia Lesquereux, 1888, Harvard Coll. Mus. Comp. Zoology Mem., v. 6, No. 2, p. 18, pl. 10, fig. 2.
Quercus pseudolyrata latifolia Lesquereux, 1888, Harvard Coll. Mus. Comp. Zoology Mem., v. 6, no. 2, p. 18, pl. 12, fig. 1.
Quercus pseudolyrata obtusiloba Lesquereux, 1888, Harvard Coll. Mus. Comp. Zoology Mem., v. 6, no. 2, p. 18, pl. 10, fig. 3.
Quercus merriami Knowlton, 1902, U.S. Geol. Survey Bull. 204, p. 49, pl. 6, figs. 6, 7; pl. 7, figs. 4, 5.
Berry, 1929, U.S. Geol. Survey Prof. Paper 170, p. 34.
Brown, 1937, U.S. Geol. Survey Prof. Paper 186, p. 172.
Chaney and Axelrod, 1959, Carnegie Inst. Washington Pub. 617, p. 169, pl. 27, figs. 3–8.
Quercus duriuscula Knowlton, 1902, U.S. Geol. Survey Bull. 204, p. 50, pl. 8, fig. 2.
Berry, 1934, U.S. Geol. Survey, Prof. Paper 185, p. 109.
Quercus ursina Knowlton, 1902, U.S. Geol. Survey Bull. 204, p. 51, pl. 7, figs. 2, 3.
Berry, 1929, U.S. Geol. Survey Prof. Paper 154, p. 246.
Berry, 1938, Torrey Bot. Club Bull., v. 65, p. 92, text fig. 8.

Discussion.—It is the opinion of Chaney and Axelrod (1959) that *Q. pseudolyrata* and *Q. merriami* are distinct species, but the intergradations of morphologic characters displayed by specimens from the Mascall Formation indicates that the two species should be synonymized. If there were two distinct populations or species present, a statistical analysis of morphologic characters should indicate this by values clustering about two norms. However, two characters selected for analysis (degree of dissection of the lamina and numbers of lobations) indicate that we are dealing with one population.

Thus far, *Quercus pseudolyrata* is known only from beds of Hemingfordian or early Barstovian age. Younger specimens show a considerably greater dissection of the lamina, a greater number of lobations, and more leaves with compound lobations. These specimens will be referred to *Q. deflexiloba* Smith. Older specimens from the Eagle Creek and equivalent formations vary from *Q. pseudolyrata* in the opposite direction, and form the basis for a new species.

Hypotypes: USNM 41905, 41906, UCMP 8640.
Occurrence: Fingerrock.

Quercus simulata Knowlton

Plate 2, figures 11–13

Quercus simulata Knowlton, 1898, U.S. Geol. Survey 18th Ann. Rept., pt. 3, p. 728, pl. 101, fig. 4; pl. 102, figs. 1, 2.
Chaney and Axelrod, 1959, Carnegie Inst. Washington Pub. 617, p. 171 (see synonymy), pl. 30, figs. 2, 3, 5–8; pl. 31, figs. 1–4.

Discussion.—Most authors have related *Quercus simulata* to the extant Asian *Q. myrsinaeflora* Blume. Although the resemblances of the foliage of the two species recommends itself to such a relationship, there are some doubts. The group of oaks to which *Q. myrsinaefolia* belongs has, by some authors, been segregated into a distinct genus, *Cyclobalanopsis*. This distinction is based, in part, on the peculiar acorn cupule which has its scales fused into a series of overlapping cups. This type of cupule would be readily recognized as a compressed fossil, but none of the several hundred cupules found associated with *Q. simulata* leaves are of that type.

If just the entire-margined leaves of *Quercus simulata* were known, they would be related to the linear varieties of *Q. chrysolepis* Liebm. Therefore, considering the lack of substantiating cupules, as well as foliar morphology, *Q. simulata* is here considered to represent an extinct line distantly related to *Q. chrysolepis*.

Hypotypes: USNM 41938–41940, UCMP 8641.
Occurrence: Fingerrock.

Order URTICALES

Family ULMACEAE

Genus ULMUS Linnaeus

Ulmus newberryi Knowlton

Plate 3, figures 4, 6,

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

Discussion.—Leaves of *Ulmus newberryi* are characterized by their narrowly rounded base and oval shape, as opposed to those of *U. speciosa* which are broadly cordate and ovate.

Hypotypes: USNM 41942, UCMP 8642, 8643.
Occurrence: Fingerrock.

Genus ZELKOVA Spach

Zelkova oregoniana (Knowlton) Brown

Plate 3, figures 2, 3, 5

Zelkova oregoniana (Knowlton) Brown, 1937, U.S. Geol. Survey Prof. Paper 186, p. 173, (see synonymy), pl. 51, figs. 11–15.
Chaney and Axelrod, 1959, Carnegie Inst. Washington Pub. 617, p. 174, pl. 31, figs. 5–8.
Myrica oregoniana Knowlton, 1902, U.S. Geol. Survey Bull. 204, p. 33, pl. 3, fig. 4.

Discussion.—In the Great Basin, *Zelkova* has not been demonstrated to occur in strata younger than Barstovian, but west of the Cascades it is known in the Troutdale flora (Chaney, 1944) of probable Clarendonian age. The fragmentary specimens called *Z. nevadensis* Axelrod do not appear to differ specifically from *Z. oregoniana.*

Hypotypes: USNM 41944–41946, UCMP 8643.
Occurrence: Fingerrock.

Order RANALES

Family BERBERIDACEAE

Genus MAHONIA Nuttall

Mahonia reticulata (MacGinitie) Brown

Plate 4, figure 3; plate 9, figures 8–10

Mahonia reticulata (MacGinitie) Brown, 1937, U.S. Geol. Survey Prof. Paper 186, p. 175, pl. 52, fig. 4.
Smith, 1939, Michigan Acad. Sci. Papers, v. 24, p. 114.
Axelrod, 1944, Carnegie Inst. Washington Pub. 553, p. 255, pl. 43, fig. 7.
Axelrod, 1956, California Univ. Pubs. Geol. Sci., v. 33, p. 296, pl. 8, fig. 16; pl. 14, figs. 3, 4, pl. 21, figs. 1–3; pl. 29, fig. 5.
Chaney and Axelrod, 1959, Carnegie Inst. Washington Pub. 617, p. 176, pl. 33, figs. 1, 4.
Clematis reticulata MacGinitie, 1933, Carnegie Inst. Washington Pub. 416, p. 54, pl. 6, fig. 4.
Odostemon hollicki auct. non Dorf. MacGinitie, 1933, Carnegie Inst. Washington Pub. 416, p. 55, pl. 7, figs. 1, 3, 5.
Odostemon simplex auct. non (Newberry) Cockerell. Berry, 1934, U.S. Geol. Survey Prof. Paper 185, p. 112, pl. 23, fig 1, only.
Dorf, 1936, Carnegie Inst. Washington Pub. 476, p. 118.
Mahonia hollicki (Dorf) of Arnold (non-typic), 1936, Michigan Univ., Mus. Paleontology, Contr., v. 5, p. 61, pl. 2, figs. 3–8; pl. 3, figs, 5, 7, 9.

Discussion.—Thus far, *Mahonia reticulata* has been substantiated only to the east of the Sierra-Cascade axis. The one western slope record (Axelrod, 1950, p. 60) is based on a fragmentary specimen that appears to be *Mahonia repens* (Lindl.) Don.

The most closely related extant species is *Mahonia repens.* Leaflets of this latter species, however, are neither entire margined nor as cuneate as those of *M. reticulata.*

Hypotypes: USNM 41951–41953, UCMP 8644.
Occurrence: Fingerrock, Stewart Spring.

Order ROSALES

Family SAXIFRAGACEAE

Genus PHILADELPHUS Linnaeus

Philadelphus nevadensis condit

Philadelphus nevadensis Condit, 1944 Carnegie Inst. Washington Pub. 553, p. 79, pl. 16, fig. 2.
Philadelphus bendirei auct. non (Knowlton) Chaney. Axelrod, 1939, Carnegie Inst. Washington Pub. 516, p. 104.

Discussion.—Leaves of *Philadelphus nevadensis* are typically 1½ to 2 times as long as broad in contrast to those of *P. lewisi* Pursh which are typically as long as broad. In addition, the most basal pair of secondaries depart, in *P. nevadensis*, almost at the base of the leaf, but in *P. lewisi* they depart above the base an eighth to a quarter of the length of the lamina.

Hypotype: USNM 41907.
Occurrence: Stewart Spring.

Genus RIBES Linnaeus

Ribes webbi Wolfe, n. sp.

Plate 9, figures 13, 14, 17, 18

Description.—Leaf simple, palmate; shape orbicular; apex rounded, base truncate to cordate; length 0.8–1.8 cm, width 1–2.2 cm; seven primary veins spreading out in a fanlike fashion, giving off one to three secondary veins; secondaries craspedodrome; tertiary venation obscure; margin with three to five lobes, which are compoundly serrate; petiole 1 cm long.

Discussion.—These fossils are nearly identical to leaves of the extant *Ribes cereum* Dougl. The only major difference is that the margin of the latter is more finely divided (compoundly serrate) than in leaves of *R. webbi.*

This species is named in honor of Mr. S. David Webb.

Holotype: USNM 41908.
Paratypes: USNM 41909–41911, UCMP 8645, 8646.
Occurrence: Stewart Spring.

Ribes (Grossularia) sp.

Plate 9, figure 11

Discussion.—The one leaf figured is deeply incised and has a few compoundly serrate teeth; hence it is referable to *Grossularia.* Foliage of extant species of this subgenus does not, in general, appear to be specifically diagnostic on the basis of a single leaf. It may be noted, however, that the fossil can be matched by some leaves of *Ribes californica* (H. and A.) Cov. and Britt.

Specimen: UCMP 8647.
Occurrence: Stewart Spring.

Family PLATANACEAE

Genus PLATANUS Linnaeus

Platanus bendirei (Lesquereux) Wolfe, n. comb.

Plate 4, figures 1, 2, 4

Acer bendirei Lesquereux, 1888 [in part], U.S. Natl. Mus. Proc., v. 11, p. 14, pl. 5, fig. 5; pl. 6, fig. 1; pl. 7, fig. 1.

Discussion.—The description of *Acer bendirei* makes clear that Lesquereux was describing primarily those leaves with closely spaced scalloped sinuses, rather than the one discordant specimen of *Acer macrophyllum*. Hence, I have resurrected the epithet of "*bendirei*" to apply to the sycamores in the Mascall and equivalent beds.

Platanus bendirei is distinguished from the younger *P. dissecta* Lesq. by features of margin and shape. No leaves of *P. dissecta* are known to have the finely and compoundly serrate margin common in *P. bendirei*. In addition, *P. bendirei* is typically three lobed.

Hypotypes: USNM 41941, UCMP 8648, 8649.
Occurrence: Fingerrock.

