Tertiary Plants from the Cook Inlet Region, Alaska

GEOLOGICAL SURVEY PROFESSIONAL PAPER 398-B

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Special Instructions Needed

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By JACK A. WOLFE

TERTIARY BIOSTRATIGRAPHY OF THE COOK INLET REGION, ALASKA

GEOLOGICAL SURVEY PROFESSIONAL PAPER 398-B

Discussion of floristic significance and systematics of some fossil plants from the Chickaloon, Kenai, and Tsadaka Formations

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1966

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

William T. Pecora, *Director*

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price 55 cents (paper cover)

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TERTIARY PLANTS FROM THE COOK INLET REGION, ALASKA

by JACK A. WOLFE

ABSTRACT

Taxonomic relations of some plants from the Paleocene Chickaloon Formation and the Neogene Tsadaka and Kenai Formations are considered. Sixteen new species from the Kenai Formation are described, and the greatest emphasis is on members of Salicaceae and Betulaceae.

The flora of the Kenai Formation may be divided into three large stratigraphic floral types. The oldest, the Seldovian flora of probable early and middle Miocene age, is an assemblage dominated by deciduous woody dicotyledons that are members of genera now characteristic of warm-temperate eastern Asia and eastern North America. Characteristic Seldovian families are Salicaceae, Juglandaceae, Betulaceae, Fagaceae, Ulmaceae, and Aceraceae. The middle flora, the Homerian of probable late Miocene age, is a cool-temperate assemblage dominated by species of Salicaceae, Betulaceae, Rosaceae, and Ericaceae. Most of the relict warm-temperate genera present in the Homerian are absent in the upper flora, the Clamgulchian, which is thought to be of Pliocene age.

Considered in the framework of the floristic succession in Alaska, the concept of the Arcto-Tertiary geoflora does not appear to be valid.

INTRODUCTION

The Alaskan tertiary floras have held the interest and speculation of North American Tertiary paleobotanists for many decades, but since the first description of some Alaskan plants by Heer (1869), only one large paper (Hollick, 1936) has been published.

In recent years it has become increasingly clear that the floral record in the Tertiary rocks of Alaska is fully as complex as that of any other region in the Northern Hemisphere and that not even the broad outlines of Alaskan floristic history have been satisfactorily determined. The speculations on migration of floras and geofloras have served only to confuse the paleobotany of Alaska.

We now have numerous, though small, plant collections from rocks dated by marine invertebrates, as well as a far better understanding of the local stratigraphic sequences than even 10 years ago. In particular, the considerable geologic mapping and the large number of fossil-plant localities in the Cook Inlet-Susitna Lowland and upper Matanuska Valley allow statements on the floristic relationships and succession.

As yet, the Paleocene flora of the Chickaloon Formation has not been thoroughly studied, and only a comparatively few forms have been determined. Many of the Chickaloon localities have produced a well-preserved and diverse flora. The difficulties inherent in working with Paleocene floras, however, and the time available for study make any detailed statements on the stratigraphic succession and floristic relationships of the Chickaloon flora largely speculative. Hence, only a few Chickaloon species are discussed and figured.

In contrast, the species of the Neogene Kenai flora (including the flora of the Tsadaka Formation) can readily be assigned to extant genera, and the considerable amount of published work on Neogene floras at middle latitudes on either side of the North Pacific allows a better understanding of the stratigraphic and floristic significance of the Kenai flora. The basic similarity between the upper Kenai and the extant Alaskan flora indicates that a continuing detailed study of the Kenai flora will lead to a better understanding of the Recent flora.

The stratigraphic occurrences and locality data were given in the preceding report (Wolfe, Hopkins, and Leopold, 1966). All species discussed in the systematic section are of stratigraphic significance and support the conclusions presented in the preceding paper.

This study has been greatly facilitated by the assistance of F. F. Barnes, D. M. Hopkins, and R. A. M. Schmidt, of the U.S. Geological Survey. Dr. H. D. MacGinitie, of the Museum of Paleontology, University of California (Berkeley), has freely given of his time and experience in the discussion of floristic problems.

Study of Heer's Alaskan and other specimens described in "Flora fossilis arctica" (Heer, 1869) was made possible by a grant (GB–406) from the National Science Foundation. Colleagues at the Naturhistoriska Riksmuseet (Stockholm), the Mineralogical Museum of the University of Copenhagen, the Grønlands Geologiske Undersøgelse, and the British Museum (Natural History) were very helpful in making these specimens available for study.

Thanks are also due to Prof. W. L. Fry, of the Museum of Paleontology, University of California (Berkeley), and Dr. Hans Tralau, of the Naturhistoriska Riksmuseet (Stockholm), for the loan of type specimens.

FLORISTIC AND ECOLOGIC INTERPRETATION

CHICKALOON FLORA

As previously stated, the taxonomic relations of most of the Chickaloon species are largely problematical. Paleocene leaf floras have, as reflected in the unqueried generic references of their species, a deceptively modern aspect. That this apparent modernity is false is well demonstrated by the extensive work on the Paleocene and early Eocene floras of England (Reid and Chandler, 1933; Chandler, 1961, 1962, 1964). This work has shown that, on the basis of fructifications, most earlier Tertiary plants should not be assigned to extant genera. The work of Reid and Chandler is in a sense an indictment of the superficial techniques most often used in the study of leaf floras. Although it might be argued that the foliage is a more conservative organ than the fructification, the evidence from pollen, which is certainly more conservative than either leaf or fruit, supports the work of Reid and Chandler. Although many extant genera of angiosperms have valid occurrences in the Paleocene, many others that have been determined on the basis of leaves do not. The superficial similarities between foliage of unrelated angiosperms has led many times to incorrect generic references.

Several of the Chickaloon species have been previously assigned, most of them incorrectly, I think, to extant genera. In this report, if the species appears to belong to a related but probably new genus, the old generic name has been enclosed in quotation marks; in other cases—those in which the familial assignment is questionable—the species has been reassigned to *Dicotylophyllum*. Some of the Chickaloon species do represent extant genera but on the basis of foliar characters, most of the species in the flora apparently represent extinct genera. The following list is not complete. Many of the Chickaloon species are new, but their familial affinities are unknown. Of the following 24 angiosperms, only 8 are referred to extant genera. The proportion of extinct to extant genera would be even higher were all the Chickaloon flora, as known in the present collections, described.

PARTIAL LIST OF FLORA OF THE CHICKALOON FORMATION

Filicinae
- *Anemia elongata* (Newb.) Knowl.
- *Dennstaedtia americana* Knowl.
- *Hymenophyllum confusum* Lesq.
- *Onoclea hesperia* R. W. Br.
- *Osmunda macrophylla* Penh.

Gymnospermae
- *Glyptostrobus nordenskioldi* (Heer) R. W. Br.
- *Metasequoia occidentalis* (Newb.) Chan.
- *Ginkgo biloba* L.

Angiospermae
- *Alismaphyllites grandifolius* (Penh.) R. W. Br.
- *Sabalites* sp.
- *Carya antiquora* Newb.
- *Pterocarya* sp.
- *Comptonia* sp.
- *Corylites fosteri* (Ward) Bell
- *Quercophyllum groenlandicus* (Heer) Koch
- "*Planera*" *microphylla* Newb.
- *Cocculus flabella* (Newb.) Wolfe
- *Trochodendroides serrulata* (Ward) Wolfe
- *Hamamelites inaequalis* (Newb.) R. W. Br.
- *Sinowilsonia* sp.
- *Macaranga* sp.
- *Macaranga* sp.
- "*Pterospermites*" sp. cf. "*P.*" *dentatus* Heer
- *Melanolepis* sp.
- "*Sapindus*" *affinis* Newb.
- *Acer* sp.
- *Decostea* sp.
- *Grewiopsis auriculaccordatus* (Holl.) Wolfe
- *Dicotylophyllum alaskanum* (Holl.) Wolfe
- *Dicotylophyllum flexuosa* (Newb.) Wolfe
- *Dicotylphyllum richardsoni* (Heer) Wolfe
- "*Piper*" *chapini* Holl.

In the light of the preceding list, floristic implications of the Chickaloon flora are difficult to analyze. This flora has no apparent floristic ties with the Campanian flora of the Chignik Formation (Hollick, 1930) or with any other known Campanian or Maestrichtian floras. Some floras from eastern Siberia do resemble the Chickaloon; although these floras were once assigned a Late Cretaceous age, more recent work indicates that they are Paleocene. The rather notable uniformity between the Siberian, Chickaloon, Fort Union, and Upper Atanikerdluk floras makes even more puzzling the floristic relationships between the Paleocene and floras of other ages. Until considerably more is known of the phylogenetic relationships of Paleocene plants, further discussion of floristics of this epoch will be uninformative.

The climatic inferences of the Chickaloon and other Alaskan Paleocene floras are, at least in general terms, clear. In the Hamilton Bay flora on Kupreanof Island (lat 57° N.) are abundant cycads, palms, Lauraceae, and Dilleniaceae. The abundance of the first two groups is particularly significant because both are generally restricted to areas of frost-free climate. Although cycads have not been recorded from the Chickaloon flora, there are palms. The dicotyledon flora is somewhat contradictory, although it should be noted that today the predominately warm-temperate *Carya*, *Pterocarya*, and *Acer* all have species living in subtropical climates. The diversity of woody Euphorbiaceae is perhaps of greater significance, for *Macaranga* and *Melanolepis* are today tropical and subtropical genera. As the following discussion indicates, the presence of a few "warm temperate" genera in floras that might otherwise be considered tropical or subtropical is characteristic of nearly all Paleogene floras. The general climate indicated by the Chickaloon and Kupreanof floras is at least subtropical; that is, a lack of frost is indicated.

KENAI FLORA

LOWER KENAI (SELDOVIAN) FLORA

Most of the Alaskan plants described by Heer (1869) came from locality 9856[1] which he called Sinus Anglorum or Englischen Bucht; actually this locality is on Coal Cove of Port Graham rather than on English Bay. Plants from this and three other nearby localities constitute the Seldovia Point flora of Wolfe, Hopkins, and Leopold (1966), which is considered to be of early or middle Miocene age. The Seldovian flora is the one of most common occurrence in the Kenai flora and has been recognized at 27 localities in the Kenai and Tsadaka Formations.

Thus far, 75 specific entities have been recognized in the Seldovian flora, and 51 of these occur in the following listed Seldovia Point flora. The Seldovia Point flora has been more extensively collected than other floras of this age in the Kenai Formation, and this is, at least in part, responsible for the comparative richness. However, the topographic diversity of the Seldovia area during the early Miocene was also probably a factor; the beds near Seldovia apparently represent, in part, channel deposits at or near the edge of the Kenai basin. Hence, the Seldovia Point flora probably contains many elements that grew on well-drained slopes, an environment uncommon or lacking in the major areas of deposition of the Kenai Formation. The thick coal beds in the type section of the Seldovian in the lower Kenai near Capps Glacier indicate that swampy conditions often prevailed in the basin itself.

SYSTEMATIC LIST OF THE SELDOVIA POINT FLORA

Tracheophyta
- Sphenopsida
  - Equisetales
    - Equisetaceae
      - *Equisetum* sp.

[1] All locality numbers given are in the U.S. Geol. Survey Paleobotany Ser.

Tracheophyta—Continued
- Pteropsida
  - Filicinae
    - Filicales
      - Polypodiaceae
        - *Dryopteris* sp.
        - *Onoclea sensibilis* L.
  - Gymnospermae
    - Ginkgoales
      - Ginkgoaceae
        - *Ginkgo biloba* L.
    - Coniferales
      - Taxodiaceae
        - *Glytostrobus europaeus* (Brong.) Heer
        - *Metasequoia glyptostroboides* Hu and Cheng
        - *Taxodium distichum* Rich.
  - Angiospermae
    - Monocotyledonae
      - Helobiae
        - Naiadaceae
          - *Potamogeton* sp.
        - Liliaceae
          - *Smilax* sp.
      - Glumiflorae
        - Gramineae
          - *Poacites tenuistriatus* Heer
        - Cyperaceae
          - *Cyperacites* sp.
    - Dicotyledonae
      - Salicales
        - Salicaceae
          - *Populus kenaiana* Wolfe
          - *Populus reniformis* Tan. and Suz.
          - *Populus* sp. aff. *P. ciliata* Wall.
          - *Salix inquirenda* Knowl.
          - *Salix picroides* (Heer) Wolfe
          - *Salix* sp.
      - Juglandales
        - Juglandaceae
          - *Carya bendirei* (Lesq.) Chan. and Axelr.
          - *Carya* sp. aff. *C. sessilis* MacG.
          - *Pterocarya mixta* (Knowl.) R. W. Br.
          - *Pterocarya nigella* (Heer) Wolfe
          - *Pterocarya* (*Cycloptera*) sp.
      - Fagales
        - Betulaceae
          - *Alnus cappsi* (Holl.) Wolfe
          - *Alnus healyensis* Wolfe
          - *Alnus fairi* (Knowl.) Wolfe
          - *Carpinus seldoviana* Wolfe
        - Fagaceae
          - *Fagus antipofi* Abich
          - *Fagus* sp. cf. *F. paleocrenata* Tan.
          - *Quercus bretzi* Chan.
          - *Quercus furuhjelmi* Heer
      - Urticales
        - Ulmaceae
          - *Ulmus longifolia* Ung.
          - *Ulmus newberryi* Knowl.
          - *Zelkova oregoniana* (Knowl.) R. W. Br.
      - Ranales
        - Nymphaeaceae
          - *Nuphar* sp.

Tracheophyta—Continued
- Pteropsida—Continued
  - Angiospermae—Continued
    - Dicotyledonae—Continued
      - Ranales—Continued
        - Cercidiphyllaceae
          - *Cercidiphyllum crenatum* (Ung.) R. W. Br.
        - Menispermaceae
          - *Cocculus auriculata* (Heer) Wolfe
      - Rosales
        - Saxifragaceae
          - *Hydrangea* sp.
        - Hamamelidaceae
          - *Liquidambar mioformosana* Tan.
        - Platanaceae
          - *Platanus bendirei* (Lesq.) Wolfe
        - Rosaceae
          - *Crataegus* sp.
          - *Prunus* sp.
          - *Spiraea? andersoni* Heer
      - Geraniales
        - Euphorbiaceae
          - *Alchornea?* sp.
          - *Mallotus* sp.
      - Sapindales
        - Aceraceae
          - *Acer ezoanum* Oishi and Huz.
          - *Acer fatisiaefolia* Huz.
          - *Acer macropterum* Heer
          - *Acer* sp. aff. *A. crataegifolium* S. and Z.
          - *Acer* sp. cf. *A. subpictum* Sap.
      - Rhamnales
        - Vitaceae
          - *Vitis* sp.
      - Malvales
        - Tiliaceae
          - *Tilia* sp.
      - Myrtiflorae
        - Nyssaceae
          - *Nyssa* sp. cf. *N. knowltoni* Berry
        - Onagraceae
          - *Hemitrapa borealis* (Heer) Miki
      - Umbelliflorae
        - Araliaceae
          - *Kalopanax* sp.
      - Contortae
        - Oleaceae
          - *Fraxinus* sp.
      - Rubiales
        - Caprifoliaceae
          - *Symphoricarpos* sp.