Family ROSACEAE

Genus AMELANCHIER Medicus

Amelanchier subserrata H. V. Smith

Plate 5, figure 1

Amelanchier subserrata H. V. Smith, 1941, Am. Midland Naturalist, v. 25, p. 514, pl. 13, fig. 1.
Amelanchier dignata auct. non (Knowlton) Brown. Smith, 1941, Am. Midland Naturalist, v. 25, p. 514, pl. 13, fig. 2.
Prunus covea auct. non Chaney. Smith, 1941, Am. Midland Naturalist, v. 25, p. 516, pl. 13, fig. 10.
Amelanchier scudderi auct. non Cockerell. Berry, 1928, U.S. Geol. Survey Prof. Paper 154, p. 252, pl. 55, fig. 4.
Amelanchier grayi auct. non Chaney. MacGinitie, 1933, Carnegie Inst., Washington Pub. 416, p. 58.

Discussion.—Two phylads of *Amelanchier* can be recognized in the western Tertiary: the *A. covea* and *A. scudderi* phylads. The latter phylad is known in the middle Oligocene and is represented by the following successively younger species: *A. grayi*, *A. dignata*, *A. alvordensis*, and the Recent *A. florida*. The nervilles of the *A. scudderi* group's leaves are, when compared to those of the *A. covea* phylad, less numerous (about half as many), depart from the secondaries at a higher angle (normally 60°–90° rather than about 45°), and are straighter and less branching. The *A. covea* type of leaf is known in *A. subserrata* and *A. alnifolia* Nutt.

Chaney and Axelrod (1959) synonymized *A. subserrata* and *A. covea*, but the latter has leaf bases that are consistently cuneate, whereas *A. subserrata* has a broad typically cordate base. Both species, however, have small often denticulate teeth; this character distinguishes both from *A. alnifolia* with its large coarse teeth. The Mascall specimen assigned to *A. covea* by Chaney and Axelrod is too poorly preserved and incomplete for familial determination.

Hypotype: USNM 41954.
Occurrence: Fingerrock.

Amelanchier cusicki Fernald

Plate 10, figure 9; figure 11

Amellanchier cusicki Fernald, 1899, Erythea, v. 2, p. 121.

Discussion.—Leaves of *Amelanchier cusicki* differ from those of other west American species of the genus by having an acute apex and, frequently, a few large teeth. All other Neogene records in the Western United States represent the phylads with a rounded apex and numerous teeth. However, early Miocene members of *A. subserrata* do occasionally have an acute apex, as does the Oligocene *A. scudderi*.

Hypotype: USNM 42009.
Occurrence: Stewart Spring.

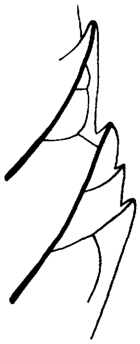


FIGURE 11.—Marginal venation of *Amelanchier*. *A. cusicki* Fernald, hypotype USNM 42009, × 5.

Genus CERCOCARPUS Humboldt, Bonpland, and Kunth

Cercocarpus antiquus Lesquereux

Plate 5, figure 2; plate 10, figures 2, 3; figure 12

Cercocarpus antiquus Lesquereux, 1878, Harvard Coll. Mus. Comp. Zoology, Mem., v. 6, no. 2, p. 37, pl. 10, figs. 6–11.
Brown, 1937, U.S. Geol. Survey Prof. Paper 186, p. 176, pl. 57, fig. 6.
Condit, 1944, Carnegie Inst. Washington Pub. 553, p. 82, pl. 16, fig. 3.
Axelrod, 1956, California Univ. Pubs. Geol. Sci., v. 33, p. 299, pl. 28, figs. 1, 12–14.

Discussion.—Several citations of *Cercocarpus antiquus*, for example Axelrod's (1944d, p. 256), are based on specimens that have comparatively small teeth and a linear decidedly obovate shape, as contrasted with the typic specimens that have large teeth and are diamond shaped. Therefore, I do not think that all the citations synonymized by Axelrod (1956, p. 299) with *C. antiquus* should be considered one species. After examining all materal of *Cercocarpus* from the Table Mountain locality, I cannot agree with Axelrod (1956, p. 299) that obovate as well as oval leaves are present.

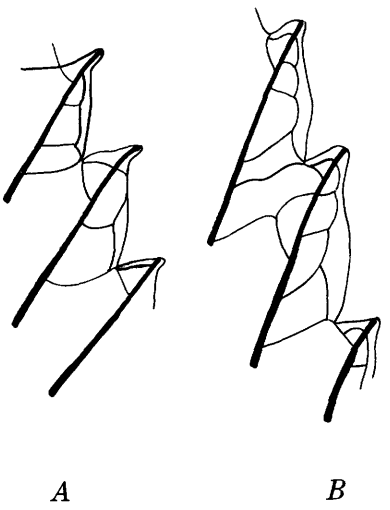
Cercocarpus is one of the genera most typical of the flora of southwestern North America. Species are found as far north as southern Oregon and as far south as northern Mexico. Today all the species are found in subhumid to semiarid climates. However, the fossil record of broad-leafed serrate *Cercocarpus* indicates that the genus or more accurately the member species of the genus had a wider range, both geographic and physiologic. The first record is *C. myricaefolius*, a large-leafed species represented in the middle Oligocene Florissant flora of central Colorado (MacGinitie, 1953, p. 115). Another species is found in the correlative or slightly younger Ruby Valley flora of western Montana (Becker, 1961, p. 71). In both of these floras, *Cercocarpus* was apparently a common plant, associated with *Sequoia*, *Metasequoia*, *Chamaecyparis*, and mesophytic dicotyledons. In the Codilleran region, however, as judged by these two described floras, the climate became drier to the south.

In the early Miocene of the Oregon Cascades, a species belonging to the Ruby Valley lineage is well represented in a decidedly mesic flora. By the Barstovian, a decendant species, *C. antiquus*, is found from southwestern Nevada north to northeastern Oregon and west into California. It is from *C. antiquus* that the extant *C. betuloides* is probably derived. Thus, this phylad has become adapted to progressively drier conditions.

In the Neogene of the Great Basin, *Cercocarpus holmesi* first appears. Axelrod (1944d, p. 257) related this species to the extant *C. paucidentatus*, *C. breviflorus*, and *C. eximinus*. Although this relationship is close, it is not likely that any of the western or northern Great Basin populations are phylogenetically related to the populations of the extant species. The occurrence of *C. holmesi* in the Creede flora of Colorado indicates that the Cordilleran populations were more likely ancestral to the Recent ones. The relationship of *C. holmesi* is with the northern group of *Cercocarpus* that occurs in the Florissant and Ruby Valley floras.

The Tertiary record is very poor in Arizona and northern Mexico. In view of the above history of *Cercocarpus*, however, it is likely that the phylads of the extant species of northern Mexico were differentiated in the later Oligocene and Miocene of the southern Cordilleran region.

Hypotypes: USNM 41912–41914, UCMP 8650, 8651.
Occurence: Fingerrock, Stewart Spring.



Figuge 12.—Marginal venation of *Cercocarpus*. *A*, *C. antiquus* Lesquereux, hypotype USNM 41913. *B*, *C. betuloides* Nutt., Recent, × 5.

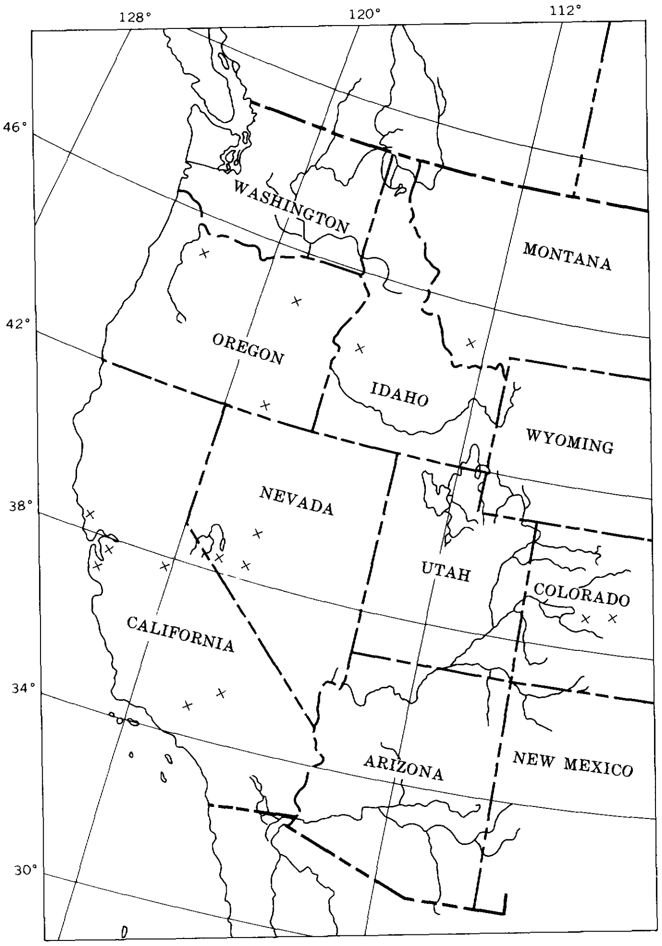


Figure 13.—Distribution map of fossil *Cercocarpus*.

Genus HOLODISCUS Maxim

Holodiscus fryi Wolfe, n. sp.

Plate 10, figures 8, 12; figure 14

Description.—Leaf simple, pinnate; shape orbicular; apex rounded, base cuneate with lamina decurrent along petiole; length 1.0–1.3 cm, width 0.9–1.2 cm; three or four pairs of straight craspedodrome secondaries; one or two craspedodrome tertiaries departing from the basal side of the basal secondaries; mesh not preserved; margin compoundly serrate, with three rounded primary teeth, petiole 0.5 cm long.

Discussion.—These leaves are similar to those of *Holodiscus dumosus* (Nutt.) Heller. In the living species, the leaves typically have four primary teeth, and the secondaries depart at a lower angle.

Holotype: USNM 41915, UCMP 8674 (counterpart).
Paratype: USNM 41916, UCMP 8652 (counterpart).
Occurrence: Stewart Spring.

Genus LYONOTHAMNUS A. Gray

Lyonothamnus parvifolius (Axelrod) Wolfe, n. comb.

Plate 10, figures 1, 14, 15; plate 11, figures, 1, 3–6; figure 15

Comptonia parvifolia Axelrod, 1956, California Univ. Pubs. Geol. Sci., v. 33, p. 287, pl. 8, figs. 13–15; pl. 28, fig. 10.

Discussion.—This species is abundantly represented in the paper shales by numerous compound leaves. The identity of these specimens with those of Axelrod's *Comptonia* is clear, although only his Middelgate specimen (his pl. 28, fig. 10) shows, by the alate rachis, that it was part of a compound leaf. One certain feature that distinguishes leaves of *Comptonia* from those of *Lyonothamnus* is that those of the latter are compound and those of *Comptonia* are simple (and hence could not have an alate rachis). Another distinguishing feature is in the venation of the leaflet lobations; in *Lyonothamnus*, the most apical secondary terminates at the tip of the lobation. In *Comptonia*, the secondary that goes to the tip of the lobation is centrally located and there is at least one other, more apical, secondary in the lobation.

Leaves of *Lyonothamnus parvifolius* can be readily distinguished from those of the extant *L. floribundus* A. Gray by the fewer number of leaflets in the latter species (five as opposed to seven or nine in the fossil species). Moreover, the individual lobations of the leaflets are nearly square in *L. floribundus* (fig. 15), but in *L. parvifolius* the lobations are elongated in a direction perpendicular to the midrib.

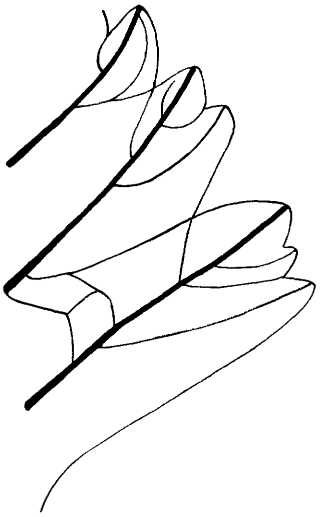


FIGURE 14.—Marginal venation of *Holodiscus*. *H. fryi* Wolfe, holotype USNM 41915, × 5.

The past distribution of *Lyonothamnus* is in interesting contrast to the present endemism on the Channel Islands (fig. 16). The first known record of the genus is in a flora of early Miocene age from the Oregon Cascades. Although this flora contains other genera of "Madro-Tertiary" type, for example *Cercocarpus*, *Arbutus*, and *Colubrina*, the flora has a highly warm-temperate mesic aspect. This same species is known from the mesic Latah flora of Washington. *L. parvifolius* is closely related to, and probably descended from, this earlier species. Hence, *L. parvifolius* appears to be another subhumid derivative of a mesic species.

On the other hand, the middle Miocene *Lyonothamnus mohavensis* (Axelrod, 1939, p. 107) is closely related to the extant *L. floribundus.* This phylad is thus recognizable as distinct from the northern one by middle Miocene. Such a distribution in space and time indicates that *Lyonothamnus* was a member of the Cordilleran flora in the Oligocene, and, following the renewed uplifting of that region in the later Oligocene, two populations or groups of populations became isolated. The southern one contains the lineage leading to the insular *L. floribundus*, whereas the northern one became extinct at the close of the Miocene.

Thus, the occurrence of *Lyonothamnus* in a flora should not necessarily be interpreted as indicating environmental conditions similar to the present area of *L. floribundus.* It is evident that lineages have under-

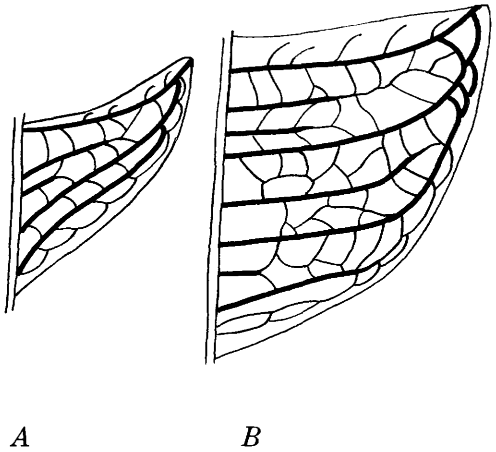


FIGURE 15.—Venation of *Lyonothamnus*. *A*, *L. parvifolius* (Axelrod) Wolfe, hypotoype USNM 42060. *B*, *L. floribundus* A. Gray, Recent, × 5.

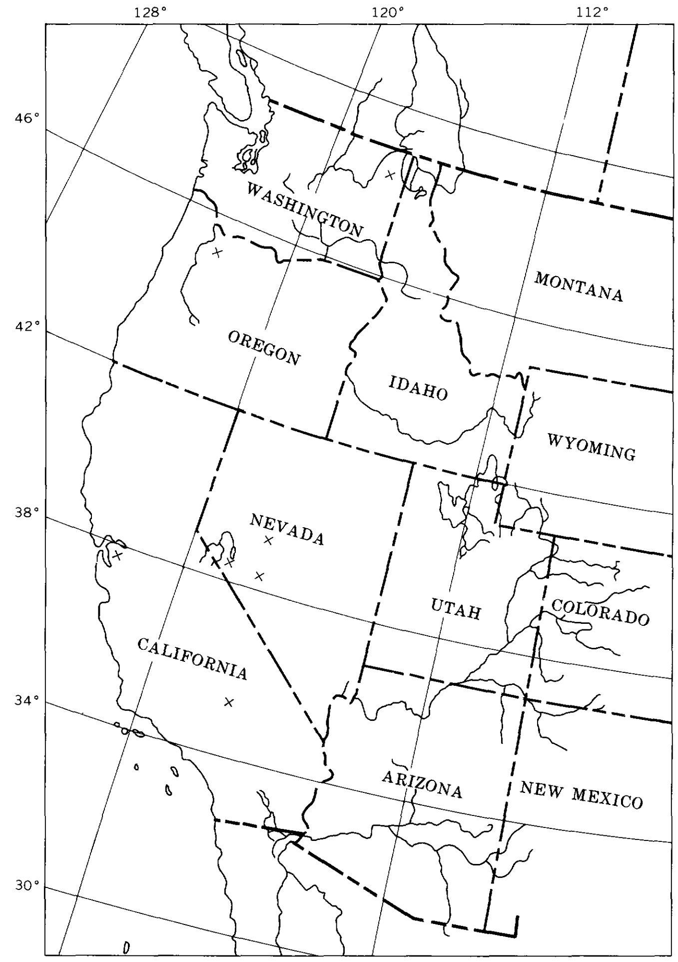


FIGURE 16.—Distribution map of fossil *Lyonothamnus*.

gone considerable physiologic evolution since the Oligocene.

Hypotypes: USNM 41917–41923, UCMP 8653, 8656.
Occurrence: Stewart Spring.

Genus PERAPHYLLUM Nuttall

Peraphyllum vaccinifolium (Knowlton) Wolfe, n. comb.

Plate 10, figures 4–6; figure 17

Salix vaccinifolia Knowlton, 1901, U.S. Geol. Survey 21st Ann. Rept., pt. 2, p. 212, pl. 30, fig. 8.

Salix knowltoni auct. non Berry. Axelrod, 1956, California Univ. Pubs. Geol. Sci., v. 33, p. 285, in part, pl. 7, figs. 1, 2; pl. 13, figs. 6, 7.

Discussion.—Of Knowlton's type material for this species, one specimen (his pl. 30, fig. 20), which Axelrod (1939) placed in *Salix kernensis*, is lost. The original figure of this specimen is so poor that the citation of *S. kernensis* in the Esmeralda flora should be discarded. Another unfigured specimen has numerous sharp teeth and venation typical of *S. succorensis*.

Knowlton's other figured and unfigured specimens, however, are similar in being linear-oval to obovate, having steeply ascending and angularly looped secondaries and an entire margin. The coarse pattern of the nervilles and the highly angular secondary loops of the fossils can be matched by the leaves of the extant *Peraphyllum ramosissimum* Nutt. This Recent species has leaves with a remotely toothed margin; the fossils do not appear to have any definite teeth, although a few specimens have small undulations on the margin.

Hypotypes: USNM 41965–41967, UCMP 8657.
Occurrence: Stewart Spring.

FIGURE 17.—Marginal venation of *Peraphyllum*. *P. vaccinifolium* (Knowlton) Wolfe, hypotype USNM 41967, × 5.

Genus PRUNUS Linnaeus

Prunus sp.

Plate 10, figures 11, 13

Discussion.—Two fragmentary leaves with percurrent nervilles, camptodrome secondaries, and a finely serrate margin can be confidently assigned to *Prunus*. Without more complete specimens, the specific relationships of the species represented must remain speculative. However, these leaves do resemble the leaves of *Prunus harneyensis* Axelr. from the Alvord Creek flora.

Specimens: USNM 41949, 41950.
Occurrence: Stewart Spring.

Genus ROSA Linnaeus

Rosa sp.

Plate 10, figure 7; figure 18

Discussion.—The difficulty of separating isolated leaflets of extant species of *Rosa* makes determination of this one fossil speculative. It may be the same species as the leaflet called *Rosa miocenica* (Axelrod, 1939, p. 111, pl. 8, fig. 12), but I prefer to maintain a conservative approach. The Stewart Spring leaflet also superficially resembles *Rosa alvordensis* (Axelrod, 1944d, p. 259, pl. 44, fig. 5), but on examining and cleaning the holotype of that species, it proved to have a long petiole and to be a variant of *Amelanchier alvordensis.*

Specimen: USNM 41924.
Occurrence: Stewart Spring.

FIGURE 18.—Marginal venation of *Rosa*. *R.* sp., USNM 41924, × 5.

Genus SORBUS Linnaeus

Sorbus sp.

Discussion.—An incomplete specimen lacking a base has the margin and venation of leaflets of *Sorbus*.

Specimen: USNM 41925.
Occurrence: Stewart Spring.

Sorbus harneyensis Axelrod

Plate 5, figure 3

Sorbus harneyensis Axelrod, 1944, Carnegie Inst. Washington Pub. 553, p. 259, pl. 44, figs. 6, 7.

Discussion.—As Axelrod (1944c, p. 259) noted, the leaflets of *Sorbus harneyensis* are similar to those of the extant *S. scopulina* Greene. The compound leaf figured here has at least 13 leaflets and is thus in this respect also similar to *S. scopulina.*

Hypotype: USNM 41977.
Occurrence: Fingerrock.

Order SAPINDALES

Family ANACARDIACEAE

Genus SCHINUS Linnaeus

Schinus savagei Wolfe, n. sp.

Plate 12, figure 10; figure 19

Description.—Leaflet pinnate; shape oval; apex rounded, base rounded; length 2 cm, width 1.2 cm; eight pairs of straight to undulatory secondaries, forking submarginally, sending tertiary branches into teeth, and forming weak loops; nervilles branched, percurrent; mesh with large polygons intruded by freely ending veinlets; margin simply and coarsely serrate; teeth rounded; apetiolulate.

Discussion.—This solitary leaflet has the undulatory forking secondaries typical of *Schinus*. Some species of *Fraxinus* are also similar to the fossil, but in the latter genus the tertiary veins enter the teeth along the apical margin as opposed to the central entry in *Schinus.*

The most closely related species is *Schinus gracilipes* Johnston, as evidenced by the foliar similarity. The fossil, however, has fewer secondaries and a broader shape than the extant leaves.

Holotype: USNM 41926, UCMP 8658 (counterpart).
Occurrence: Stewart Spring.

Genus RHUS Linnaeus

Rhus integrifolia (Nuttall) Bentham and Hooker

Plate 12, figure 2

Rhus integriflora Bentham and Hooker, 1874, in Wheeler, Geog. and Geol. Explor., Rep. Botany, p. 84.