The Seldovia Point flora is a warm-temperate assemblage, as indicated by the numerical and taxonomic dominance of Taxodiaceae, Salicaceae, Juglandaceae, Fagaceae, Ulmaceae, and Aceraceae. Temperate floras with diversity in these families are today restricted to east-central Asia and southeastern North America. The Miocene floras of both Japan (Tanai, 1961) and the Northwestern United States (Chaney in Chaney and Axelrod, 1959) are this type of flora, and indeed the early Miocene floras of the Northwest, Alaska, and Japan are so similar, on both the generic and specific levels, that they should be considered as parts of one floristic province. Floras of the Northwest and Japan do not have many species in common, but the Seldovian flora has many species common to both of these other two floras.

There are some differences between the Seldovian flora and its contemporaneous floras at more southern latitudes. Tanai's Aniai-type flora contains several (although not numerically dominant) genera of tropical and very warm temperate climates such as *Litsea*, *Lindera*, and *Alangium*. Similarly, the Collawash flora in Oregon contains *Litsea*, *Lindera*, and *Exbucklandia*. Of course these elements may yet be found in the Seldovian flora; a Seldovian locality in the Alaska Range coal-bearing formation contains involucres of the tropical to subtropical genus *Engelhardia*. There is no definite evidence that the Seldovian flora lived in a markedly cooler climate than prevailed in the early Miocene of Oregon or Japan.

Where did this uniform flora come from? This type of flora at middle latitudes was readily explained by the adherents to the Arcto-Tertiary theory: the flora was virtually the high-latitude early Tertiary flora that had migrated south. The fossil floras at middle latitudes have been interpreted to support this. Certainly it is true that these Arcto-Tertiary (deciduous temperate) elements occur in and first dominate middle-latitude floras of middle or late Oligocene age; equally certainly, similar floras are not found in the Paleocene and Eocene rocks at middle latitudes. Consequently, if one thinks that communities are long enduring, this type of flora must have originated somewhere else, and where else but in the north? In fact, similar floras were known in areas such as Alaska, and it was assumed that these floras must be Eocene or Paleocene. Therefore, after Gardner (in Gardner and Ettingshausen, 1879) first advanced the Arcto-Tertiary concept, all the Alaskan Tertiary floras were either Paleocene or Eocene; it apparently never seemed anomalous to any paleobotanist that the fossil plant record of about the last 40 million years was entirely lacking in Alaska.

Gradually, as more fossil plants have been collected from rocks dated independently on the basis of marine invertebrates, the Alaskan floristic record has become clearer. Although no independent date is available on the Chickaloon flora, the similarity to the Paleocene floras both farther north (Upper Atanikerdluk, Greenland) and south (Fort Union) is strong evidence that the Chickaloon is Paleocene. The general aspect of the Chickaloon flora is so greatly dissimilar to the overlying Seldovian flora that it is evident that, as a floristic type, the Seldovian flora did not exist in the Kenai region during the Paleocene. The nearest well-dated Eocene floras are those of middle and late Eocene age at the head of the Gulf of Alaska. These floras contain abundant *Lygodium*, *Sabalites*, *Artocarpoides*, *Ficus*, *Ocotea*, and *Microcos*. Clearly, this is not a Seldovian type of flora—rather these Eocene floras look very much like those in the Eocene at middle latitudes. The early Oligocene floras of Alaska are very poorly known, although the few genera determined include *Artocarpoides* and *Macclintockia*. This indicates a continuation of the early Tertiary subtropical flora. On Sitkinak Island and in the Gulf of Alaska coastal section, the oldest floras that have a preponderance of the broad-leaved deciduous element are of middle to late Oligocene age. These floras are represented by small collections, but because both the Sitkinak Island and Gulf of Alaska floras are well dated on the basis of marine megafossil invertebrates, these small collections are of considerable significance. The forms determined are: *Metasequoia glyptostroboides; Alnus* sp., cf. *A. alaskana; Carpinus* sp., aff. *C. cappsensis;* and *Cercidiphyllum crenatum*. The only difference between this type of flora and the Seldovian is the inclusion in the former of distinct and probably ancestral species of Betulaceae.

It was also in the middle and late Oligocene of Asia and Northwestern United States that the *Metasequoia-Alnus-Carpinus-Cercidiphyllum* association first became dominant, although in these areas, Betulaceae are represented by different species. Thus, no evidence supports the hypothesis that a warm-temperate deciduous flora was present at high latitudes at any significantly earlier time than the same type of flora was present at middle latitudes. Although it could be argued that the Seldovian type of flora originated still farther north than the Cook Inlet basin (lat 59°–62° N.) or farther north than the floras of Seldovian age in the Alaska Range (lat 64° N.), such arguments have no factual support.

Our knowledge of Tertiary plants should be reexamined for alternative concepts to the Arcto-Tertiary theory. Is it reasonable, in fact, to expect the Seldovian type of flora to have existed in the Paleocene and Eocene? Mason (1947) and MacGinitie (1962) think not, and I agree with them. For example, such typical Arcto-Tertiary genera as *Glyptostrobus*, *Metasequoia*, *Ginkgo*, *Carya*, *Pterocarya*, *Alnus*, *Fagus*, *Ulmus*, *Cercidiphyllum*, *Liquidambar*, *Acer*, *Vitis*, *Nyssa*, and *Fraxinus* are often found (sometimes abundantly) in basically tropical Paleogene floras at middle latitudes. Thus, the question previously asked, "where did this uniform flora come from?" is the wrong question. Each of the species and phylads probably became a part of the association at different times, in different proportions, and in different areas. In other words, the association or community must be continually redefined in terms of its constituents at any particular place or point in time because the association is continually changing.

MIDDLE KENAI (HOMERIAN) FLORA

The type Homerian flora is a composite one and comes from localities distributed through about 3,000 feet of section. The probable late Miocene age is based on plants from the type Homerian and from the Chuitna River flora, which is basal Homerian.

The Chuitna River flora, listed below, is the richest single flora from the Homerian.

SYSTEMATIC LIST OF THE HOMERIAN FLORA FROM CHUITNA RIVER

Tracheophyta
- Pteropsida
  - Filicinae
    - Filicales
      - Osmundaceae
        - *Onoclea* sp. cf. *O. sensibilis* L.
        - *Osmunda* sp.
  - Gymnospermae
    - Coniferales
      - Taxodiaceae
        - *Glyptostrobus europaeus* (Brong.) Heer
        - *Metasequoia glyptostroboides* Hu and Cheng
  - Angiospermae
    - Monocotyledonae
      - Pandanales
        - Typhaceae
          - *Typha* sp.
      - Glumiflorae
        - Cyperaceae
        - *Cyperacites* sp.
    - Dicotyledonae
      - Salicales
        - Salicaceae
          - *Populus kenaiana* Wolfe
          - *Salix chuitensis* Wolfe
          - *Salix hesperia* (Knowl.) Cond.
          - *Salix tyonekana* Wolfe
      - Juglandales
        - Juglandaceae
          - *Pterocarya* sp. cf. *P. nigella* (Heer) Wolfe
      - Fagales
        - Betulaceae
          - *Alnus corylina* Knowl. and Cock.
          - *Alnus adumbrata* (Holl.) Wolfe?
          - *Betula* sp. cf. *B. thor* Knowl.
          - *Corylus chuitensis* Wolfe
      - Rosales
        - Rosaceae
          - *Rubus* sp.
          - *Spiraea hopkinsi* Wolfe
        - Leguminosae
          - *Cladrastis japonica* (Tan. and Suz.) Wolfe
          - *Sophora* sp.

Tracheophyta—Continued
  Pteropsida—Continued
    Angiospermae—Continued
      Dicotyledonae—Continued
        Myrtiflorae
          Elaeagnaceae
            Elaeagnus sp. aff. *E. canadensis*
        Umbelliflorae
          Cornaceae
            Cornus sp.
            Cornus sp.
          Araliaceae
            Aralia sp.
        Ericales
          Ericaceae
            Arbutus sp.
            Rhododendron weaveri (Holl.) Wolfe
            Vaccinium homerensis Wolfe
            Vaccinium sp.
        Rubiales
          Caprifoliaceae
            Diervilla sp.
            Symphoricarpos sp.

In some respects the Chuitna River flora is only a modified Seldovian flora; the following species are either found in or have probably ancestral species in the Seldovian: *Glyptostrobus europaeus*, *Metasequoia glyptostroboides*, *Populus kenaiana*, *Salix chuitensis*, *Salix picroides*, *Pterocarya* sp. c. *P. nigella*, *Alnus corylina*, *Alnus adumbrata?*, *Corylus chuitensis*, *Spiraea hopkinsi*, *Cladrastis japonica*, and *Symphoricarpos* sp. However, this is a comparatively small percentage of species for floras that occur in a narrow stratigraphic range. Even when the Seldovian element in the type Homerian (in the following list) is added (*Taxodium distichum*, *Salix confirmata*, *S. kachemakensis*, *Carya bendirei*, *Carpinus cobbi*, *Spiraea weaveri*, *Acer* sp. cf. *A. glabroides*), the number of total Homerian species that are closely related to known Seldovian species is still less than one-third of the Homerian flora. Undoubtedly more collections from both the Seldovian and Homerian would add to the list; for example, megafossils of Ulmaceae have not been found in the Homerian, and leaves of Ericaceae have not been found in the Seldovian, although both families are represented by pollen in both stages. However, the scarcity of common phylads indicates that a major change was taking place in the flora of the Kenai basin.

SYSTEMATIC LIST OF FLORA OF THE TYPE HOMERIAN

Tracheophyta
  Pteropsida
    Gymnospermae
      Coniferales
        Taxodiaceae
          Glyptostrobus europaeus (Brong.) Heer
          Metasequoia glyptostroboides Hu and Cheng
          Taxodium distichum Rich.

Tracheophyta—Continued
  Pteropsida—Continued
    Angiospermae
      Monocotyledonae
        Glumiflorae
          Cyperaceae
            Cyperacites sp.
      Dicotyledonae
        Salicales
          Salicaceae
            Populus eotremuloides Knowl.
            Populus kenaiana Wolfe
            Populus washoensis R. W. Br.
            Salix alaskana Holl.
            Salix chuitensis Wolfe
            Salix confirmata (Holl.) Wolfe
            Salix kachemakensis Wolfe
            Salix tyonekana Wolfe
        Myricales
          Myricaceae
            Myrica sp.
        Juglandales
          Juglandaceae
            Carya bendirei (Lesq.) Chan. and Axelr.
        Fagales
          Betulaceae
            Alnus corylina Knowl. and Cock.
            Alnus adumbrata (Holl.) Wolfe
            Carpinus cobbi Wolfe
            Corylus chuitensis Wolfe
        Rosales
          Saxifragaceae
            Hydrangea bendirei (Ward) Knowl.
            Ribes sp.
          Rosaceae
            Prunus sp.
            Spiraea weaveri Holl.
            Spiraea hopkinsi Wolfe
          Leguminosae
            Cladrastis japonica (Tan. and Suz.) Wolfe
        Myrtiflorae
          Elaegnaceae
            Elaeagnus sp. aff. *E. canadensis*
        Umbelliflorae
          Cornaceae
            Cornus sp.
        Ericales
          Ericaceae
            Rhododendron weaveri (Holl.) Wolfe
            Vaccinium homerensis Wolfe
            Symphoricarpos sp.
        Ebenales
          Styracaceae
            Halesia sp.

What factors are involved in this floristic change is not clear. Although the continued filling of the Kenai basin probably affected the flora somewhat, there is no evidence in the sedimentary history that the edaphic factors changed significantly. The most obvious environmental factor is that of climate, but in this regard the evidence is apparently conflicting. There are two primary methods of arriving at an idea of paleoclimates that are based on floras: an analysis of leaf margins and an analysis of genera and species in terms of their present climatic distribution.

A comparison of dicotyledon leaf-margin percentages between the Seldovian and Homerian floras is given as follows:

Flora	*Number of species*	*Percent with entire margins*
Type Homerian	25	23
Chuitna River Homerian	24	33
Seldovia Point	44	14

Most paleobotanists have directly compared the percentages obtained from fossil floras to the percentages given by Bailey and Sinnott (1916), which are based on regional floras containing hundreds of species. This comparison, without qualifications, may not be valid because, as MacGinitie (1953, p. 45f) has pointed out, fossil floras are dominated by lacustrine and fluviatile plants. This means, particularly in regard to Neogene floras, that the families with nonentire leaf margins such as Betulaceae and Salicaceae are overrepresented and give the flora a cool aspect as reflected in the leaf-margin analysis. Another factor that may detract from the value of leaf-margin analysis is the time of diversification of particular families. Although Bailey and Sinnott have shown the high correlation between entire-margined leaves and physiologically arid environments, the margin of the leaf is nevertheless probably genetically controlled; that is, the leaf margin is dependent on environment within definite genetic limitations. For example, in such a family as Lauraceae, where entire-margined species are overwhelmingly dominant, a few species in warm-temperate climates do have simple lobations; however, most of the warm-temperate members of this family have entire margins. Similarly, most species of the primarily tropical family Tiliaceae have nonentire margins even in tropical regions. It seems probable, therefore, that the type of leaf margin is not a simple function of environment, but that genetic factors are also involved. The greater diversity and abundance in the Neogene of such families as the Rosaceae and Ericaceae, which are generally rare or lacking in Paleogene floras, are probably an actual reflection of the evolutionary history of these groups. In particular, the inclusion of *Elaeagnus*, *Cornus*, *Ericaceae*, and *Symphoricarpos* in the Homerian flora may give this flora a warmer aspect than merited if only the leaf-margin analysis is relied upon.

That the Homerian flora is cool temperate, rather than warm temperate as the leaf-margin analysis indicates, can be deduced from the present distribution of the Homerian genera and families. The abundance and diversity of Salicaceae, Betulaceae, Rosaceae, and Ericaceae, the lack of Fagaceae, and scarcity of Ulmaceae and Juglandaceae definitely indicate that the Homerian climate was considerably cooler than the Seldovian.

One curious aspect of the Homerian pollen assemblages is the poor representation of probable herbaceous types. Compositae are rare, as are other families that are today predominantly herbaceous. Most botanists have thought that the herbaceous types developed and diversified primarily at northern latitudes in response to the colder climate there. Of course the Homerian flora is certainly not frigid, as indicated by the occurrence of *Cladrastis*, *Glyptostrobus*, and *Metasequoia*. In contrast to the Kenai record, the entire Miocene of Wyoming shows a great abundance of pollen of herbaceous types (E. B. Leopold, oral commun., 1963). The highly seasonal climates of the developing arid regions may have had a greater impetus on the evolution of herbs than did the cooling at northern latitudes.

UPPER KENAI (CLAMGULCHIAN) FLORA

The Clamgulchian flora of the upper part of the Kenai Formation is known from relatively few localities, partly because of the poor exposures and poor lithification and partly because of the comparatively little time spent collecting from the upper Kenai. At the known localities, the most striking feature of the following flora listed, which is probably early Pliocene, is its depauperate character.

SYSTEMATIC LIST OF THE TYPE CLAMGULCHIAN FLORA

Tracheophyta
- Sphenopsida
  - Equisetales
    - Equisetaceae
      - *Equisetum* sp.
- Pteropsida
  - Gymnospermae
    - Coniferales
      - Taxodiaceae
        - *Glyptostrobus europaeus* (Brong.) Heer
  - Angiospermae
    - Monocotyledonae
      - Helobiae
        - Naiadaceae
          - *Potamogeton* sp.
          - *Potamogeton* sp.
      - Glumiflorae
        - Cyperaceae
          - *Carex* sp.
          - *Cyperacites* sp.
    - Dicotyledonae
      - Salicales
        - Salicaceae
          - *Populus tacamahacca* Mill.
          - *Salix cookensis* Wolfe
          - *Salix crassijulis* Trautv.