Discussion.—The one Stewart Spring specimen of *Rhus* is an entire folded leaf; the counterpart has been cleaned to show the other side of the lamina. This specimen is indistinguishable from leaves of the extant *Rhus integrifolia*, except that the latter do not typically have a base as broadly rounded as the fossil. However,

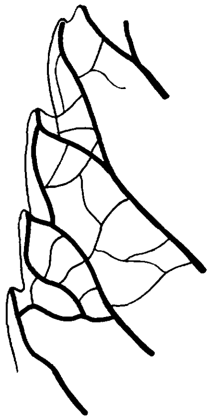


FIGURE 19.—Marginal venation of *Schinus*. *S. savagei* Wolfe, holotype USNM 41926, × 5.

on the basis of one specimen, it is not possible to determine whether this type of base is typical of the Stewart Spring form.

Rhus integrifolia appears to be descended from the middle Miocene *R. preintegrifolia*, which is found in the Tehachapi flora. *R. integrifolia* is the only definite "Madro-Tertiary" species in the Stewart Spring flora.

Hypotype: USNM 42011, UCMP 8659 (counterpart).
Occurrence: Stewart Spring.

Astronium mawbyi Wolfe, n. sp.

Plate 12, figure 7; figure 20

Description.—Leaflet pinnate; shape asymmetrical, ovate; length 2.0 cm, width 1.2 cm; base asymmetrical and cuneate, apex acuminate; 13 pairs of secondaries, departing at an angle of 45°–50°, straight but curving apically near margin to enter teeth; nervilles branching, departing perpendicular to secondaries; tertiaries craspedodrome; mesh not preserved; margin finely serrate with narrowly triangular teeth; apetiolulate.

Discussion.—This solitary leaflet has the asymmetrical V-shaped base found in *Astronium truncatum* (Lesq.) MacG. *A. mawbyi* differs from leaflets of that species by being less asymmetrical, less linear, and more finely serrate. It is possible, however, that *A. mawbyi* is descended from *A. truncatum*.

This species is named in honor of Mr. John Mawby.

Holotype: USNM 41948.
Occurence: Stewart Spring.

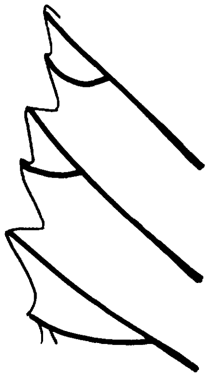


FIGURE 20.—Marginal venation of *Astronium*. *A. mawbyi* Wolfe, holotype USNM 41948, × 5.

Family ACERACEAE

Genus ACER Linnaeus

Acer bolanderi Lesquereux

Plate 5, figure 7

Acer bolanderi Lesquereux, 1878, Harvard Coll. Mus. Comp. Zoology, Mem., v. 6, no. 2, p. 27, pl. 7, figs. 7–11.
Chaney and Axelrod, 1959, p. 192 (see synonymy), pl. 39, figs. 7–12; pl. 40, fig. 7.

Discussion.—This one seed appears referable to *Acer bolanderi*. This species is known from the late Hemingfordian through Barstovian. A closely related species is *A. minutifolia* Chaney from the early Miocene of Oregon.

Hypotype: USNM 41955.
Occurrence: Fingerrock.

Acer macrophyllum Pursh

Plate 5, figures 4–6

Acer macrophyllum Pursh, 1814, Fl. Am. Sept., v. 1, p. 267.
Acer oregonianum Knowlton, 1902, U.S. Geol. Survey Bull. 204, p. 75, pl. 13, figs. 5, 7, 8.
Jennings, 1920, Carnegie Mus., Mem., v. 8, p. 423, pl. 32, fig. 3.
Oliver 1934, Carnegie Inst. Washington Pub. 45, p. 24.
Chaney and Axelrod, 1959, Carnegie Inst. Washington 617, p. 195, pl. 41, figs. 11–14.
Acer septilobatum Oliver, 1934, Carnegie Inst. Washington Pub. 455, p. 25, pl. 4, figs. 1, 2.
Acer bendirei auct. non Lesquereux. Brown, 1937, U.S. Geol. Survey Prof. Paper 186, p. 179, pl. 58, figs. 20–22.
Smith, 1938, Torrey Bot. Club Bull., v. 65, p. 561.
Acer merriami auct. non Knowlton. MacGinitie, 1933, Carnegie Inst. Washington Pub. 416, p. 61, pl. 10, fig. 1.
Lamotte, 1936, Carnegie Inst. Washington Pub. 455, p. 135, pl. 12, fig. 7.

Acer chaneyi auct. non Knowlton. MacGinitie, 1933, Carnegie Inst. Washington Pub. 416, p. 61.

Discussion.—No paleobotanist has yet shown what characters distinguish recent seeds and leaves of *Acer macrophyllum* from the specimens on which the above citations are based. I also concur that the fossils and recent specimens are indistinguishable and have hence included them under the same epithet.

Although *Acer alvordensis* Axelr. is clearly a maple of the *macrophyllum*-type, the deep dissection of the lamina, often into a compound leaf, is a feature not typically found in the living members of *A. macrophyllum.* Axelrod (1944d, p. 261) noted that in the drier parts of its range *A. macrophyllum* is more deeply dissected, although not as deeply as in *A. alvordensis.*

Hypotypes: USNM 41956, 41957, UCMP 8660, 8661.
Occurrence: Fingerrock.

Family SAPINDACEAE

Genus SAPINDUS Linnaeus

Sapindus sp.

Plate 12, figure 1

Discussion.—The specimen figured here is not sufficiently well preserved to make certain the generic reference. The highly falcate shape of the leaflet, the revolute margin, and the looping secondaries, however, are features typically found in leaflets of *Sapindus.*

Several leaflets possibly conspecific with the above specimen have been recorded from the Pliocene of California under the name of *Sapindus oklahomensis* Berry. All these specimens are linear in shape, but the Oklahoma material is typically linear-ovate and probably represents a separate species.

Specimen: USNM 41970, UCMP 8662 (counterpart).
Occurrence: Stewart Spring.

Order RHAMNALES

Family RHAMNACEAE

Genus COLUBRINA Richard

Colubrina sp.

Plate 12, figure 3

Discussion.—One fragmentary palmate specimen has the coarse teeth with glands on the lamina that is characteristic of leaves of *Colubrina.* This specimen appears to be conspecific with a new species from the early Miocene of Oregon.

Specimen: USNM 41927, UCMP 8663 (counterpart).
Occurrence: Stewart Spring.

Order MYRTIFLORAE

Family ELAEAGNACEAE

Genus ELAEAGNUS Linnaeus

Elaeagnus cedrusensis Wolfe, n. sp.

Plate 12, figures 6, 8, 9; figure 21

Description.—Leaves simple, pinnate; shape oval to linear-oval; length 3.0–4.5 cm, width 0.8–1.6 cm; base cuneate to broadly rounded with lamina decurrent along petiole; apex broadly to narrowly rounded; midrib thick near base, thinning and forking before reaching apex; six to nine pairs of irregularly spaced secondaries, departing at angles of 40°–90°, undulatory, forking in the broader leaves, looping apically in the linear leaves; intersecondaries numerous; nervilles irregularly branching and forming a coarse polygonal pattern; areoles about 0.2 mm wide, intruded by once or twice branching freely ending veinlets; margin entire; petiole thick, 0.3–0.9 cm long.

Discussion.—In gross aspects of venation and shape these fossils resemble the leaves of the extant *Elaeagnus utilis* Nels. One peculiar feature of both fossil and Recent leaves is the tendency for the midrib to fork before reaching the apex. No stellate trichomes, which are characteristic of the extant species, have been detected on the fossils, but the size of the individual hairs is about same as the grain size of the matrix and hence might not be preserved. The areoles in *E. utilis* are about 0.5 mm wide in contrast to the width of 0.2 mm in *E. cedrusensis.* This is the first authentic fossil record of *Elaeagnus* from North America.

Holotype: USNM 41962, UCMP 8664 (counterpart).
Paratypes: USNM 41963, 41964, UCMP 8665, 8666.
Occurrence: Stewart Spring.

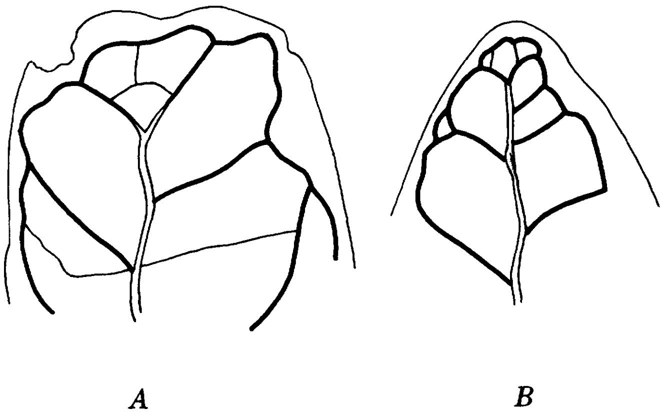


FIGURE 21.—Apical venation of *Elaeagnus*. *A*, *E. cedrusensis* Wolfe, holotype USNM 41962. *B*, *E. utilis* Nels., Recent, × 5.

Order ERICALES

Family ERICACEAE

Genus ARBUTUS L.

Arbutus traini MacGinitie

Plate 5, figures 8, 9; plate 12, figures 11–14

Arbutus traini MacGinitie, 1933, Carnegie Inst. Washington Pub. 416, p. 64, pl. 12, fig. 3; pl. 13, figs. 1, 2.

Discussion.—The Stewart Spring specimens are typical of *Arbutus traini* in being either entire margined or sharply serrate. The much broader leaves of the extant *A. menziesi* Pursh are, except in shape, similar to the fossils. Whether *A. traini* is directly ancestral to *A. menziesi* is uncertain, although the fact that the former species is apparently older than *A. menziesi* does indicate such a relationship. Late Miocene specimens of *A. traini* from the Cascades are slightly broader than the Great Basin specimens, and this could be interpreted to mean that the coastal members of *A. traini* gave rise to *A. menziesi.* Today the distribution of the latter species is primarily along the western slopes of the Sierra-Cascade axis.

Hypotypes: USNM 41928–41932, UCMP 8667–8669.
Occurrence: Fingerrock, Stewart Spring.

Genus ARCTOSTAPHYLOS Adanson

Arctostaphylos masoni Wolfe, n. sp.

Plate 11, figure 2; figure 22

Description.—Leaves simple, pinnate; oval to obovate; length 2.4–3.3 cm, width 1.1–1.6 cm; base cuneate, apex rounded to acuminate and spine tipped; six to eight pairs of secondaries departing at an angle of 30°–50°, curving apically, looping but giving off strong tertiary loops; marginal tertiaries forming a series of ladderlike loops with margin, often forking just submarginally; intersecondaries numerous and weak; nervilles irregularly branching; ultimate venation not preserved; margin entire.

Discussion.—The fossils have the unusual ladderlike marginal tertiaries (see fig. 22) characteristic of leaves of *Arctostaphylos.* In general features of shape and venation, *A. masoni* most closely resembles the extant *A. nevadensis* Gray, which has been recorded as a fossil under the name of *A. verdiana* (Axelrod, 1958, p. 133). *A. masoni* differs from *A. nevadensis* by having leaves that occasionally have a rounded apex and that have more numerous secondaries.

Holotype: USNM 42000.
Paratypes: USNM 42001, UCMP, 8670.
Occurrence: Stewart Spring.

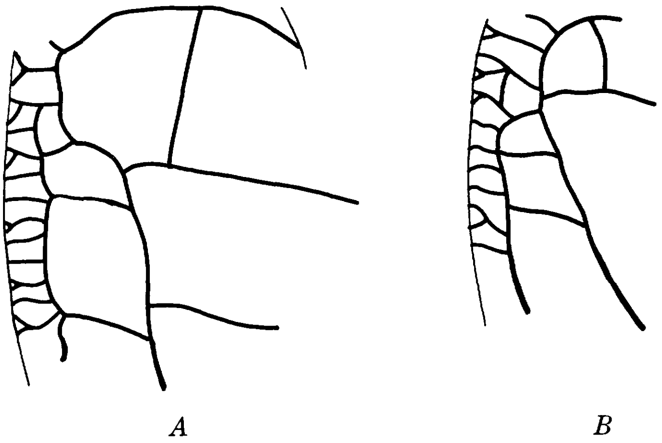


FIGURE 22.—Marginal venation of *Arctostaphylos.* *A, A. masoni* Wolfe, holotype USNM 42000. *B, A. nevadensis* A. Gray, Recent, × 5.

INCERTAE SEDIS

INDETERMINED LEAF

Plate 12, figure 5

Discussion.—This leaf has a prominent mesh of large areoles intruded by much-branched freely ending veinlets. The marginal venation is formed of a series of regularly shaped loops. The nervilles are irregularly branching. As yet, I have not seen any Recent leaf comparable to the fossil. There are superficial resemblances to some leaves of Lauraceae, but the fossil lacks the basal secondaries characteristic of that family.

Specimen: USNM 42012, UCMP 8673 (counterpart).
Occurrence: Stewart Spring.

INDETERMINED FLORAL REMAINS

Plate 10, figures 10, 16–19

Discussion.—Several fossils of different types of inflorescences have been found. As impressions or compressions, most floral remains are difficult to determine because the three-dimensional relationship of the various parts is not known. Suggestions as to the taxonomic relationships can be made, for example the four-parted calyx (pl. 10, fig. 19) could be Cruciferae, but even these suggestions are of dubious value.

Specimens: 42013–42015, 42029, 42030.

REFERENCES CITED

Axelrod, D. I., 1939, A Miocene flora from the western border of the Mohave desert: Carnegie Inst. Washington Pub. 516, 129 p., 12 pls.

——— 1944a, The Mulholland flora: Carnegie Inst. Washington Pub. 553, p. 103–146, 8 pls.

——— 1944b, The Oakdale flora: Carnegie Inst. Washington Pub. 553, p. 147–165, 2 pls.

——— 1944c, The Sonoma flora: Carnegie Inst. Washington Pub. 553, p. 167–206, 6 pls.

——— 1944d, The Alvord Creek flora: Carnegie Inst. Washington Pub. 553, p. 225–262, 7 pls.

——— 1950, Studies in late Tertiary paleobotany: Carnegie Inst. Washington Pub. 590, 360 p., 19 pls.

——— 1956, Mio-Pliocene floras from west-central Nevada: California Univ. Pubs. Geol. Sci., v. 33, 322 p., 32 pls.

——— 1958, The Pliocene Verdi flora of western Nevada: California Univ. Pubs. Geol. Sci., v. 34, p. 91–160, pls. 13–23.

Beck, G. F., 1945, Tertiary coniferous woods of western North America: Northwest Sci., v. 19, no. 3, p. 67–69.

Becker, H. F., 1961, Oligocene plants from the upper Ruby River basin, southwestern Montana: Geol. Soc. America Mem., v. 82, 127 p., 32 pls.

Berry, E. W., 1927, Flora of the Esmeralda formation in western Nevada: U.S. Natl. Mus., Proc., v. 72, art. 23, 15 p., 2 pls.

Brown, R. W., 1937, Addition to some fossil floras of the western United States: U.S. Geol. Survey Prof. Paper 186–J, p. 163–206, pls. 45–63.

——— 1940, A bracket fungus from the late Tertiary of southwestern Idaho: Washington Acad. Sci. Jour., v. 29, p. 422–424.

——— 1949, Pliocene plants from Cache Valley, Utah: Washington Acad. Sci. Jour., v. 39, p. 224–229.

Chaney, R. W., 1936, The succession and distribution of Cenozoic floras around the northern Pacific Basin *in* Essays in Geobotany in honor of William Setchell: California Univ. Press, Berkeley, Calif., p. 55–85.

——— 1944a, The Dalles flora: Carnegie Inst. Washington Pub. 553, p. 285–321, 5 pls.

——— 1944b, The Troutdale flora: Carnegie Inst. Washington Pub. 553, p. 323–351, 11 pls.

——— 1952, Conifer dominants in the middle Tertiary of the John Day Basin, Oregon: Paleobotanist, v. 1, p. 105–113.

——— 1959, Miocene floras of the Columbia Plateau, Part I. Composition and interpretation: Carnegie Inst. Washington Pub. 617, p. 1–134.

Chaney, R. W. and Axelrod, D. I., 1959, Miocene floras of the Columbia Plateau, Part II. Systematic considerations: Carnegie Inst. Washington Pub. 617, p. 135–237, 44 pls.

Condit, Carleton, 1944a, The Remington Hill flora: Carnegie Inst. Washington Pub. 553, p. 21–55, 12 pls.

——— 1944b. The Table Mountain flora: Carnegie Inst. Washington Pub. 553, p. 57–90, 9 pls.

Dorf, Erling, 1930, Pliocene floras of California: Carnegie Inst. Washington Pub. 412, p. 1–108, 13 pls.

Krystofovich, A. N., ed., 1956, Oliogotsenovalaia flora Gory Ashutas v Kazahtstane [Oligocene flora of Mount Ashutas in Kazakhstan]: Akad. Nauk SSSR Inst. Botanicheskii Komarova Trudy, ser. 8, Palaeobotanica, v. 1, 179 p., 61 pls.

Knowlton, F. H., 1901, Fossil plants of the Esmeralda formation: U.S. Geol. Survey 18th Ann. Rept., pt. 2, p. 209–222, pl. 30.

Lamotte, R. S., 1936, The Upper Cedarville flora of northwestern Nevada and adjacent California: Carnegie Inst. Washington Pub. 455, p. 57–142, 14 pls.

——— 1952, Catalogue of the Cenozoic plants of North America through 1950: Geol. Soc. America Mem. 51, 381 p.

MacGinitie, H. D., 1933, The Trout Creek flora of southeastern Oregon: Carnegie Inst. Washington Pub. 416, p. 21–68, 16 pls.

——— 1953, Fossil plants of the Florissant beds, Colorado: Carnegie Inst. Washington Pub. 599, 198 p., 75 pls.

MacNeil, F. S., Wolfe, J. A., Miller, D. J., and Hopkins, D. M., 1961, Correlation of the Tertiary formations of Alaska: Am. Assoc. Petroleum Geologists, Bull., v. 45, p. 1801–1809.

Manning, W. E., 1957, The Genus Juglans in Mexico and Central America: Arnold Arbor, Jour., v. 38, p. 121–150.

Mason, H. L., 1934, Pleistocene flora of the Tomales formation: Carnegie Inst. Washington Pub. 415, p. 81–179, 11 pls.

——— 1944, A Pleistocene flora from the McKittrick asphalt deposits of California: California Acad. Sci. Proc., v. 25, p. 221–233.

——— 1947, Evolution of certain floristic associations in western North America: Ecol. Monographs, v. 17, p. 201–210.

——— 1953, Plant geography in the delimitation of genera *in* Plant genera—their nature and definition—a symposium: Chronica Botanica, v. 14, no. 3, p. 154–159.

Savage, D. E., 1955, Nonmarine lower Pliocene sediments in California—a geochronologic-stratigraphic classification: California Univ. Pubs. Geol. Sci., v. 31, no. 1, 26 p.

Turner, H. H., 1900, The Esmeralda formation, a freshwater lake deposit: U.S. Geol. Survey 21st Ann. Rept., pt. 2, p. 191–208.

Webber, I. E., 1933, Woods from the Ricardo Pliocene of Last Chance Gulch, California: Carnegie Inst. Washington Pub. 412, p. 113–134, 5 pls.

Wolfe, J. A., 1961, Age of the Keechelus Andesitic Series of the Cascade Range, Washington: art. 231, U.S. Geol. Survey Prof. Paper 424C, p. C228–C230.

Wolfe, J. A., and Barghoorn, E. S., 1960, Generic change in Tertiary floras in relation to age: Am. Jour. Sci., v. 258–A, p. 388–399.

Wolfe, J. A., Gower, H. D., and Vine, J. D., 1961, Age and correlation of the Puget group in King County, Washington: art. 232, U.S. Geol. Survey Prof. Paper 424C, p. C230–C232.

Wood, H. E., Chaney, R. W., Clark, John, Colbert, E. H., Jepson, G. L., Reeside, J.B., and Stock, Chester, 1941, Nomenclature and correlation of the North American continental Tertiary: Geol. Soc. America Bull., v. 52, p. 1–48, 1 pl.

INDEX

[Italic page numbers indicate descriptions]

U. S. GOVERNMENT PRINTING OFFICE : 1964 O - 695-377

PLATES 1–12

PLATE 1

[All figures natural size]

FIGURE 1, 4. *Pinus ponderosa* Douglass. (p. N15).
Hypotypes USNM 42017.
2, 9. *Pinus monticola* Douglass. (p. N15).
Hypotypes USNM 42016 (fig. 2,) UCMP (fig. 9).
3, 5. *Picea magna* MacGinitie. (p. N15).
Hypotypes USNM 42026–42028.
6. *Cyperacites* sp. (p. N16).
USNM 41976.
7. *Carya bendirei* (Lesquereux) Chaney and Axelrod. (p. N20).
Hypotype USNM 41943.
8, 11. *Glyptostrobus* sp. (p. N16).
USNM 41933, 41934.
10. *Abies concolor* Lindley. (p. N14).
Hypotypes USNM 42025.
12. *Populus lindgreni* Knowlton. (p. N17).
Hypotype USNM 41947.
13. *Alnus relata* (Knowlton) Brown. (p. N20).
Hypotype USNM 41969.
14. *Betula thor* Knowlton. (p. N21).
Hypotype USNM 41971.