Tracheophyta—Continued
  Pteropsida—Continued
    Angiospermae—Continued
      Dicotyledonae—Continued
        Salicales—Continued
          Salicaceae—Continued
            Salix kenaiana Wolfe
            Salix leopoldae Wolfe
            Salix ninilchikensis Wolfe
        Fagales
          Betulaceae
            Alnus incana (L.) Moench
            Alnus schmidtae Wolfe
        Rosales
          Rosaceae
            Spiraea sp. cf. *S. beauverdiana* Schn.
            Malus sp. cf. *M. fusca* (Rafin.) Schn.
        Sapindales
          Anacardiaceae
            Rhus. sp. cf. *R. glabra* L.

The Clamgulchian flora is clearly cool temperate. It is dominated, both numerically and taxonomically, by species of *Alnus* and *Salix*. The presence of *Glyptostrobus* in a cool-temperate flora may appear to be peculiar, but a member of this genus is known to have adapted to an increasingly arid and seasonal climate in eastern Oregon (Chaney and Axelrod, 1959), and other members of the genus could equally well have adapted to cool conditions. Of course, the presence of *Glyptostrobus* and *Rhus* in the megafossil flora and possibly of *Pterocarya* and *Liquidambar* in the microfossil flora indicate that the Clamgulchian flora probably lived in a climate considerably warmer than that of the Cook Inlet area today, although cooler than either the Homerian or Seldovian. The occurrence of *Pterocarya* and *Liquidambar* in the Clamgulchian flora could be questioned on the possibility of redeposition.

The Clamgulchian flora is virtually a depauperate Homerian flora, with most if not all of the warm elements eliminated. Most of the species of *Alnus*, *Salix*, and *Populus* have probable ancestors lower in the Kenai, and the *Rhus* is related to a species found at one Seldovian locality. The decrease in diversity of the flora was probably not sudden; the upper part of the Homerian lacks many of the lower Homerian species. Similarly, the Recent woody dicotyledon flora of the Cook Inlet region could be considered a modified Clamgulchian flora. In south-central Alaska, however, even in swampy areas, the present association of dicotyledons with conifers such as *Picea* cannot be duplicated by any Clamgulchian megafossil flora, although nearly every Kenai pollen flora has an abundance of bisaccate types. Thus, although the Clamgulchian flora has several similarities to the Recent flora, the two floras should not be considered as representing the same association or community.

SYSTEMATICS

CHICKALOON FLORA

Dennstaedtia americana Knowlton

Plate 1, figure 5

Dennstaedtia americana Knowlton, 1910, Smithsonian Misc. Colln., v. 52, p. 492, pl. 63, fig. 4; pl. 64, figs. 3–5.
Brown, 1962, U.S. Geol. Survey Prof. Paper 375, p. 42, pl. 6, figs. 1, 2, 5–7.

Discussion.—The collections in the U.S. National Museum from the Greenland Paleocene contain a sterile pinnule of *Dennstaedtia americana*. Most of the figured specimens of *D. blomstrandi* from the Paleocene of eastern Siberia also seem to represent this species. Many sterile and fertile specimens were collected in the Mrak mine in association with *Onoclea*.

Occurrence: Chickaloon Formation: 9873.
Hypotype: USNM 42182.

Onoclea hesperia Brown

Onoclea hesperia Brown, 1962, U.S. Geol. Survey Prof. Paper 375, p. 43, pl. 7, figs. 1, 4.
Onoclea sensibilis auct. non Linnaeus. Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 35, pl. 2, figs. 2–4.

Discussion.—Brown excluded the Alaskan specimens from *Onoclea hesperia* because of their finely serrate margin. Examination of Newberry's types of *O. sensibilis fossilis* (these are also the types of *O. hesperia*) under a microscope reveals that any individual fragment may be both finely serrate and entire. Probably most of the specimens referred by Brown to *Woodwardia arctica* are conspecific with *O. hesperia*.

Occurrence: Chickaloon Formation: 9871–9873.

Carya antiquora Newberry

Plate 1, figure 1

Carya antiquorum Newberry, 1868, New York Lyceum Nat. History Annals, v. 9, p. 72.
Newberry, 1898, U.S. Geol. Survey Mon. 35, p. 35, pl. 31, figs. 1–4.
Brown, 1962, U.S. Geol. Survey Prof. Paper 375, p. 55, pl. 17, figs. 1–7; pl. 18, fig. 4.
Hicoria antiquorum (Newberry) Knowlton, 1898, U.S. Geol. Survey Bull. 152, p. 117.
Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 83, pl. 37, fig. 1.
Juglans nigella auct. non Heer. Hollick, 1936 [part], U.S. Geol. Survey Prof. Paper 182, p. 81, pl. 38, figs. 1, 5.
Juglans picroides auct. non Heer. Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 82, pl. 37, fig. 2.
Fraxinus juglandina auct. non Saporta. Hollick, 1936 [part], U.S. Geol. Survey Prof. Paper 182, p. 163, pl. 100, fig. 1.

Discussion.—Two of the major features that characterize the leaflets of *Carya antiquora* are the smooth arching of the secondary veins and the lack of prominent tertiary branches. Thus far, *C. antiquora* is known definitely only from Paleocene rocks.

Occurrence: Chickaloon Formation: 9870, 9872, 9881.
Hypotype: USNM 42183.

"Planera" microphylla Newberry

Plate 2, figure 5

Planera microphylla Newberry, 1868, New York Lyceum Nat. History Annals, v. 9, p. 55.
Newberry, 1898, U.S. Geol. Survey Mon. 35, p. 81, pl. 33, figs. 3, 4.
Brown, 1962, U.S. Geol. Survey Prof. Paper 375, p. 60, pl. 24, figs. 1–11, 13, 15, 16.
Juglans? pseudopuctata Hollick, 1936 [part], U.S. Geol. Survey Prof. Paper 182, p. 82, pl. 104, figs. 3–5.
Fraxinus? pseudobliqua Hollick, 1936 [part], U.S. Geol. Survey Prof. Paper 182, p. 164, pl. 104, fig. 7a.
Ulmus longifolia auct. non Unger. Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 107, pl. 58, fig. 4.

Discussion.—All the Alaskan specimens cited above fall well within the range of variation of *Planera microphylla.* Although not abundant, leaves of this species occur at several localities in the Chickaloon.

The reference of these leaves to *Planera* does not seem to be valid. In the shape of the teeth, they are most similar to leaves of *Hemiptelea*, which, however, are simply serrate. The cordate base of the fossil is similar to that of some species of *Ulmus*, but the conspicuous and irregular forking of the secondary veins indicates a relationship to *Planera.* Other than in tooth shape, the fossils differ from leaves of *Planera* by having uniformly and closely spaced nervilles.

Occurrence: Chickaloon Formation: 5892, 9871–9873, 9881.
Hypotypes: USNM 42281, 42285.

Cocculus flabella (Newberry) Wolfe, new combination

Plate 1, figure 2; figure 1*A*

Populus flabellum Newberry, 1863, Boston Jour. Nat. History, v. 7, p. 524.
Newberry, 1898, U.S. Geol. Survey Mon. 35, p. 44, pl. 20, fig. 4.
Populus arctica Heer, 1866, Naturf. Gesel. Zurich, Vierteljahrsch, v. 11, p. 275.
Heer, 1868, Flora fossilis arctica, v. 1, p. 100, pl. 4, figs. 6a, 7; pl. 5; pl. 6, figs. 5, 6; pl. 8, figs. 5, 6.
Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 60, pl. 22, fig. 5a; pl. 23, figs. 1, 2; pl. 24, figs. 1–3; pl. 27, fig. 4; pl. 117, figs. 4–8; pl. 118, fig. 5.
Piper septentrionalis Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 58, pl. 113; pl. 114, fig. 1.
Piper controvertabilis Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 59, pl. 114, figs. 2, 3a, 4–9.
Cercidiphyllum arcticum (Heer) Brown, 1939 [part], Jour. Paleontology, v. 13, p. 492, pl. 53, figs. 3–5.
Brown, 1962 [part], U.S. Geol. Survey Prof. Paper 375, p. 70, pl. 37, figs. 10, 17; pl. 38, figs, 14, 16.
Populus amblyrhyncha auct. non Ward. Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 63, pl. 25, fig. 5.
Populus zadachi auct. non Heer. Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 69, pl. 24, figs. 4, 5.

Discussion.—A complete synonymy of *Cocculus flabella* would cover several pages and is not given here. The epithet "*flabella*" has priority, although Brown (1939, p. 492) chose "*arctica*" for the widely used "*Cercidiphyllum arcticum.*" Several different forms have been included in *C. arcticum*, discussed as follows under *Trochodendroides serrulata.*

Thus far, *Cocculus flabella* is not known above the lower Eocene and was most widespread during the Paleocene.

Considerable confusion has resulted because of the tendency to place many palmate leaves in *Cercidiphyllum arcticum*, primarily because of a superficial resemblance to *Cercidiphyllum* leaves and a joint occurrence with the fruits variously known as *Nyssidium* or *Jenkinsella.* Chandler (1961, p. 84–90) demonstrated that the fruits of *Jenkinsella* are not related to *Cercidiphyllum*, and this in turn indicates that the Paleogene leaves also referred to *Cercidiphyllum* should be reexamined. The investigation of this foliage is not yet completed, but certain data have been collected. Among the Fort Union Paleocene leaves assigned to *C. arcticum*, at least five basically different types of ultimate venation can be recognized. This indicates that certainly five different species are represented, and, concomitant with the megascopic characters, five different genera and families are probably also represented. Two of these species I have not been able to assign to any extant family; because they are not present in the Chickaloon flora they are here ignored.

The remaining three entities are present in the Chickaloon as well as in the Fort Union flora. One of these forms, *Trochodendroides serrulata*, has the extensive secondary and tertiary looping and finely crenate margin similar to *Cercidiphyllum.* However, the ultimate venation (fig. 1*A*) is strikingly different from that of the Recent *C. japonicum*, and I hesitate to make the two species congeneric without more evidence. Specimens of *T. serrulata* are uncommon in comparison with the other two segregates of *C. arcticum* discussed here.

A second species, *Cocculus flabella*, is the most common dicotyledon leaf in the Chickaloon Formation but is comparatively uncommon in the Fort Union. Included in this species are the types of Heer's *Populus arctica.* Most *C. flabella* leaves do not have the ultimate venation preserved, or the leaf is represented by a structureless carbonized mass. The leaf was apparently very thick, and the only specimens on which I have observed the ultimate venation (fig. 1*B*) are ones that appear to have been partly decayed before burial.

Most specimens, even if the ultimate venation is not preserved, display a prominent surface pattern of small (about 0.08 mm) closely spaced mounds. On specimens in which the leaf is partly decayed, the pattern appears as a reticulation of carbon filling the crevices between the bare mounds. The ultimate venation is composed of small areoles that typically lack freely ending veinlets. Such a pattern is common in members of Menispermaceae, as is the presence of a conspicuous marginal vein. Leaves of *Cocculus* in particular have the same mixture of coarse irregular lobes and an entire margin. Tropical species of *Cocculus* also display the same peculiar surface pattern as the fossils.

A third species is *Dicotylophyllum richardsoni*. Leaves of this species are commonly coarsely and doubly serrate, have glandular teeth, and may form shallow lobes. The ultimate venation, in comparison with the two other species, has large areoles intruded by thin branching veinlets. The familial relationship of this species is uncertain. Some resemblance in superficial venation pattern and margin to leaves of *Triumfetta* (Tiliaceae) may be noted, and the ultimate venation pattern is somewhat similar. On the other hand, the fossils have typically craspedodrome secondaries unlike the camptodrome pattern in *Triumfetta*. Other genera of Tiliaceae, for example *Grewia*, do have craspedodrome secondaries, but *Grewia*, as most Tiliaceae, has small quadrangular areoles intruded by few and simple veinlets. Because no familial assignments of the fossils can be made with confidence at this time, they are referred to the form genus *Dicotylophyllum*.

Occurrence: Chickaloon Formation. 9870–9874, 9881.
Hypotypes: USNM 42185, 42282, 42286.

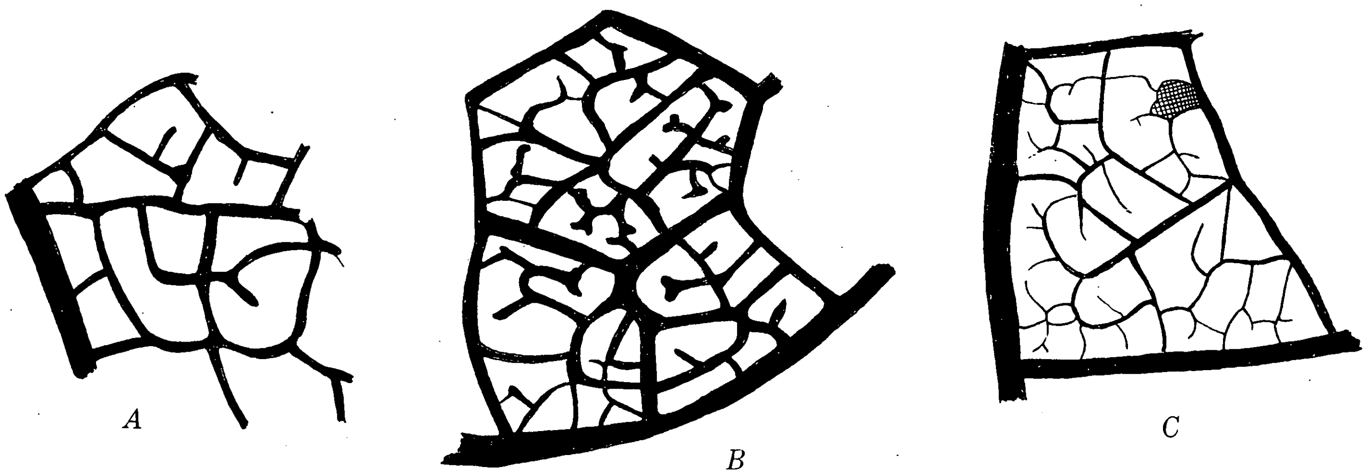

FIGURE 1.—Ultimate venation of leaves of the "*Cercidiphyllum arcticum*" type. *A, Cocculus flabella* (Newberry) Wolfe, USNM 42185, locality 9881. *B, Trochodendroides serrulata* (Ward) Wolfe, USNM 42187, locality 9870. *C, Dicotylophyllum richardsoni* (Heer) Wolfe, USNM 42262, locality 9870. × 18.

Trochodendroides serrulata (Ward) Wolfe, new combination

Plate 1, figure 3; figure 1*B*

Zizyphus serrulata Ward, 1885, U.S. Geol. Survey 6th Ann. Rept., p. 554, pl. 51, figs. 14, 15.

Cercidiphyllum arcticum (Heer) Brown, 1939 [part], Jour. Paleontology, v. 13, p. 492, pl. 53, fig. 6 (specimen on right).

Brown, 1962 [part], U.S. Geol. Survey Prof. Paper 375, p. 70, pl. 38, fig. 10.