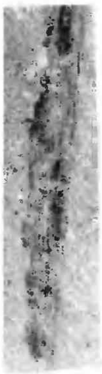

1

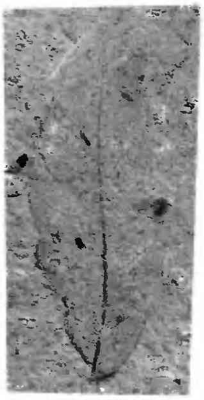

2


3

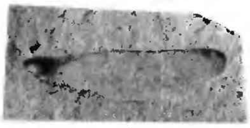

4


5


6

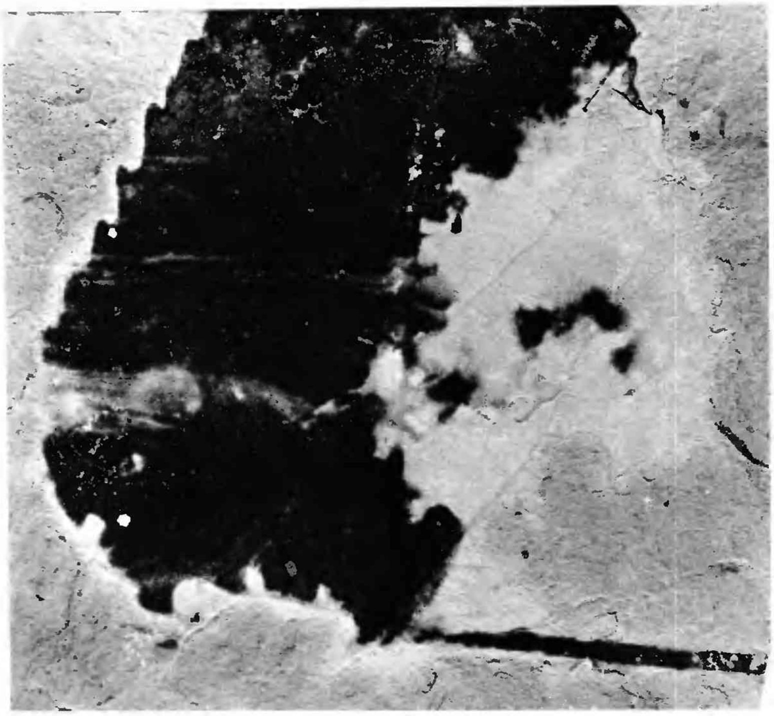

7

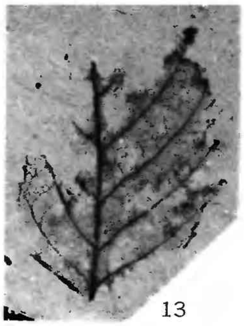

8


9


10


11


12


13


14

FINGERROCK FLORA

PLATE 2

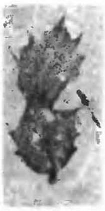
[All figures natural size]

FIGURES 1–10, 14. *Quercus chrysolepis* Liebmann. (p. N21).
Hypotypes USNM 41887–41897.
11–13. *Quercus simulata* Knowlton. (p. N22).
Hypotypes USNM 41938–41940.

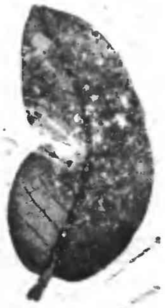

1


2


3


4


5

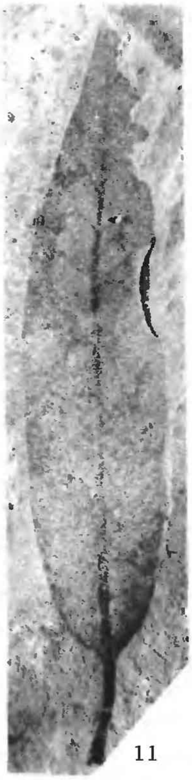

6

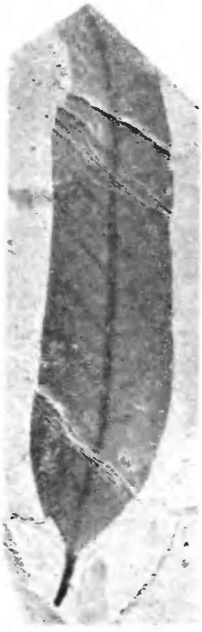

7

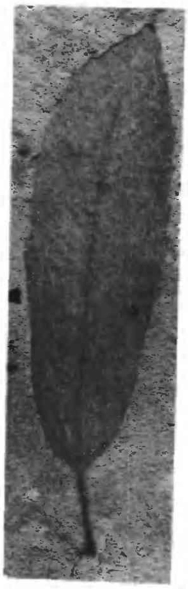

8

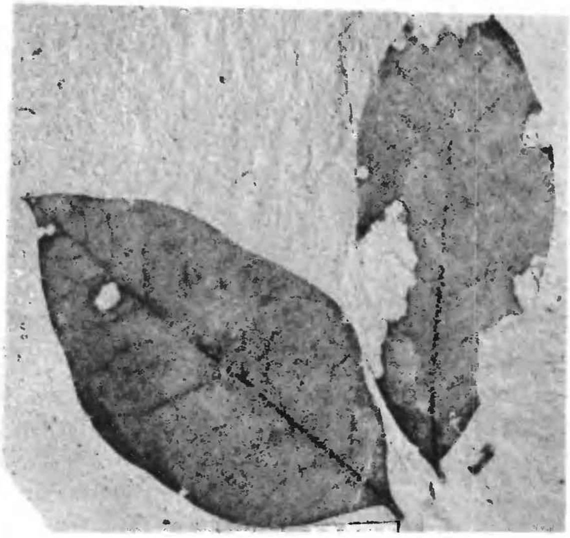

9


10


11


12


13

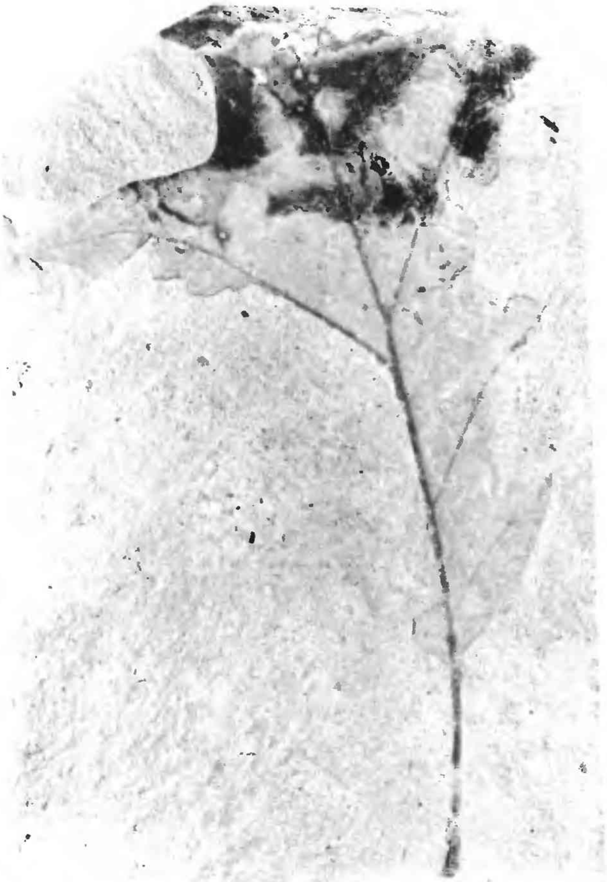

14

FINGERROCK FLORA

PLATE 3

[All figures natural size]

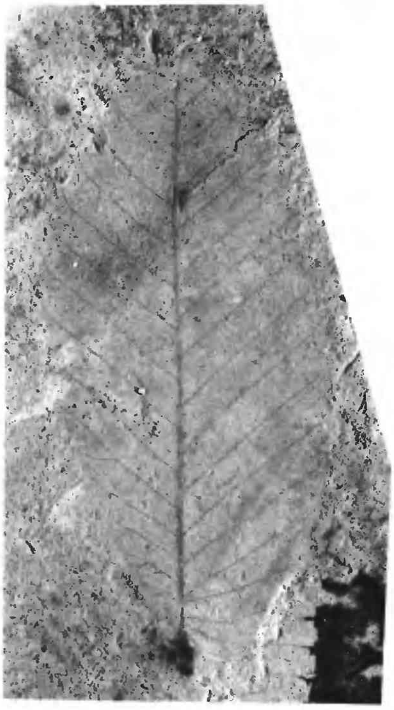
FIGURE 1. *Quercus pseudolyrata* Lesquereux. (p. N22).
Hypotype USNM 41905.
2, 3, 5. *Zelkova oregoniana* (Knowlton) Brown. (p. N23).
Hypotypes USNM 41944–41946.
4, 6. *Ulmus newberryi* Knowlton. (p. N22).
Hypotypes USNM 41942 (fig. 6), UCMP 8642 (fig. 4).



1

2

3



4

5

6

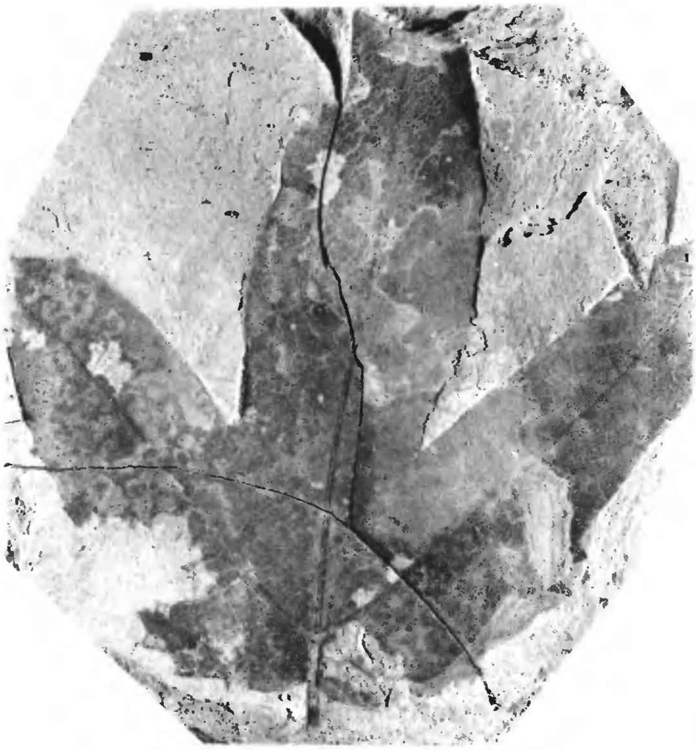
FINGERROCK FLORA

PLATE 4

[All figures natural size]

FIGURES 1, 2, 4. *Platanus bendirei* (Lesquereux) Wolfe. (p. N24).
Hypotypes USNM 41941 (fig. 2), UCMP 8648, 8649 (figs. 1, 4). The margin of the specimen in fig. 1 is broken and hence simulates *P. paucidentata*.