Discussion.—Many leaves that have finely crenate margins and consistently camptodrome venation have been assigned by various authors to *Cercidiphyllum arcticum*. These leaves thus appear in gross features to differ significantly from the typical range of variation found in *Cocculus flabella*, which has large rounded teeth or an entire margin.

Trochodendroides serrulata is much less common than *Cocculus flabella*. Leaves of the former have been found at two localities in the Chickaloon Formation, but the leaves of the latter species are common at almost all localities. Many of the leaves referred to *Cercidiphyllum arcticum* from middle Eocene and younger rocks appear to belong to the *T. serrulata* phylad, although probably not to *T. serrulata* itself.

Occurrence: Chickaloon Formation: 9870, 9872.
Hypotypes: USNM 42186, 42187.

Hamamelites inaequalis (Newberry) Brown

Plate 1, figure 7

Hamamelites inaequalis (Newberry) Brown, 1962 [part], U.S. Geol. Survey Prof. Paper 375, p. 72, pl. 40, fig. 5.

Protoficus inaequalis Newberry, 1883, U.S. Natl. Mus. Proc., v. 5, p. 512.

Newberry, 1898, U.S. Geol. Survey Mon. 35, p. 89, pl. 58, fig. 2; pl. 60, fig. 1.

Hamamelites fothergilloides auct. non Saporta. Ward 1887, U.S. Geol. Survey Bull. 37, p. 64, pl. 29, fig. 1.

Discussion.—I have accepted only one of Brown's figured specimens as validly assigned to *Hamamelites inaequalis*. His plate 40, figure 4, shows a specimen that has widely spaced percurrent nervilles, several basal secondary veins departing at nearly 90°, and a consistently dentate margin; this is a platanoid leaf and should probably be assigned to *Credneria*. Brown's plate 40, figure 6, is a battered leaf that can be more readily matched by leaves of *Viburnum antiquum* (Brown, 1962, pl. 63, figs. 3, 8).

Occurrence: Chickaloon Formation: 9870.
Hypotype: USNM 42188.

"Sapindus" affinis Newberry

Plate 2, figure 3

Sapindus affinis Newberry, 1868, New York Lyceum Nat. History Annals, v. 9, p. 51.
Newberry, 1898, U.S. Geol. Survey Mon. 35, p. 116, pl. 30, fig. 1; pl. 40, fig. 2.
Brown, 1962, U.S. Geol. Survey Prof. Paper 375, p. 76, pl. 47, figs 1–8.
Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 137, pl. 76, fig. 5.

Discussion.—Several well-preserved specimens recently collected substantiate Hollick's queried referral of his Chickaloon specimen to this common Fort Union species. Both the Fort Union and the Chickaloon specimens lack the numerous prominent and nearly craspedodrome tertiary branches characteristic of leaflets of Recent *Sapindus*. In addition, the fossils have a distinct marginal vein, which is lacking in *Sapindus*. I have not been able to find all the characters of the fossils in any extant genus of Sapindaceae, although *Euphoria* appears to be closest.

Occurrence: Chickaloon Formation: 5892, 9871, 9873, 9881.
Hypotype: USNM 42189.

Dicotylophyllum alaskana (Hollick) Wolfe, new combination

Plate 2, figure 2

Grewiopsis alaskana Hollick, 1936 [part], U.S. Geol. Survey Prof. Paper 182, p. 149, pl. 85, fig. 2–4.
Populus latior auct. non Braun. Hollick, 1936 [part], U.S. Geol. Survey Prof. Paper 182, p. 64, pl. 26, fig. 4.
Populus glandulifera auct. non Heer. Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 65, pl. 116, fig. 1.
Populus balsamoides auct. non Goeppert. Hollick, 1936 [part], U.S. Geol. Survey Prof. Paper 182, p. 65, pl. 116, fig. 3.
Populus gaudini auct. non Fischer-Ooster. Hollick, 1936 [part], U.S. Geol. Survey Prof. Paper 182, p. 67, pl. 25, fig. 2.
Acer arcticum auct. non Heer. Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 133, pl. 77, fig. 1.

Discussion.—The familial affinities of these leaves are unknown. Although they superficially resemble *Populus*, their sharp nonglandular teeth, lack of petiolar glands, angular loops of the secondary veins, and other features indicate that *Dicotyphyllum alaskana* is not closely related to *Populus*. The palmate venation and camptodrome secondaries exclude *D. alaskana* from *Grewiopsis*.

Occurrence: Chickaloon Formation: 9870, 9782, 9881.
Hypotype: USNM 42190.

Dicotylophyllum flexuosa (Newberry) Wolfe, new combination

Plate 2, figure 1

Quercus flexuosa Newberry, 1863, Boston Jour. Nat. History, v. 7, p. 521.
Newberry, 1898, U.S. Geol. Survey Mon. 35, p. 74, pl. 19, figs. 4–6.
Quercus sullyi Newberry, 1883, U.S. Natl. Mus. Proc., v. 5, p. 506.
Newberry, 1898, U.S. Geol. Survey Mon. 35, p. 79, pl. 60, fig. 2.
Brown, 1962 [part], U.S. Geol. Survey Prof. Paper 375, p. 59, pl. 23, figs. 1, 2, 4–7; pl. 27, fig. 9; pl. 57, figs. 6, 7.
Pterocarya septentrionale Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 84, pl. 40, figs. 5–7.
Quercus conjunctiva Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 101, pl. 42, figs. 3, 4a.
Dryophyllum aquilonium Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 104, pl. 43, fig. 6.
Rosa cetera Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 125, pl. 70, fig. 8.
Mohrodendron inopinum Hollick, 1936 [part], U.S. Geol. Survey Prof. Paper 182, p. 162, pl. 103, fig. 2.
Fraxinus inordinata Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 163, pl. 101, figs. 1–7.
Juglans crossii auct. non Knowlton. Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 80, pl. 44, fig. 4; pl. 40, figs. 1–4.
Juglans juglandiformis auct. non (Sternberg) Giebel. Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 80, pl. 43, figs. 3–5; pl. 39, figs. 1–6.
Quercus juglandina auct. non Heer. Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 101, pl. 42, figs. 1a, 2; pl. 43, fig. 2.
Quercus artocarpites auct. non Ettingshausen. Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 102, pl. 43, fig. 1.
Quercus meriana auct. non Heer. Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 102, pl. 44, fig. 1.
Quercus alaskana auct. non Trelease. Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 102, pl. 44, fig. 2.
Dryophyllum longipetiolatum auct. non Knowlton. Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 104, pl. 42, fig. 5.
Fraxinus juglandina auct. non Saporta. Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 163, pl. 42, fig. 4b.
Fraxinus johnstrupi auct. non Heer. Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 164, pl. 105, fig. 3.

Discussion.—As the above synonymy indicates, leaves of *Dicotylophyllum flexuosa* are common in the Chickaloon Formation. This species is also found in the Paleocene Chuckanut and Fort Union floras of the conterminous United States, and some of the leaves of *Ilex* and *Quercus* described from the Greenland Paleocene may also be representatives of this species. Brown's synonymy of *Q. sullyi* with Sanborn's *Aralia taurinensis* does not appear to be valid; hence, *D. flexuosa* is not known in other than Paleocene rocks.

It is extremely doubtful that these fossils belong in *Quercus;* one specimen from the Chickaloon appears to be two leaflets attached to a rachis. *D. flexuosa* may be related to the species of *Meliosma* with compound leaves.

Occurrence: Chickaloon Formation: 5982, 9881.
Hypotype: USNM 42191.

Dicotylophyllum richardsoni (Heer) Wolfe, new combination

Plate 1, figure 4; figure 1*C*

Populus richardsoni Heer, 1868, Flora fossilis arctica, v. 1, p. 98, pl. 4, figs. 1–5; pl. 6, figs. 7, 8; pl. 15, fig. 1c.
Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 61, pl. 27, figs. 1–3; pl. 33, fig. 1a.
Cercidiphyllum arcticum (Heer) Brown. Brown, 1962 [part], U.S. Geol. Survey Prof. Paper 375, p. 70, pl. 37, figs. 13, 15, 18, 20; pl. 52, fig. 9.

Discussion.—See page B10.
Occurrence: Chickaloon Formation: 9870, 9872, 9881.
Hypotypes: USNM 42184, 42262.

Grewiopsis auriculaecordatus (Hollick) Wolfe, new combination

Plate 1, figure 6

Pterospermites auriculaecordatus Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 151, pl. 92, figs. 1–5.
Pterospermites conjunctivus Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 152, pl. 91, figs. 1, 2.
Grewiopsis alaskana Hollick, 1936 [part], U.S. Geol. Survey Prof. Paper 182, p. 149, pl. 85, fig. 1 [not figs. 2 and 3 which are retained as *Dicotylophyllum alaskana*].
Viburnum cupanioides (Newberry) Brown, 1962 [part], U.S. Geol. Survey Prof. Paper 375, p. 87.

Discussion.—These leaves have a pseudopalmate pinnate venation, craspedodrome secondary veins, percurrent nervilles, a dentate margin, and arcuate sinuses. Hence, the fossils fall within the boundaries of *Grewiopsis* as originally defined. Despite the generic name, *Grewiopsis* is not related to *Grewia*, whose leaves have palmate venation, a serrate margin, and angular sinuses.

Several unfigured Fort Union specimens referred to *Viburnum cupanioides* by Brown have the diagnostic features of *Grewiopsis auriculaecordatus.*

Occurrence: Chickaloon Formation: 9870, 9872–9874, 9881.
Hypotypes: USNM 42283, 42284.

Pterospermites cf. P. dentatus Heer

Plate 2, figure 4

Pterospermites dentatus Heer, 1868, Flora fossils arctica, v. 1, p. 138, pl. 21, fig. 15b; pl. 23, figs. 6, 7.

Discussion.—The fragmentary specimens on which Heer based *Pterospermites dentatus* appear to be conspecific with the complete specimen figured here. The peltate leaf, palmate venation, and dentate margin characterize this species.

Leaves should not be assigned to *Pterospermites.* The type of the genus, *P. vagans* Heer, is a small seed from the Miocene of Switzerland. This type of peltate leaf has never been found above the Paleocene and is apparently a relict of a Cretaceous group. The familial affinities of this foliage are unknown at present, although several Menispermaceae have peltate leaves. A more probable relationship is with Euphorbiaceae: *Macaranga tanarius* Muell.-Arg. has peltate leaves that have similar bifurcating primary and secondary veins and a nonentire margin. The fossils lack, however, conspicuous regularly spaced percurrent nervilles and percurrent quaternary veins between the nervilles, features that are characteristic of *Macaranga* and numerous other Euphorbiaceae.

Occurrence: Chickaloon Formation: 9881.
Specimen: USNM 42192.

KENAI FLORA

SALICACEAE

Populus kenaiana Wolfe, new name

Plate 3, figure 1

Vitis crenata Heer, 1869, Flora fossilis alaskana, p. 36, pl. 8, fig. 6.
Populus lindgreni Knowlton, 1898, U.S. Geol. Survey 18th Ann. Rept., pt. 3, p. 725, pl. 100, fig. 3.

Discussion.—The combination *Populus crenata* was used by Unger, and hence a new epithet is needed. The specific epithet "*heeriana*" was applied to *Vitis crenata* by Knowlton and Cockerell (in Knowlton, 1919, p. 648) because of homonymy, but the combination *Populus heeriana* would be an orthographic variant of *P. heerii* Saporta.

In the features shown by Heer's type specimen, his *Vitis crenata* is conspecific with Knowlton's *Populus lindgreni.* This synonymy is further supported by the numerous specimens from the type Seldovian and other Kenai localities that have been directly compared with both Knowlton's and Heer's types.

Occurrence: Seldovian: 9365, 9845?, 9846, 9848, 9850, 9856, 9858, 9863?, 9866, 9867. Homerian: 5821, 9844, 9852.
Hypotype: USNM 42264.

Salix cappsensis Wolfe, n. sp.

Plate 4, figure 6

Description.—Leaves simple, pinnate; shape linear oval, falcate; length 7.7–9.3 cm; width 1.9–2.4 cm; base cuneate; apex acuminate; 11–13 pairs of irregularly spaced secondary veins, departing at an angle of 40°–60°, convex, forming angular loops with adjacent secondaries; intersecondaries common, parallel to secondaries; tertiaries craspedodrome; nervilles branching, obcurrent; areoles large, irregularly polygonal, intruded by profusely branching veinlets; margin serrate, with arcuate sinuses; teeth typically two per secondary, sharp, narrowly triangular.

Discussion.—An undescribed specimen from Kukak Bay was labeled, apparently by Knowlton, as "*Andromeda* sp." (USNM 30216). This specimen and two from the Capps Glacier Seldovian are here considered conspecific.

Leaves of *Salix cappsensis* and *S. chuitensis*, a description of which follows, resemble those of the extant *S. richardsoni* Hook. in having sharp sickle-shaped teeth, an acute base, and an acuminate apex. In shape, venation, and number of teeth, however, the three species are distinguishable. *S. cappsensis* is linear and falcate in shape, has two teeth per secondary and arcuate sinuses and obcurrent nervilles. The younger *S. chuitensis* is slightly falcate and oval in shape and has two teeth per secondary, acute sinuses, and percurrent nervilles. The extant *S. richardsoni* is broadly oval in shape, has three teeth per secondary, and has acute sinuses. As yet, this phylad is unknown from the type section of the Clamgulchian.

Occurrence: Seldovian: 9845.
Holotype: USNM 42261.
Paratype: USNM 30216.

Salix chuitensis Wolfe, n. sp.

Plate 4, figures 1, 2

Description.—Leaves simple, pinnate; shape oval to ovate; slightly falcate; base cuneate; apex acuminate; length 3.8–7.5 cm; width 1.9–3.4 cm; 8–13 pairs of irregularly spaced secondary veins, departing at an angle of 30°–70°, curving apically near margin to form a series of angular loops with adjacent secondaries, camptodrome; tertiaries craspedodrome; intersecondaries common, parallel to secondaries; nervilles irregullarly spaced, branching percurrent to obcurrent; margin serrate, with uniformly spaced, narrowly triangular teeth, sinuses arcuate; petiole more than 0.2 cm long.

Discussion.—See under *Salix cappsensis* (p. B12).
Occurrence: Homerian: 9361, 9844, 9853, 9868.
Holotype: USNM 42200.
Paratype: USNM 42201.

Salix tyonekana Wolfe, n. sp.

Plate 3, figure 7

Fraxinus juglandina auct. non Saporta. Hollick, 1936 [part], U.S. Geol. Survey Prof. Paper 182, p. 163, pl. 101, fig. 10.

Description.—Leaves simple, pinnate,; shape linear oval, falcate to straight; length 4.0–9.0 cm; width 1.2–2.4 cm; base cuneate; apex highly acuminate; 18–20 pairs of irregularly spaced secondary veins, departing at an angle of 50°–80°, convex, looping smoothly near margin; intersecondaries common, subparallel to secondaries; series of submarginal tertiary loops; quaternaries craspedodrome; nervilles obcurrent; areoles about 0.5–0.6 cm across, irregularly polygonal, intruded by once- or twice-branching veinlets; margin finely crenate, with glandular teeth; teeth typically 3–5 per secondary; petiole thick, at least 0.6 cm long.

Discussion.—Leaves of *Salix tyonekana* most closely resemble those of *S. lasiandra* Benth., particularly in shape, marginal and secondary venation, and number and type of teeth. *Salix lasiandra*, however, has percurrent nervilles and less conspicuous and numerous intersecondary veins.

Occurrence: Homerian: 5821, 9844, 9852.
Holotype: USNM 42265.
Paratypes: USNM 38779, 42266.

Salix alaskana Hollick

Plate 4, figure 5

Salix alaskana Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 69, pl. 31, fig. 4.
Juglans? *pseudopunctata* Hollick, 1936 [part], U.S. Geol. Survey Prof. Paper 182, p. 82, pl. 104, fig. 2.
Prunus hartungi aequalis Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 126, pl. 70, figs. 1–3.
Prunus olympica auct. non Ettingshausen. Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 127, pl. 70, figs. 5, 6.

Discussion.—All specimens cited above intergrade in all features, and all are from the same locality. *Salix alaskana* is apparently ancestral to *S. kenaiana*, but the former has leaves that have consistently serrate margins. In the upper Homerian, however, the teeth are sparser and smaller. If it were not for the presence of minute teeth, these leaves would be assigned to *S. kenaiana*.

Occurrence: Homerian: 5820, 9361, 9853.
Hypotype: USNM 42198.

Salix kenaiana Wolfe, n. sp.

Plate 4, figure 7

Description.—Leaves simple, pinnate; shape oval to obovate; base narrowly to broadly rounded; apex acute; length 2.7–8.5 cm; width 1.8–2.7 cm; 8–16 pairs of irregularly spaced secondary veins, departing from midrib at an angle of 30°–80°, curving smoothly apically, forming a series of loops with adjacent secondaries, camptodrome; intersecondaries uncommon, parallel to secondaries; nervilles uniformly spaced, branching, percurrent; areoles irregularly polygonal, intruded by profusely branching veinlets; margin entire; petiole 0.3–0.5 cm long; lower surface pubescent.

Discussion.—*Salix kenaiana* has leaves similar to those of *S. alaskana* Holl. but lacking an indication of teeth. The recent *S. sitchensis* Sans. has similar leaves, but these have a consistently acute base and larger areoles, whereas *S. kenaiana* has a rounded base and smaller areoles.

Occurrence: Clamgulchian: 9360, 9763, 9859, 9860, 9862.
Holotype: USNM 42199.

Salix confirmata (Hollick) Wolfe, new combination

Plate 3, figure 2

Rosa confirmata Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 125, pl. 70, fig. 9.
Rhamnus gaudini auct. non Heer. Hollick, 1936 [part], U.S. Geol. Survey Prof. Paper 182, p. 139, pl. 78, fig. 4.
Diospyros anceps auct. non Heer. Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 161, pl. 105, fig. 2.

Discussion.—Hollick's type has a petiole and is hence a leaf and not a leaflet. The type and similar specimens from the Homerian are closely similar to the extant *Salix barclayi* Anders. The fossils differ from the Recent leaves primarily by having about half as many teeth, an acuminate apex, and a higher angle of departure of the secondaries.

Occurrence: Homerian: 5820, 5821, 9853, Clamgulchian: 9854.
Hypotype: USNM 42267.

Salix kachemakensis Wolfe, n. sp.

Plate 4, figures 3, 4, 8

Salix tenera auct. non Al. Braun. Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 72, pl. 34, figs. 9, 10.
Juglans salicifolia auct. non Goeppert. Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 79, pl. 28, fig. 3.
Magnolia inglefieldi auct. non Heer. Hollick, 1963 [part], U.S. Geol. Survey Prof. Paper 182, p. 114, pl. 62, fig. 3.
Laurus princeps auct. non Heer. Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 120, pl. 67, fig. 1.

Description.—Leaves simple, pinnate; shape oval to obovate; base narrowly to broadly rounded; apex acuminate; length 4.0–9.4 cm; width 2.1–4.6 cm; 12–20 pairs of secondary veins, departing at an angle of 40°–90°, irregularly convex, often branching, forming angular loops with adjacent secondaries, craspedodrome or camptodrome; intersecondaries numerous, parallel to secondaries; nervilles irregularly branching, obcurrent; areoles irregularly polygonal, intruded by thick profusely branching veinlets; margin thickened, entire or with irregularly spaced coarse teeth; petiole at least 1.5 cm long.

Discussion.—In some of the foliar variations, particularly in regard to the margin, *Salix kachemakensis* and the Recent *S. scouleriana* Barr. are very similar. The fossil species, however, has many leaves that have smoothly arching secondary veins and an entire margin, and typically the fossils are much broader than the Recent leaves.

Occurrence: Homerian: 4129, 5822, 9361, 9852, 9853.
Holotype: USNM 42193.
Paratypes: USNM 42195, 42196.

Salix leopoldae Wolfe, n. sp.

Plate 4, figure 9

Description.—Leaves simple, pinnate; shape broadly oval to ovate; base acute; apex acuminate; length 8.0 to (estimated) 11.0 cm; width 3.2–4.3 cm; 12–16 pairs of irregularly spaced secondaries, departing at an angle of 30°–80°, broadly convex to undulatory, forming angular loops submarginally, forking conspicuously; intersecondaries common, subparallel to secondaries; tertiaries camptodrome or craspedodrome; nervilles irregularly and broadly spaced, obcurrent; ultimate venation not known; margin irregularly and sparsely crenate; length of petiole unknown.

Discussion.—These fossils are similar to the leaves of both the extant *Salix scouleriana* Barr. and the Homerian *S. kachemakensis*. Leaves of *S. leopoldae* differ from those of *S. scouleriana* Barr. by their broad shape and acuminate apex; their acute base and crenate margin distinguishes them from leaves of *S. kachemakensis*.

This species is named for Estella B. Leopold.

Occurrence: Clamgulchian: 9360, 9763, 9854, 9855, 9861, 9862.
Holotype: USNM 42197.
Paratype: USNM 42268.

Salix ninilchikensis Wolfe, n. sp.

Plate 3, figure 6

Diopspyros lancifolia auct. non Lesquereux. Heer, 1869, Flora fossilis alaskana, p. 35, pl. 3, fig. 12.

Description.—Leaf simple, pinnate; shape oval, linear, rarely falcate; base cuneate to rounded; apex acuminate; length 6.5–11.5 cm; width 2.0–4.5 cm; 17–19 pairs of irregularly spaced secondaries, departing at an angle of 40°–80°, convex, curving near margin to form a series of uniform marginal loops with adjacent secondaries; nervilles not percurrent, tending to be perpendicular to midrib, branching, regularly spaced; areoles about 0.5 mm across, irregularly polygonal, intruded by thin, profusely branching veinlets; margin entire, with pubescence; petiole 0.7–0.9 cm long.

Discussion.—*Salix ninilchikensis* is closely related to the extant *S. amplifolia* Cov. The fossils differ from leaves of the Recent species by being oval and more linear and by having more numerous secondary veins.

Occurrence: Clamgulchian: 9862.
Holotype: USNM 42269.

Salix picroides (Heer) Wolfe, new combination

Juglans (Carya) picroides Heer, 1869, Flora fossilis alaskana, p. 39, pl. 9, fig. 5.

Discussion.—Heer's specimen of *Juglans picroides* does not have teeth as large as illustrated. The teeth are small and irregularly distributed. The submarginal loops of the tertiary veins are angular. In the character of the teeth, the marginal venation, and the almost percurrent venation, Heer's specimen is similar to most specimens referred by various authors to *Salix hesperia* (Knowl.) Cond. Numerous specimens, however, of *Salix picroides* from the Seldovian and lower Homerian indicate that in *S. picroides* the base is typically rounded and the apex is greatly attenuated; the margin near the apex changes from a concave admedial curvature to a concave abmedial curvature. In *S. hesperia* the base is typically cordate and the apex is less attenuated without a marked change in curvature. *S. picroides* also occurs in early Miocene beds in Oregon; this species may possibly be ancestral to *S. hesperia*, which is only known from late Miocene and younger horizons. On the other hand, except for the larger sharper uniform teeth of *S. cookensis* from the upper Homerian and Clamgulchian, this younger species and *S. picroides* would be considered conspecific. Perhaps *S. picroides* gave rise to *S. cookensis* in the north and to *S. hesperia* in the south.

Occurrence: Seldovian: 9849, 9850, 9856. Homerian: 9844.

Salix cookensis Wolfe, n. sp.

Plate 3, figures 4, 5

Salix varians auct. non Goeppert. Heer, 1869 [part], Flora fossilis alaskana, p. 27, pl. 3, figs. 1–3.

Description.—See Heer, 1869, p. 27.

Discussion.—The leaves here called *Salix cookensis* are uniform in having well-defined sharp teeth, percurrent nervilles, a linear ovate shape, and a highly acuminate apex. *Salix cookensis* is apparently related to the early and middle Miocene *S. picroides*. In venation, leaves of *S. cookensis* resemble those of the extant *S. pseudomonticola* Ball. The latter, however, are broader and have an acute apex.

Occurrence: Homerian: 9853. Clamgulchian: 9360, 9862.
Holotype: USNM 42270.
Paratype: USNM 42271.

JUGLANDACEAE

Pterocarya nigella (Heer) Wolfe, new combination

Plate 3, figure 3

Juglans nigella Heer, 1869, Flora fossilis arctica, v. 2, pt. 2, p. 38, pl. 9, figs. 2–4.

Juglans oregoniana Lesquereux, 1878, Harvard Coll. Mus. Comp. Zoology Mem., v. 6, no. 2, p. 35, pl. 9, fig. 10.

Knowlton, 1902, U.S. Geol. Survey Bull. 204, p. 36.

Salix varians auct. non Goeppert. Heer, 1869 [part], Flora fossilis arctica, v. 2, pt. 2, p. 27, pl. 2, fig. 8.

Pterocarya mixta auct. non (Knowlton) Brown. Chaney and Axelrod, 1959, Carnegie Inst. Washington Pub. 617, p. 157, pl. 21, figs. 1, 2.

Discussion.—The single series of marginal loops, evenly spaced secondary veins, and narrowly to broadly triangular evenly spaced teeth indicate that these fossils are members of the subgenus *Platyptera* of *Pterocarya*. Characteristic large winged seeds of *Platyptera* have been found associated with the leaflets at four localities.

Comparison of topotypic material indicates that it is conspecific with the miocene leaflets cited above from conterminous Northwestern United States. *Pterocarya nigella* is most similar to the Oligocene "*Juglans*" *orientalis* MacGinitie from California and Oregon. The latter species, however, has leaflets that are linear and have more acuminate apices.

Occurrence: Seldovian: 8380, 9359, 9845, 9848, 9850, 9856–9858. Homerian: 9844?
Hypotype: USNM 42272.

BETULACEAE

The abundance and diversity of foliage of Betulaceae is one of the most characteristic aspects of the Kenai floras. Fifteen species are discussed and illustrated as follows; in addition, *Betula papyrifera*, *B. sublutea*, and fragmentary specimens of a species of *Alnus* are also known from the Kenai. Because of this diversity of the family and the stratigraphic significance of the various species, the following key to the named species is presented:

A. Leaves with teeth in groups (lobations)
  B. Base decurrent along petiole
    C. Nervilles 7 or 8 per cm
      D. Secondaries 15 or more pairs ---------- *Alnus evidens*
      D. Secondaries 12 or less pairs
        E. Teeth sharp ---------- *A. cappsi*
        E. Teeth narrowly to broadly rounded
          F. Three or less secondary teeth per lobation ---------- *A. corylina*
          F. Some lobations with at least four secondary teeth ---------- *A. incana*
    C. Nervilles 5 or 6 per cm
      G. Apex abruptly acute ---------- *A. barnesi*
      G. Apex acuminate
        H. Lobations with or without one secondary tooth on apical side ---------- *A. adumbrata*
        H. Some lobations with two secondary teeth on apical side ---------- *A. schmidtae*

- A. Leaves with teeth in groups (lobations)—Continued
  - B. Base not decurrent along petiole
    - I. Lobations rounded in outline
      - J. Teeth apiculate
        - K. Teeth narrowly triangular — *Carpinus alaskana*
        - K. Teeth broadly triangular — *C. seldoviana*
      - J. Teeth not apiculate — *C. cobbi*
    - I. Lobations triangular in outline
      - L. Teeth very extended, secondary veins forking — *Corylus harrimani*
      - L. Teeth not or only moderately extended, secondary veins smoothly curving
        - M. Teeth typically reflexed basally — *C. chuitensis*
        - M. Teeth typically pointing toward apex
          - N. Teeth in central part of margin more than six per secondary vein — *Betula sublutea*
          - N. Teeth in central part of margin six or less per secondary vein — *B. papyrifera*
- A. Leaves without lobations
  - O. Secondary teeth rounded — *A. fairi*
  - O. Secondary teeth sharp
    - P. Secondary teeth spinose — *A. healyensis*
    - P. Secondary teeth triangular — *A. largei*

Alnus largei (Knowlton) Wolfe, new combination

Plate 7, figure 5; figure 2

Betula? *largei* Knowlton, 1926 [part], U.S. Geol. Survey Prof. Paper 140, p. 34, pl. 17, fig. 2.
Berry, 1929, U.S. Geol. Survey Prof. Paper 154, p. 244, pl. 50, fig. 12.
Alnus relatus (Knowlton) Brown, 1937 [part], U.S. Geol. Survey Prof. Paper 186, p. 170, pl. 49, figs. 3, 4, 6.
Wolfe, 1964, U.S. Geol. Survey Prof. Paper 454–N, p. N20, pl. 1, fig. 13.
Prunus rustii auct. non Knowlton. Berry, 1929, U.S. Geol. Survey Prof. Paper 154, p. 252, pl. 55, fig. 1.
Betula fairii auct. non Knowlton. Brown, 1937 [part], U.S. Geol. Survey Prof. Paper 186, p. 171, pl. 47, figs. 6, 7.

Discussion.—On the basis of all foliar features observed, the Alaskan specimens from the Seldovian are conspecific with forms from the Northwest synonymized above. Particularly characteristic of *Alnus largei* are the recurved ultimate veinlets, attenuated apex, numerous large sharp teeth, and the presence of a subsidiary tooth on the basal flank of the tooth entered by the most basal tertiary branch of each secondary vein. The last feature may not be present in the apical part of the leaf but is in the basal half. Late Miocene specimens referred to *A. relatus* (Chaney and Axelrod, 1959, p. 159) lack the subsidiary tooth, have narrowly rounded teeth, and the craspedodrome veins enter the teeth along the apical side; considering these differences, these specimens are here excluded from *A. largei.*

The epithet "*relatus*," originally applied to *Phyllites relatus* Knowlton (1926, p. 48, pl. 28, fig. 8), has been widely used by several authors for alder leaves of the *A. largei*-type. The type of *P. relatus* is poorly preserved and fragmentary; the ultimate venation, the marginal area in the lower half of the leaf, and the base are lacking. *P. relatus* is, therefore, considered to be a nomen nudum. Even if the epithet were considered valid, Knowlton's *Betula largei* would be the senior synonym.

Occurrence: Seldovian: 9850, 9856, 9864.
Hypotypes: USNM 42211, 42273.