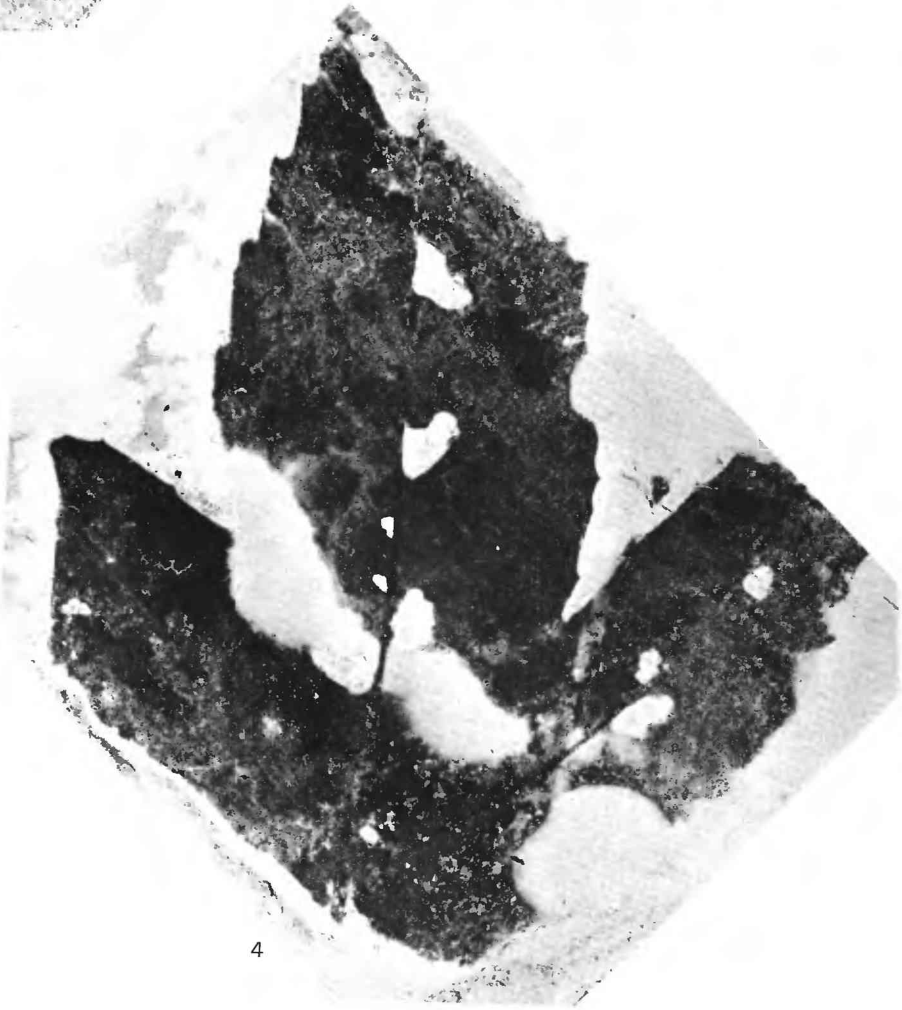
3. *Mahonia reticulata* (MacGinitie) Brown, (p. N23).
Hypotype USNM 41953.



1

2

3



4

FINGERROCK FLORA

PLATE 5

[All figures natural size]

FIGURE 1. *Amelanchier subserrata* Smith. (p. N24).
Hypotypes USNM 41954.

2. *Cercocarpus antiquus* Lesquereux. (p. N24).
Hypotype USNM 41912.

3. *Sorbus harneyensis* Axelrod. (p. N28).
Hypotype USNM 41977.

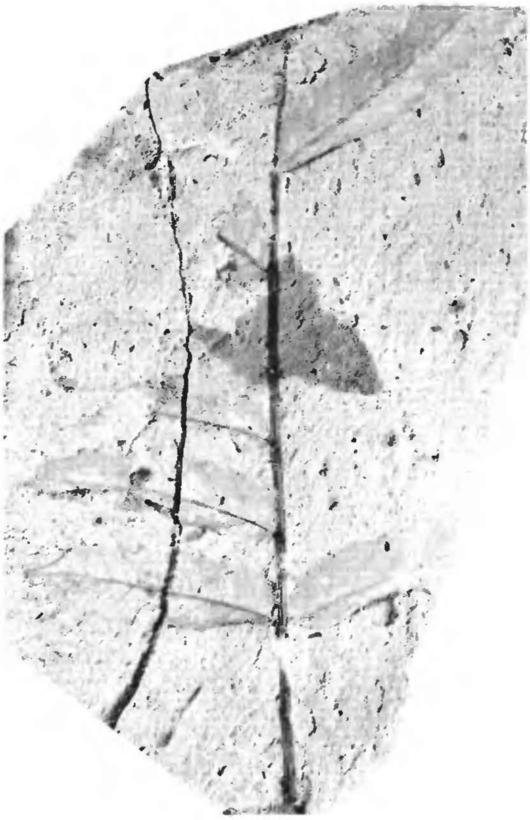
4–6. *Acer macrophyllum* Pursh. (p. N29).
Hypotypes USNM 41956, 41957, UCMP 8660.

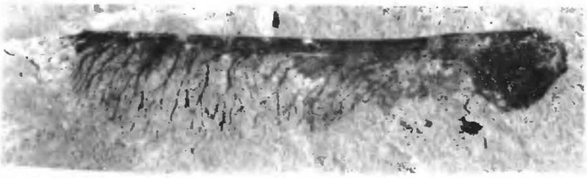
7. *Acer bolanderi* Lesquereux. (p. N29).
Hypotype USNM 41955.

8, 9. *Arbutus traini* MacGinitie. (p. N31).
Hypotypes USNM 41928, 41929.


1


2


3

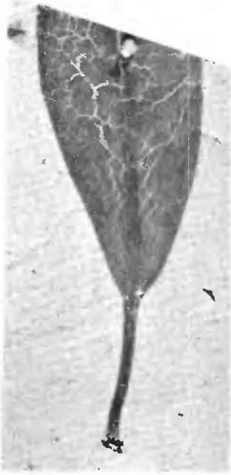

4


5


6


7


8


9

FINGERROCK FLORA

PLATE 6

[All figures natural size]

FIGURES 1–3, 6, 10, 11. *Abies concolor* Lindley. (p. N14).
Hypotypes USNM 42032–42037.

4, 5, 8, 9, 13, 14, 19. *Picea breweriana*; S. Watson. (p. N14).
Hypotypes USNM 42042–42048.

7, 12, 17, 18, 22. *Picea magna* MacGinitie. (p. N15).
Hypotypes USNM 42049–42053.

15, 16, 20, 21, 24. *Tsuga heterophylla* Sargent. (p. N15).
Hypotypes USNM 42053–42057.

23, 28, 29. *Larix occidentalis* Nuttall. (p. N14).
Hypotypes USNM 42040, 42041 (figs. 23, 29), UCMP 8604 (fig. 28).

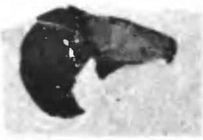
25. Indetermined coniferous seed.
USNM 42058.

26. *Juniperus nevadensis* Axelrod. (p. N16).
Hypotype UCMP 8612.

27, 30, 31, 34–37. *Chamaecyparis nootkatensis* (Lambert) Spach. (p. N15).
Hypotypes USNM 42020, 42021 (figs. 27, 30), 42022–42024 (figs. 34, 36, 37), UCMP 8613, 8614 (figs. 31, 35).

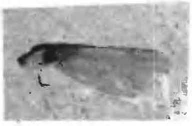
32, 33. *Pinus ponderosa* Douglas. (p. N15).
Hypotypes USNM 42038, 42039.


1


2

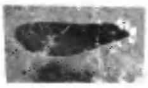

3

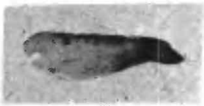

4


5


6


7


8

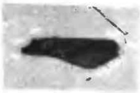

9


10


11


12


13


14


15


16


17


18


19

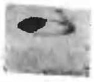

20


21


22


23


24


25

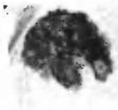

26


27

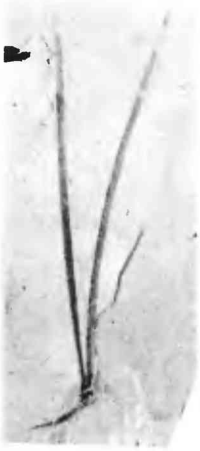

28


29


30

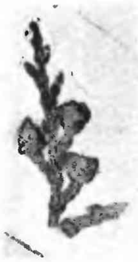

31


32


33


34


35


36


37

STEWART SPRING FLORA

PLATE 7

FIGURE 1. *Poacites* sp. (p. N16).
USNM 41973, × 1.

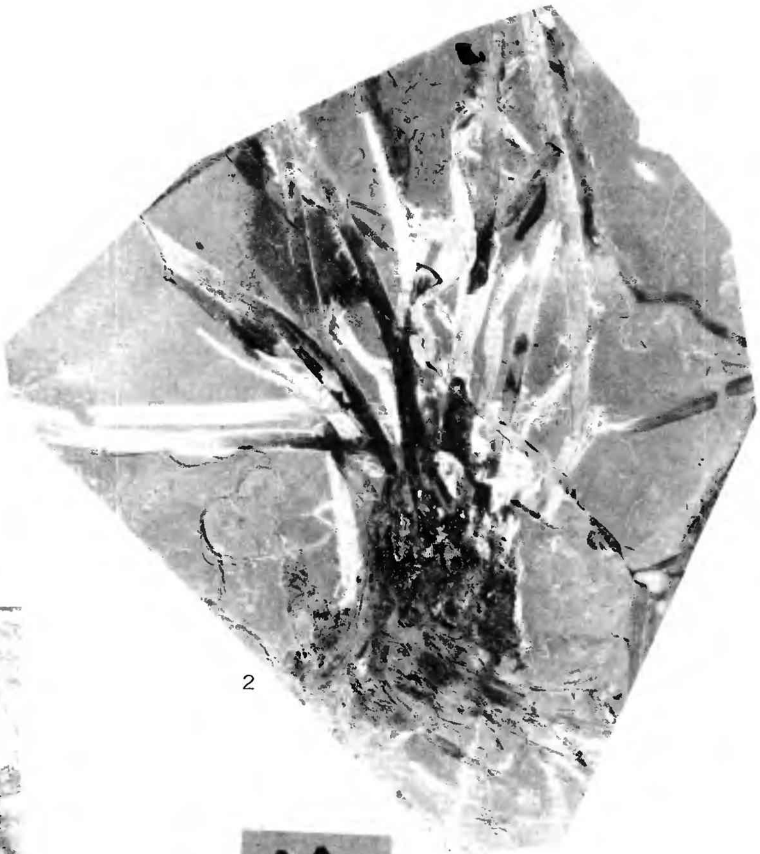
2. *Cyperacites* sp. (p. N16).
USNM 41972, × ½.

3. *Populus* sp. (p. N18).
USNM 41937, × 2.

4, 5, 8. *Populus cedrusensis* Wolfe. (p. N16).
Holotype USNM 41876 (fig. 8); paratypes USNM 41877, 41878 (figs. 4, 5), × 1.

6, 7. *Populus washoensis* Brown. (p. N18).
Hypotypes, USNM 41885, 41886.