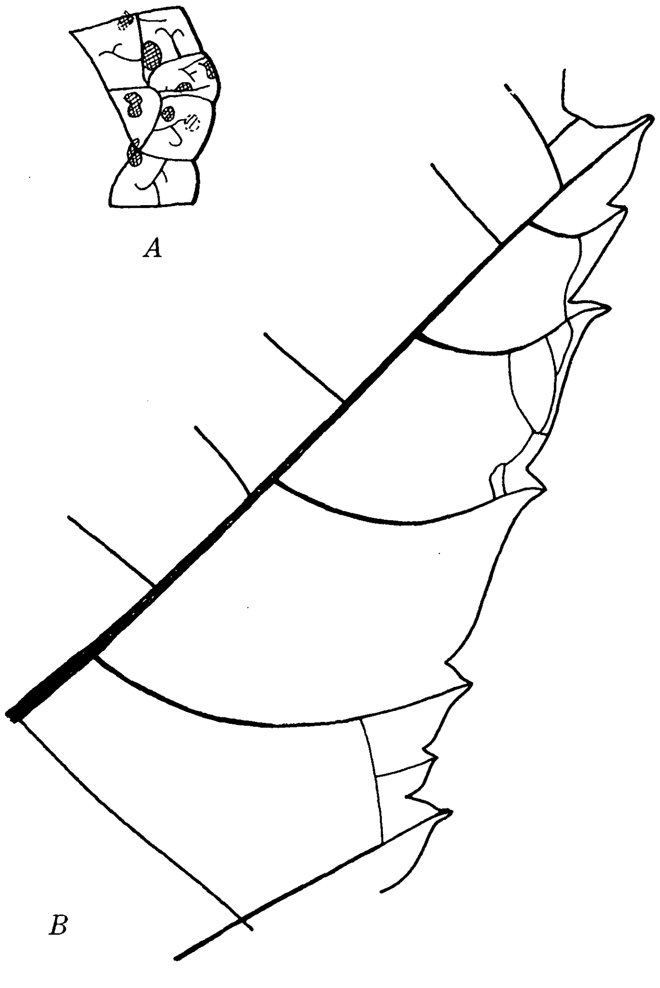

FIGURE 2.—Venation of *Alnus largei* (Knowl.) Wolfe. USNM 42273, locality 9850. *A*, × 24. *B*, × 5.

Alnus fairi (Knowlton) Wolfe, new combination

Plate 7, figure 3; figure 3

Betula fairii Knowlton, 1926, U.S. Geol. Survey Prof. Paper 140, p. 33, pl. 17, fig. 4.
Celastrus fernquisti Knowlton, 1926, U.S. Geol. Survey Prof. Paper 140, p. 44, pl. 28, fig. 2.
Alnus prerhombifolia Berry, 1929, U.S. Geol. Survey Prof. Paper 154, p. 244, pl. 50, fig. 11.
Carpinites truncatus Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 85, pl. 49, fig. 2.
Corylus macquarrii auct. non (Forbes) Heer. Heer, 1869 [part], Flora fossilis Alaskana, p. 29, pl. 4, fig. 6.
Betula prisca auct. non Ettingshausen. Heer, 1869, Flora fossilis Alaskana, p. 28, pl. 5, figs. 3, 6.

Discussion.—The type specimens of *Betula fairi* have narrowly rounded subsidiary teeth, broad primary teeth, and ultimate veinlets that typically branch once or twice. These specimens are, therefore, not *Betula* leaves but are those of *Alnus*. The specimens referred to *B. fairi* by Chaney and Axelrod (1959, p. 160) have sharp teeth and a sharp apical bend of the secondary veins on entering the teeth; on the basis of these characters, Chaney and Axelrod's specimens are indeed *Betula*. Another characteristic of *A. fairi* is the broadly acute apex, which contrasts with the attenuated apex of *A. largei*.

Occurrence: Seldovian: 9365, 9858.
Hypotype: USNM 36994, 42210, 42274.

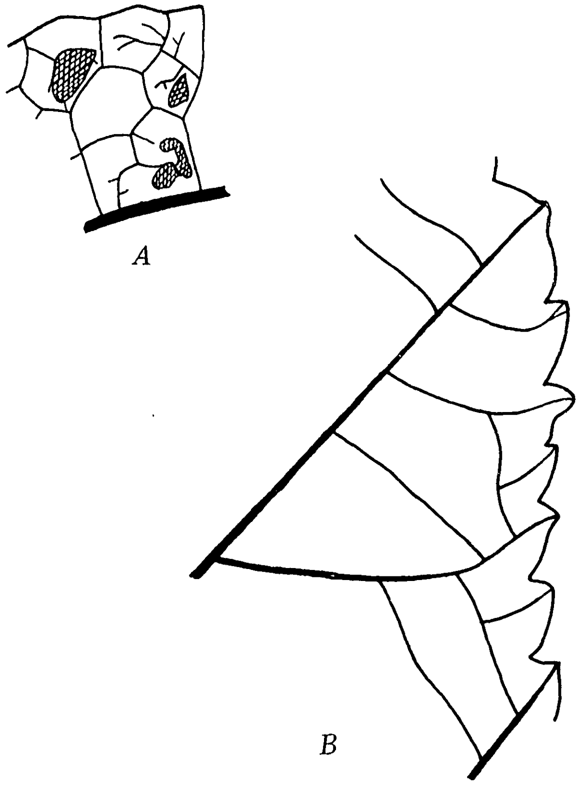

FIGURE 3.—Venation of *Alnus fairi* (Knowl.) Wolfe. *A*, USNM 42274, locality 7875 (Latah Formation) × 24. *B*, USNM 36994 (Latah Formation), holotype of *Celastrus fernquisti* × 5.

Alnus healyensis Wolfe, new name

Plate 7, figure 4; figure 4

Artocarpidium alaskanum Hollick, 1936 [part], U.S. Geol. Survey Prof. Paper 182, p. 108, pl. 59, fig. 5.
Quercus oregoniana auct. non Knowlton. Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 103, pl. 50, fig. 5.

Supplementary description.—Leaves simple pinnate; shape oval to obovate; base cuneate, decurrent along petiole; apex acuminate; length 3.8–9.1 cm; width 1.7–4.5 cm; 8–11 pairs of irregularly spaced secondary veins, departing at an angle of 20°–70°; straight to broadly convex, craspedodrome; giving off two or three craspedrome tertiary branches basally; nervilles arcuate, percurrent on the apical side of a secondary but not percurrent on the basal side; areoles about 1.0 mm across, irregularly polygonal, intruded by twice- or thrice-branching thin veinlets; margin serrate to dentate; primary teeth broadly triangular, often reflexed basally; secondary teeth small, sharp; petiole at least 0.5 cm long.

Discussion.—Some of the Latah specimens referred to *Alnus relata* possess very sharp (almost spinose) small

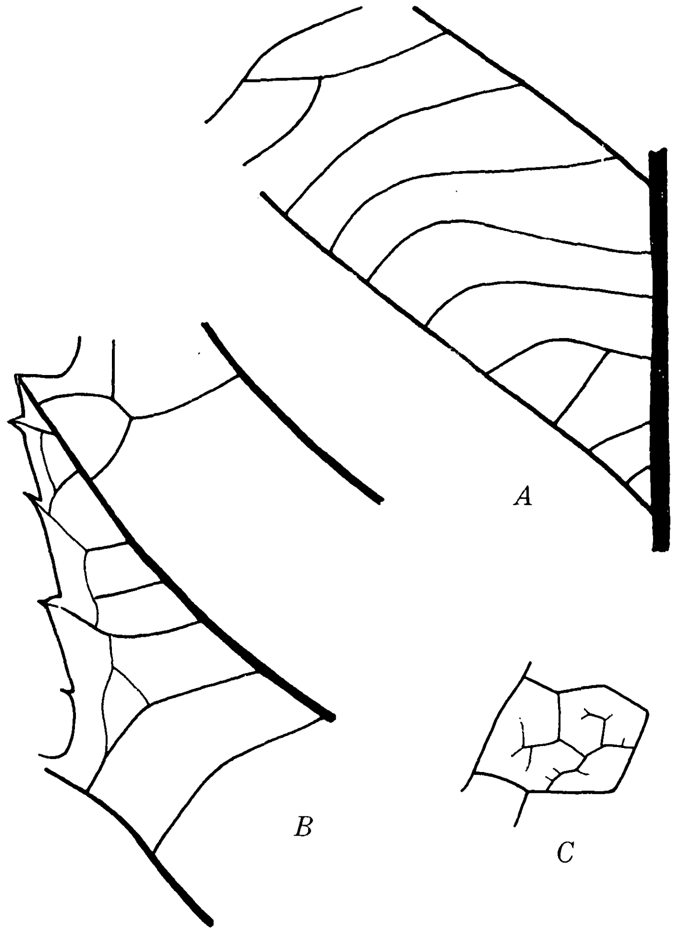

FIGURE 4.—Venation of *Alnus healyensis* Wolfe. USNM 42209, locality 9850. *A*, × 7. *B*, × 5. *C*, × 24.

and recurved secondary teeth and large areoles intruded by ultimate veinlets that branch once or, more typically, twice. In addition, these specimens lack a subsidiary tooth on the basal flank of lower secondary teeth. Thus, these specimens are readily distinguished from typical *A. largei* but are similar to one of the specimens described by Hollick as *Artocarpidium alaskanum.* Because the epithet "*alaskana*" has been previously applied to *Alnus*, the new epithet "*healyensis*" is proposed.

Occurrence: Seldovian: 9365, 9845, 9850, 9856, 9858, 9937.
Lectotype: USNM 38900.
Hypotypes: USNM 38851, 42209.

Alnus evidens (Hollick) Wolfe, new combination

Plate 5, figures 3, 4; figure 5

Corylus evidens Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 86, pl. 49, fig. 3.

Discussion.—Three species allied to the Recent *Alnus incana*, as well as *A. incana* itself, are represented in the Kenai Formation. The stratigraphic relation of the two Seldovian species of this phylad are not certainly known, although the rest of the flora as well as the morphologic characters of *A. cappsi* indicate that it is intermediate between *A. evidens* and the Homerian *A. corylina.* In the Clamgulchian, the phylad is represented by *A. incana.*

A species related to *Alnus evidens* occurs in Oligocene rocks on Sitkinak Island and in the Gulf of Alaska coastal section. This species may be conspecific with *A. alaskana* Newb., originally described from the Oligocene of Admiralty Island; Newberry's type specimen is poorly preserved, and the other Oligocene specimens in hand are referred to *A.* sp., cf. *A. alaskana* pending description and designation of an adequate type. This Oligocene species has a consistently cordate base, closely spaced secondary veins, and the teeth are of equal size without grouping into lobations.

Leaves of *A. evidens* are typically asymmetric and have a broadly rounded or cordate base and an acuminate apex. The teeth are triangular and of nearly equal size, although they are grouped as lobations. The number of secondary teeth is typically two or three, although on the enlarged part of asymmetric laminae, four teeth may be present; on the basal size of the lowest secondary tooth on some lobations, a subsidiary tooth may be present.

The leaves of *A. cappsi* are similar to those of *A. evidens* in shape of lamina, number of secondary teeth, and presence of a subsidiary tooth. The lobations of *A. cappsi* are, however, more pronounced, the primary tooth being considerably larger than the secondary tooth. In addition, the lobations have a more rounded outline, an extreme form of which is illustrated (pl. 8, figs. 1, 4). In number of secondary veins, the two species are also readily distinguished: *A. evidens* typically has at least 15 pairs, and *A. cappsi* has 12 or less pairs.

Rounding of the lobations is even more conspicuous in leaves of *A. corylina*, and this apparently led the artist who illustrated the types to ignore the small secondary teeth. On some specimens, the secondary teeth are considerably reduced in relation to the primary teeth, and the primary teeth are typically rounded. In the two older species, the leaves typically lack a tooth on the apical side of the primary teeth, although this tooth is more common in *A. cappsi* than in *A. evidens*. In *A. corylina* this apical subsidiary tooth is almost always present.

In leaves of *A. incana* of Clamgulchian and Recent age, the lobations are even more deeply incised. The apical sides of the primary teeth consistently have at least one and typically two subsidiary teeth, particularly on lobations at the widest part of the laminae. The leaf bases of *A. incana* tend to be rounded to acute, as opposed to the rounded to cordate shape of leaf bases of *A. corylina.* In addition, the typical leaf shape is oval in *A. incana* but is ovate in *A. corylina.*

Occurrence: Seldovian: 8380?, 9359, 9364, 9761, 9863?, 9865?, 9866, 9887.
Hypotypes: USNM 42275, 42276.

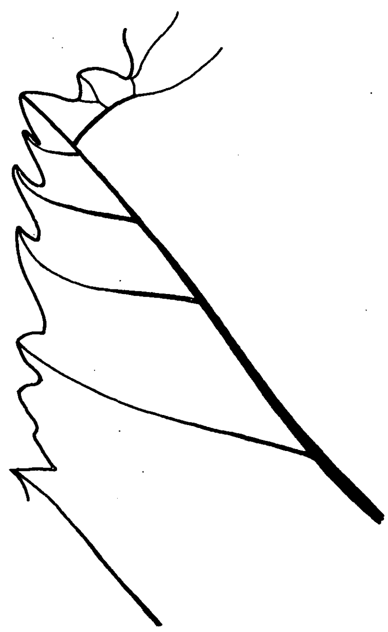

FIGURE 5.—Venation of *Alnus evidens* (Holl.) Wolfe. USNM 38844, locality 3517 (Kukak Bay). × 5.

Alnus cappsi (Hollick) Wolfe, new combination

Plate 6, figures 1, 4; plate 7, figures 2, 6; figure 6

Crataegus cappsi Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 86, pl. 49, fig. 3.

Alnus iljinskiae Vcherashnjaja, 1964, Paleontologicheskii Zhurnal, Akad. Nauk SSSR, no. 3, p. 96, pl. 11, fig. 1; text fig. 1.

Crataegus gracilens auct. non MacGinitie. Chaney and Axelrod, 1959 [part], p. 184, pl. 37, fig. 2.

Discussion.—The fragmentary type illustrated by Vcherashnjaja as *Alnus iljinskiae* is from Oligocene or early Miocene beds in the Aldan River basin of eastern Siberia; considering the stratigraphic distribution of *A. cappsi*, the age of these beds is probably Miocene. Vcherashnjaja also pointed out that the Mascall specimen of *Crataegus gracilens* is conspecific with her species, which is here considered a junior synonymn of *A. cappsi.*

Occurrence: Seldovian: 6063, 9365, 9846, 9858, 9867, 9937.
Hypotypes: USNM 42205, 42206, 42259, 42260.

Alnus corylina Knowlton and Cockerell

Plate 6, figures 2, 5; figure 7

Alnus corylina Knowlton and Cockerell, 1919, U.S. Geol. Survey Bull. 696, p. 63.

Alnus corylifolia Lesquereux, 1883, U.S. Natl. Mus. Proc., v. 5, p. 446, pl. 7, figs. 1–4.

Quercus dalli Lesquereux, U.S. Natl. Mus. Proc., v. 5, p. 446, pl. 8, figs. 2–5.

Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 103, pl. 52, fig. 4.

Corylus adumbrata Hollick, 1936 [part], U.S. Geol. Survey Prof. Paper 182, p. 86, pl. 47, fig. 6; pl. 49, figs. 5, 6.

Fagus alnitifolia Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 97, pl. 52, fig. 5a.

Betula prisca auct. non Ettingshausen. Hollick, 1936 [part], U.S. Geol. Survey Prof. Paper 182, p. 91, pl. 52, fig. 2.

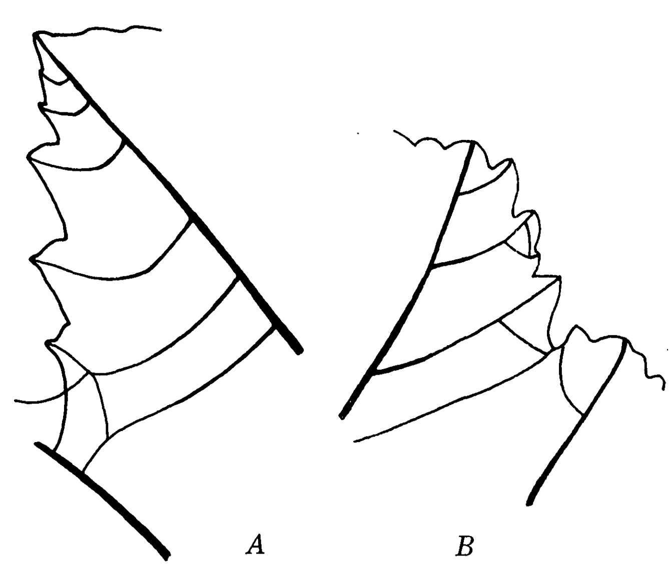

FIGURE 6.—Venation of *Alnus cappsi* (Holl.) Wolfe. *A*, USNM 42205. *B*, USNM 42259. Locality 9365. × 4.

Quercus olafseni auct. non Heer. Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 99, pl. 52, fig. 3.

Quercus steenstrupiana auct. non Heer. Hollick, 1936 [part], U.S. Geol. Survey Prof. Paper 182, p. 100, pl. 52, fig. 5b.

Alnus harneyana Chaney and Axelrod, 1959 [part], Carnegie Inst. Washington Pub. 617, p. 158, pl. 21, figs. 4–9.

Discussion.—Although Lesquereux's illustrations of the types of *Quercus dalli* show leaves that have apparently simple lobations, the types themselves have secondary teeth similar to the specimens illustrated here. Such compoundly serrate leaves are found in Betulaceae but not in Fagaceae. Leaves of *Alnus* are most similar to the fossils in having a cordate base decurrent along the petiole and rounded lobations.

Specimens recently described as *Alnus harneyana* display the same rounded lobations and blunt primary teeth as *A. corylina.* In all other details observed, *A. harneyana* and *A. corylina* are conspecific.

Occurrence: Homerian: 4129–4131, 9361, 9844, 9851, 9852?, 9853, 9868.
Hypotypes: USNM 42207, 42208.

Alnus barnesi Wolfe, n. sp.

Plate 5, figure 5, 7; figure 8

Description.—Leaves simple, pinnate; shape broadly oval to ovate; base cordate, asymmetric, decurrent along petiole; apex abruptly acute; length 3.5 to (estimated)

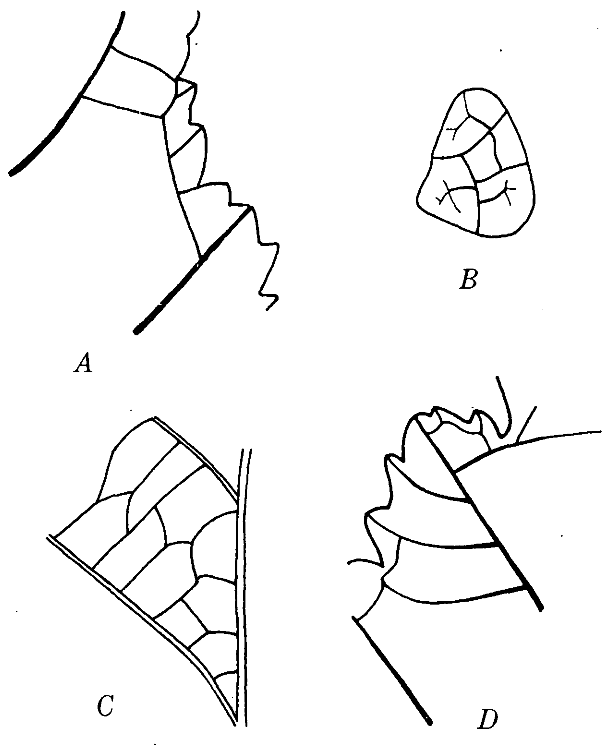

FIGURE 7.—Venation of *Alnus corylina* and *A. incana*. *A–C*, *A. corylina* Knowl. and Cock., USNM 42207, locality 9844; *D*, *A. incana* (L) Moench, USGS reference collection 886. *A, D*, × 5. *B*, × 10. *C*, × 3.

8.0 cm; width 3.0–7.2 cm; 8–13 pairs of secondary veins, departing at an angle of 40°–90°, broadly convex to straight, giving off one of three craspedodrome tertiary branches basally, craspedodrome; nervilles percurrent, branching, uniformly spaced; areoles irregularly polygonal, about 0.4 mm across, intruded by once- or twice-branching veinlets; margin finely serrate with groups of teeth forming lobations; typically without any secondary teeth on apical side of lobation, but rarely one is present; teeth narrowly or typically broadly rounded; petiole at least 2.0 cm. long.

Discussion.—Representatives of three species related to the extant *Alnus crispa* have been found in the Kenai Formation. The oldest of these, *A. barnesi*, is known from two localities in the Seldovian, and even there it is poorly represented. The characters that distinguish *A. barnesi* from the Homerian *A. adumbrata* are: (1) The abruptly acute apex in the older species and the acuminate apex in *A. adumbrata*, (2) the typical lack of a subsidiary tooth on the apical sides of the primary teeth in *A. barnesi*, and (3) the more deeply incised lobations in *A. adumbrata*. The last two differences can probably be correlated with each other; that is, on the apical side of a deeply incised lobation there is room for a subsidiary tooth. One specimen of *A. barnesi* also has considerably blunter teeth than any specimen of the more abundant *A. adumbrata*, but most specimens of the two species overlap in this feature.

The Clamgulchian *Alnus schmidtae* is intermediate in foliar characters between *A. adumbrata* and *A. crispa*. In *A. adumbrata*, the four most apical lobations lack secondary teeth, but in *A. schmidtae* and *A. crispa* secondary teeth are present. The laminar shape in both *A. adumbrata* and *A. schmidtae* is oval; it is typically ovate in the Recent species. All three species have at least one apical subsidiary tooth, although in some specimens of *A. schmidtae* and *A. crispa* subsp. *sinuata*, two apical subsidiary teeth are present. *A. adumbrata* lacks subsidiary teeth on the basal sides of the secondary teeth, but these are present in *A. schmidtae* and *A. crispa*. Perhaps the most conspicuous difference between *A. crispa* and all the older species of its phylad is in the nervilles: although the nervilles anastomose and branch in the older species, they are of uniform strength throughout their course. In *A. crispa*, the nervilles, particularly those in the basal third of the lamina, thin conspicuously in the center of the intercostal area.

Hultén (1944, p. 587) considered *A. sinuata* to be a subspecies of the more widely distributed *A. crispa*. He noted, however, that the two subspecies may have different topographic ranges and ecologic requirements. My observations in the Chitina River valley and adjacent Wrangell Mountains coincide with those of Gorman (in Hultén, 1944, p. 589): *A crispa* is confined to th higher altitudes (1,700 ft and above) and drier ground; *A. sinuata* is found at lower altitudes and is most common on the bottomlands of the Chitina River and its tributaries. The more elongate teeth, deeply cordate base, consistent presence of two apical subsidiary teeth, and more numerous subsidiary teeth on the basal sides of the secondary teeth are features that are probably of specific rank. It seems probable that the two species or subspecies were both derived from *A. schmidtae* in the latest Neogene.

This species is named in recognition of the notable contributions made by F. F. Barnes to the geology of the Cook Inlet region.

Occurrence: Seldovian: 9937, 9845, 9886.
Holotype: USNM 42202, 42277.

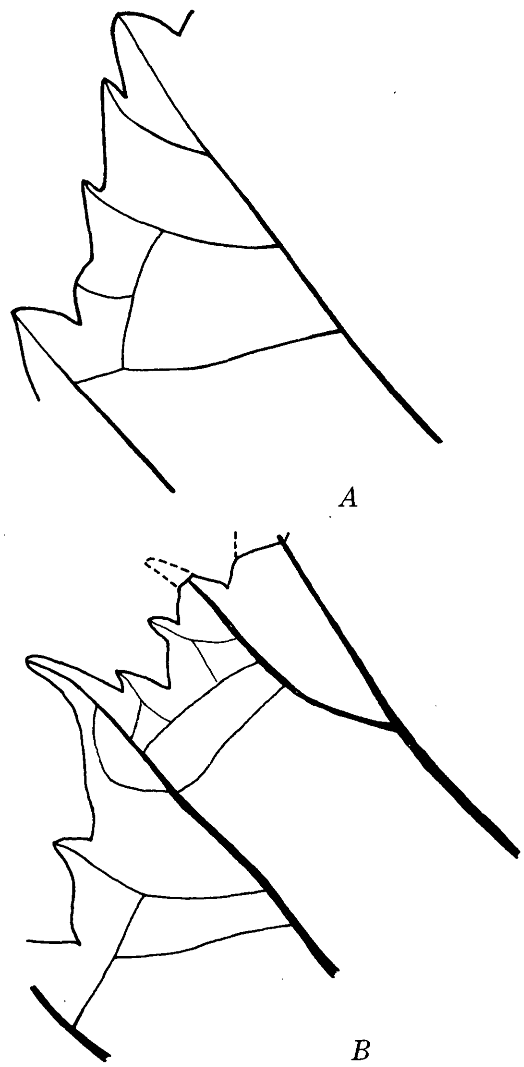

FIGURE 8.—Venation of *Alnus barnesi* Wolfe. *A*, USNM 42202; *B*, USNM 42277; locality 9845. × 5.

Alnus adumbrata (Hollick) Wolfe, new combination

Figure 9

Corylus adumbrata Hollick, 1936 [part], U.S. Geol. Survey Prof. Paper 182, p. 86, pl. 49, fig. 7.
Corylus kenaiana Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 87, pl. 45, figs. 1–3a; pl. 46, figs. 1b–5; pl. 47, figs. 1–5.
Carpinus grandis auct. non Unger. Hollick, 1936 [part], U.S. Geol. Survey Prof. Paper 182, p. 84, pl. 49, fig. 1.
Corylus americana fossilis auct. non Newberry. Hollick, 1936 [part], U.S. Geol. Survey Prof. Paper 182, p. 86, pl. 45, fig. 3b; pl. 48, figs. 1, 2.
Betula prisca auct. non Ettingshausen. Hollick, 1936 [part], U.S. Geol. Survey Prof. Paper 182, p. 91, pl. 50, fig. 3a.
Alnus corylina auct. non Knowlton and Cockerell. Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 93, pl. 46, fig. 1a; pl. 49, figs. 8, 9; pl. 50, fig. 1.
Ulmus borealis auct. non Heer. Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 106, pl. 57, figs. 1, 2.

Discussion.—All the above items intergrade morphologically and are here considered to be synonymous. *Alnus adumbrata* has leaves that are typically strongly cordate and asymmetric, although as characteristic of *Alnus*, the lamina is decurrent along the petiole.

Occurrence: Homerian: 4130, 5821, 9361, 9844?, 9851, 9853, 9868.
Hypotype: USNM 38831, 38832.

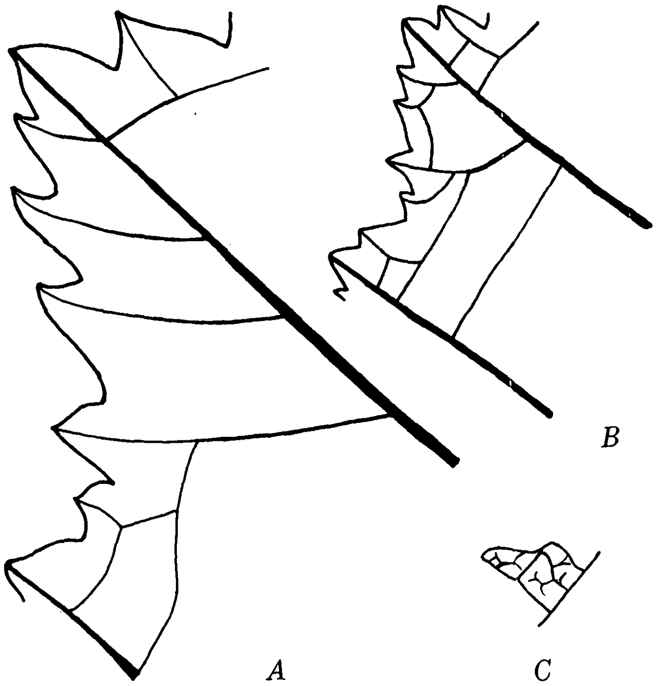

FIGURE 9.—Venation of *Alnus adumbrata* (Holl.) Wolfe. *A, C,* USNM 38832. *B,* USNM 38831, locality 5821. *A, B,* × 5. *C,* × 10.

Alnus schmidtae Wolfe, n. sp.

Plate 5, figure 1; figure 10

Corylus MacQuarrii auct. non (Forbes) Heer. Heer, 1869 [part], Flora fossilis alaskana, p. 29, pl. 3, fig. 9; pl. 4, figs. 1–4.
Alnus kefersteinii auct. non Goeppert. Heer, 1869 [part], Flora fossilis alaskana, p. 28, pl. 3, fig. 7.

Description.—Leaves simple, pinnate; shape broadly oval to ovate; base cordate to broadly rounded, asymmetric, decurrent along petiole; apex acuminate; length 3.2–10.4 cm; width 1.6–7.7 cm; 10–15 pairs of uniformly spaced secondary veins, departing at an angle of 40°–90°, straight to broadly convex, giving off two or three prominent craspedodrome tertiaries basally, craspedodrome; nervilles percurrent, branching, uniformly spaced; aeroles irregularly polygonal, about 0.4 mm across, intruded by once or twice-branching veinlets; margin finely serrate with groups of teeth forming

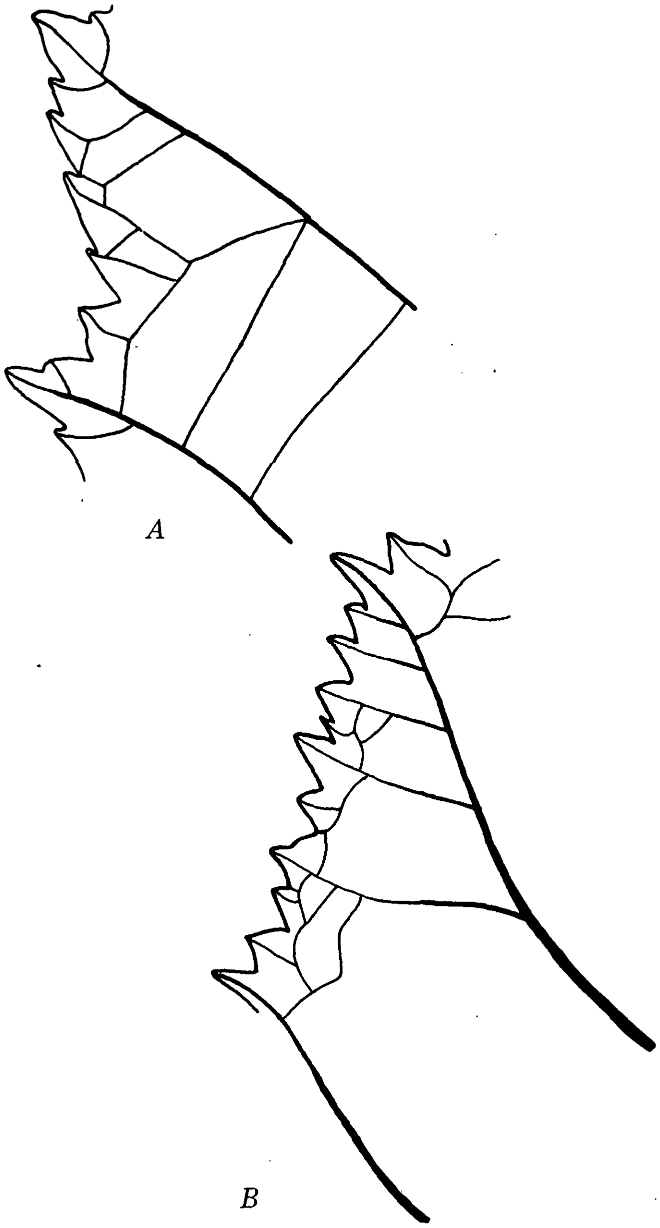

FIGURE 10.—Venation of *Alnus schmidtae* and *A. crispa*. *A, A. schmidtae* Wolfe, USNM 42203, locality 9862. *B, A. crispa* (Pursh) Ait., USGS reference collection 884. × 5.

lobations; in widest part of leaf typically two secondary teeth on apical side of lobation; teeth narrowly rounded to broadly triangular; petiole at least 1.5 cm long.