1

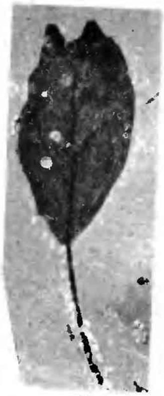


2

3

6

4



5

8

7

STEWART SPRING FLORA

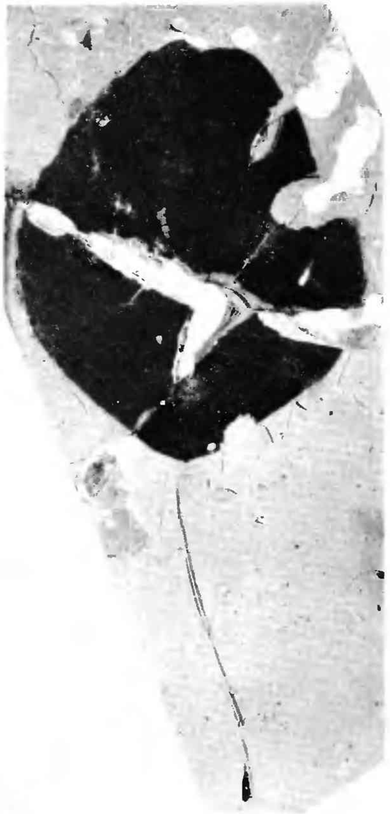
PLATE 8

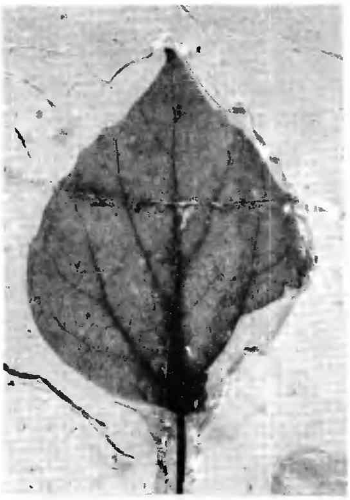
[All figures natural size]

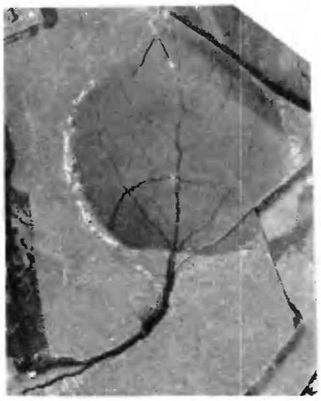
FIGURES 1, 2, 8. *Salix pelviga* Wolfe. (p. N18).
Hypotypes USNM 41958, 41959 (figs. 1, 8), UCMP 8625 (fig. 2).
3, 11, 12. *Populus trichocarpa* Torrey and Gray. (p. N18).
Hypotypes USNM 41882–41884.
4. *Populus cedrusensis* Wolfe. (p. N16).
Paratype USNM 41879.
5–7. *Populus tremuloides* Michaux. (p. N17).
Hypotypes USNM 41880, 41881 (figs. 5, 6), UCMP 8620 (fig. 7).
9, 10. *Juglans major* Torrey. (p. N20).
Hypotypes USNM 41960–41961.


1

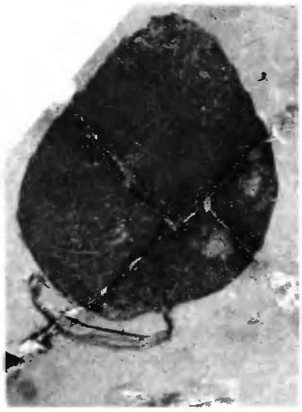

2

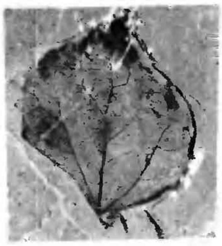

3

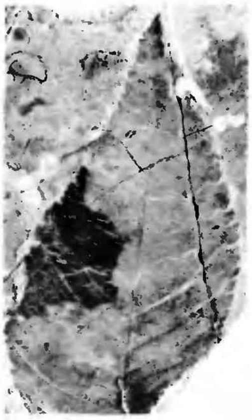

4


7


8


5


6


9


10


11


12

STEWART SPRING FLORA

PLATE 9

[All figures natural size]

FIGURE 1. *Betula* sp. (p. N21).
USNM 42008.

2, 3, 5–7, 12, 16. *Quercus chrysolepis* Liebmann. (p. N21).
Hypotypes USNM 41898, 41903, 41904, 41899–41902.

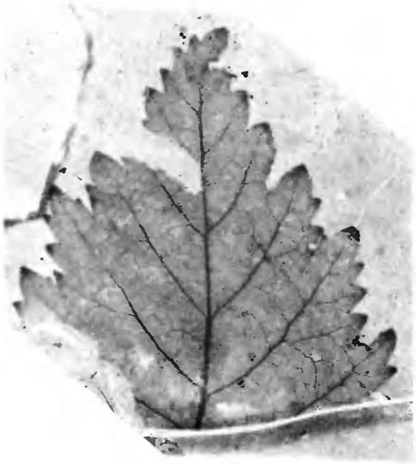
4. *Philadelphus nevadensis* Condit. (p. N23).
Hypotype USNM 41907.

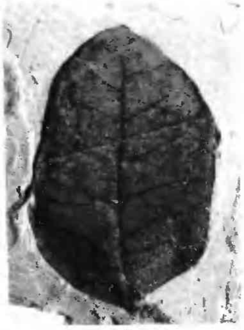
8–10. *Mahonia reticulata* (MacGinitie) Brown. (p. N23).
Hypotypes USNM 41951, 41952 (figs. 9, 10), UCMP 8644 (fig. 8).

11. *Ribes* (*Grossularia*) sp. (p. N23).
UCMP.

13, 14, 17, 18. *Ribes webbi* Wolfe. (p. N21).
Holotype, USNM 41908 (fig. 13); Paratypes USNM 41909–41911 (figs. 14, 17, 18).

15. *Quercus cedrusensis* Wolfe.
Holotype USNM 41968.


1


2


3


4


5


6


7


8


9


10


11


12


13


14


15


16


17


18

STEWART SPRING FLORA

PLATE 10

FIGURES 1, 14, 15. *Lyonothamnus parvifolius* (Axelrod) Wolfe. (p. N26).
Hypotypes USNM 41917, 41918 (figs. 1, 14), UCMP 8653 (fig. 15) × 1.

2, 3. *Cercocarpus antiquus* Lesquereux. (p. N24).
Hypotypes USNM 41913, 41914, × 1.

4–6. *Peraphyllum vaccinifolia* (Knowlton) Wolfe. (p. N27).
Hypotypes USNM 41965–41967, × 1.

7. *Rosa* sp. (p. N28).
USNM 41924, × 1.

8, 12. *Holodiscus fryi* Wolfe. (p. N26).
Holotype USNM 41915 (fig. 8); paratype USNM 41916 (fig. 12), × 1.

9. *Amelanchier cusicki* Fernald. (p. N24).
Hypotype USNM 42009, × 1.

10, 16–19. Indetermined inflorescences. (p. N31).
USNM 42029, 42013–42015, 42030, × 2.

11, 13. *Prunus* sp. (p. N28).
USNM 41949, 41950.


1


2


3


4


5

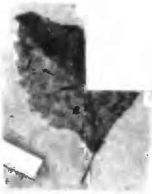

6


7


8

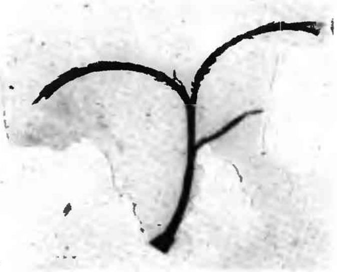

9


10


11

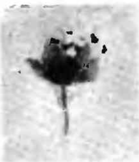

12

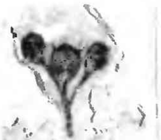

13


14


15


16


17


18


19

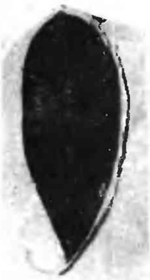
STEWART SPRING FLORA

PLATE 11

[All figures natural size]

FIGURES 1, 3–6. *Lyonothamnus parvifolius* (Axelrod) Wolfe. (p. N26).
Hypotypes USNM 41920–41923 (figs. 1, 3, 4, 6), UCMP 8654 (fig. 5).
2. *Arctostaphylos masoni* Wolfe. (p. N31).
Holotype USNM 42000.

1

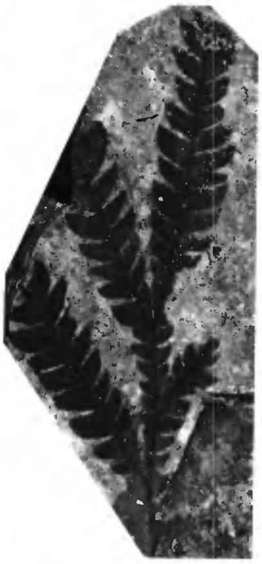


2

3

4

5



6

STEWART SPRING FLORA

PLATE 12

[All figures natural size]

FIGURE 1. *Sapindus* sp. (p. N30).
USNM 41920.

2. *Rhus integrifolia* Liebmann. (p. N28).
Hypotypes USNM 42011.

3. *Colubrina* sp. (p. N30).
USNM 41927.

4. *Garrya axelrodi* Wolfe. (p. N19).
Holotype USNM 41935.

5. Indetermined leaf. (p. N31).
USNM 42012.

6, 8, 9. *Elaeaqnus cedrusensis* Wolfe. (p. N30).
Holotype USNM 41962 (fig. 9), paratypes USNM 41963, 41964 (figs. 6, 8).

7. *Astronium mawbyi* Wolfe. (p. N29).
Holotype USNM 41948.

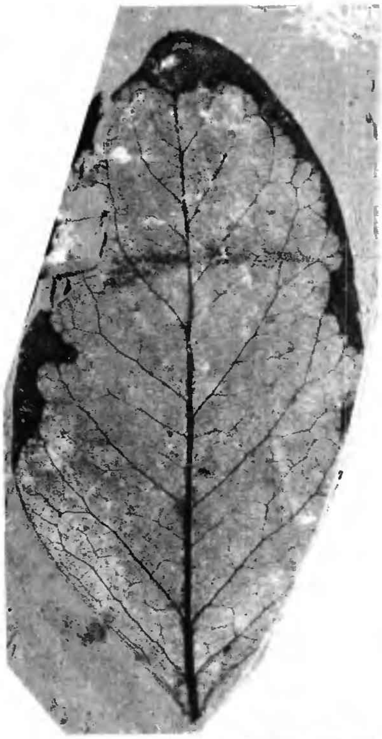
10. *Schinus savagei* Wolfe. (p. N28).
Holotype USNM 41926.

11–14. *Arbutus traini* MacGinitie. (p. N31).
Hypotypes USNM 41930–41932 (figs. 12–14), UCMP 8667 (fig. 11).

1

2

3



4

7

5

6

8

9

10

11

12

13

14

STEWART SPRING FLORA