Discussion.—Heer's figures cited above do not show secondary teeth on the apical side of the lobations. Specimens from the same stratigraphic interval that were collected in 1955, however, do have these teeth; their lack in Heer's somewhat crude drawings is probably not significant.

I take pleasure in naming this species for R. A. M. Schmidt, who has assisted in the collection of the Kenai flora.

Occurrence: Clamgulchian: 9360, 9855, 9859, 9860, 9862.
Holotype: USNM 42203.
Paratype: USNM 42204.

Carpinus cappsensis Wolfe, n. sp.

Plate 6, figure 3; figure 11, *A–C*

Corylus macquarrii auct. non (Forbes) Heer. Knowlton, 1904, Harriman Alaskan Exped., p. 153.
Alnus corylifolia auct. non Lesquereux. Knowlton, 1904, Harriman Alaskan Exped., p. 155.

Description.—Leaves, simple, pinnate; shape oval; base deeply cordate; apex acuminate; length 3.5 to (estimated) 11 cm; width 2.1–5.0 cm; 14–16 pairs of regularly spaced secondary veins, departing at an angle of 50°–90°, straight to broadly convex, craspedodrome, giving off two to five pairs of craspedodrome tertiaries basally; nervilles closely spaced, branching, percurrent; areoles quadrangular or pentagonal, intruded by unbranching or once-branching veinlets; margin compoundly serrate, with lobations rounded in outline; five or six teeth per lobation at widest part of lamina, typically with one tooth on apical side of lobation; teeth broadly triangular and pronouncedly apiculate.

Discussion.—*Carpinus cappsensis* is closely related to *C. seldoviana*, and superficially some specimens of the two species appear identical. The presence of apical teeth on the lobations, and the conspicuously apiculate teeth in *C. cappsensis* are constant and distinguishing features.

The apical teeth are probably an ancestral character in this phylad; these teeth are present in middle or late Oligocene specimens of a closely related species from Sitkinak Island.

Occurrence: Seldovian: 8380, 9359, 9364, 9845, 9846, 9864?
Holotype: USNM 42213.
Paratypes: USNM 30185, 30189.

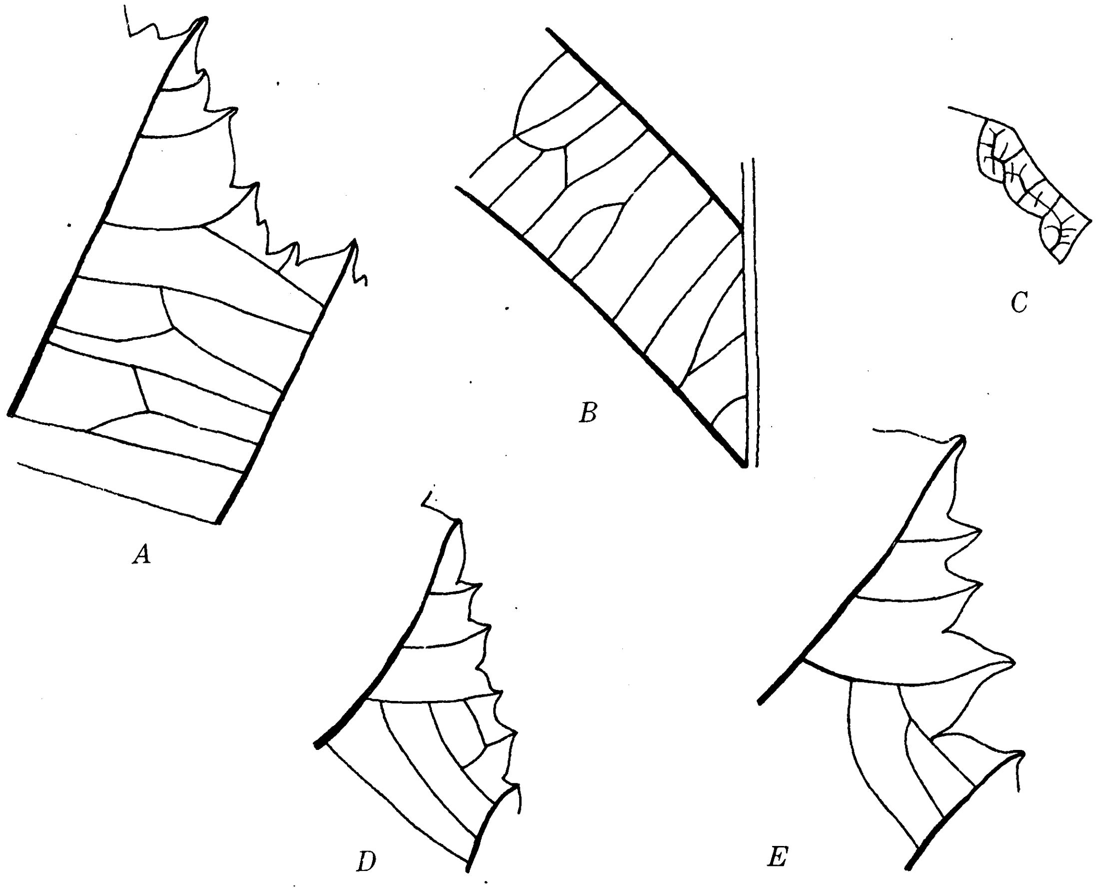

FIGURE 11.—Venation of *Carpinus*. *A–C, C. cappsensis* Wolfe USNM 42213, locality 9845. *D, C. seldoviana* Wolfe, USNM 42212, locality 9858. *E, C. cobbi* Wolfe, USNM 42214, locality 9361. *A, D, E,* × 5. *B,* × 3. *C,* × 10.

Carpinus seldoviana Wolfe, n. sp.

Plate 6, figure 6; figure 11*D*

Corylus MacQuarrii auct. non (Forbes) Heer. Heer, 1869 [part], Flora fossilis alaskana, p. 30, pl. 4, figs. 6–8.

Description.—Leaves simple, pinnate; shape broadly oval to obovate asymmetric; base deeply cordate; apex acuminate; length 6.0–10.0 cm, with 4.8–9.2 cm; 12–22 pairs of uniformly spaced secondary veins, departing at an angle of 40°–130°, broadly convex or straight, giving off two to four craspedodrome tertiary branches basally, craspedodrome; nervilles closely spaced, branching, percurrent; areoles quadrangular or pentagonal, intruded by unbranching or once-branching veinlets; margin uniformly and compoundly serrate, with broadly apiculate teeth.

Discussion.—*Carpinus seldoviana* is most similar to the extant *C. erosa* Blume, which has leaves with a cordate base and apiculate teeth somewhat similar to the fossils. Leaves of the two species differ in the more numerous and closely spaced secondaries of the fossils.

Occurrence: Seldovian: 9856, 9858.
Holotype: USNM 42212.

Carpinus cobbi Wolfe, n. sp.

Plate 6, figure 7; figure 11*E*

Alnus alaskana auct. non Newberry. Hollick, 1936 [part], U.S. Geol. Survey Prof. Paper 182, pl. 51, fig. 8.

Description.—Leaves simple, pinnate; shape broadly oval; base deeply cordate; apex acuminate; length 7.2–12.0 cm, width 5.0–7.5 cm; 12–16 pairs of secondary veins, departing at an angle of 40°–110°, broadly convex, giving off two or three craspedodrome tertiary branches basally, craspedodrome; nervilles closely spaced, branching, percurrent; areoles quadrangular or pentagonal; intruded by unbranching or once-branching veinlets; margin compoundly serrate to dentate, with primary teeth broadly apiculate and secondaries narrowly to broadly triangular; petiole at least 3.0 cm long.

Discussion.—Although leaves of *Carpinus cobbi* closely resemble those of *C. seldoviana*, there are significant differences. Leaves of the latter species have teeth of about equal size and shape, and the teeth are typically serrate. *C. cobbi* has teeth that are very unequal in size and shape, and many of the teeth are dentate. *C. seldoviana* also has a more deeply cordate base, and most of the specimens have more numerous secondaries.

Carpinus cobbi is named for E. H. Cobb, in recognition of his valuable contributions to the geology of the Homer district.

Occurrence: Homerian: 4130, 9361.
Holotype: USNM 42214.

Corylus harrimani Knowlton

Figure 12*A*

Corylus harrimani Knowlton, 1904, Harriman Alaskan Exped., p. 154, pl. 23, fig. 1.
Corylus? palachei Knowlton, 1904, Harriman Alaskan Exped., p. 154, pl. 22, fig. 2; pl. 28, fig. 1.
Pterospermites magnifolia Knowlton, 1904, Harriman Alaskan Exped., p. 156, pl. 31.
Pterospermites alaskana Knowlton, 1904, Harriman Alaskan Exped., p. 156, pl. 26, fig. 2; pl. 32.
Crataegus alaskensis Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 125, pl. 71, fig. 5.

Discussion.—All the specimens united above have the same tendency towards irregular and forking secondary venation, very apiculate teeth, and a typically rounded base. The very large specimens described as *Corylus harrimani* and *Pterospermites* are probably leaves from sucker shoots, whereas the specimens described as *C.? palachei* are more typical of the species.

Occurrence: Seldovian: 8380?, 9359.
Hypotype: USNM 30069.

Corylus chuitensis Wolfe, n. sp.

Plate 5, figures 2, 6; figure 12*B*

Betula confusa lata Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 91, pl. 52, fig. 1.

Description.—Leaves simple, pinnate; shape oval; base broadly rounded to cordate; apex acuminate; length 3.2–11.1 cm; width 2.7–7.5 cm; 10–13 pairs of secondaries, departing at an angle of 40°–90°, straight to broadly convex, craspedodrome, giving off one to four craspedodrome tertiary branches basally; nervilles branching, percurrent; margin compoundly serrate, with 6–15 teeth per secondary at widest part of lamina; primary teeth broadly triangular and apiculate or nar-

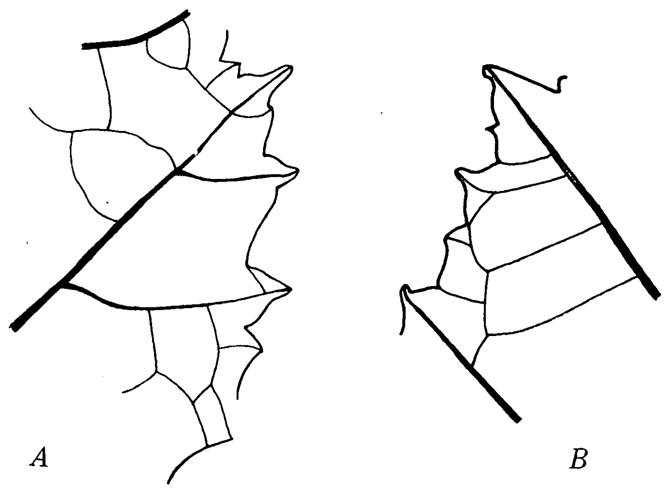

FIGURE 12.—Venation of *Corylus*. *A*, *C. harrimani* Knowlton, USNM 30069. *B*, *C. chuitensis* Wolfe, USNM 42258, locality 9844. × 5.

rowly rounded; subsidiary teeth broadly triangular and apiculate; petiole at least 2.0 cm long.

Discussion.—Leaves of *Corylus chuitensis* are similar to the leaves of *C. harrimani*, and the two species are probably related phylogenetically. *C. chuitensis* differs from the latter species by having more regular secondary venation, a more rounded and typically cordate base, and less apiculate teeth. Moreover, *C. chuitensis* lacks subsidiary teeth on the apical side of the primary teeth.

Occurrence: Homerian: 5820, 9361, 9844, 9868.
Holotype: USNM 42257.
Paratype: USNM 42258, 38862.

MENISPERMACEAE

Cocculus auriculata (Heer) Wolfe, new combination

Plate 7, figure 1

Hedera auriculata Heer, 1869, Flora fossilis arctica, v. 2, no. 2, p. 36, pl. 9, fig. 6.
Populus heteromorpha Knowlton, 1926, U.S. Geol. Survey Prof. Paper 140, p. 30, pl. 12, figs. 8–10; pl. 13, figs. 1–7; pl. 14, figs. 1–3; pl. 15, figs. 3–5.
Cocculus heteromorpha (Knowlton) Brown, 1946, Washington Acad. Sci. Jour., v. 36, p. 352. (See synonymy.)
Tanai, 1961, Hokkaido Univ. Fac. Sci. Jour., ser. IV, p. 324, pl. 21, fig. 7.

Discussion.—Comparisons between leaves of *Hedera auriculata* from the beds near Seldovia with leaves of *Cocculus heteromorpha* from several localities in the conterminous United States indicate that the two groups are conspecific. The specimens from the Miocene of Japan do not show any features distinguishing them from *C. auriculata.* Thus, a probable distribution around the shores of the North Pacific is indicated for *C. auriculata* during the early and middle Miocene.

Several leaves of *Cocculus auriculata* are also present in a small collection from the coal-bearing formation of the Alaska Range.

Occurrence: Seldovian: 9856, 9858.
Hypotype: USNM 42278.

ROSACEAE

Spiraea hopkinsi Wolfe, n. sp.

Plate 8, figure 2

Ulmus sorbifolia auct. non Goeppert. Hollick, 1936 [part], U.S. Geol. Survey Prof. Paper 182, p. 106, pl. 57, figs. 4, 5.

Description.—Leaf compound, pinnate; terminal leaflets broadly ovate; petiolule 2.0 cm long; lateral leaflets narrowly ovate, 3.5–9.5 cm long; 2.0–3.0 cm wide; base asymmetric, cuneate; apex acuminate; 17–24 pairs of broadly convex to straight secondary veins departing at an angle of 50°–70°, giving off typically three tertiary veins basally; secondaries and tertiaries craspedodrome; nervilles obcurrent, forming chevrons pointing toward margin; numerous intersecondaries, parallel to secondaries; margin compoundly serrate, with sharp, narrowly triangular teeth, V-shaped sinuses, conspicuous subsidiary tooth on apical side of primary tooth; apetiolulate.

Discussion.—This foliage is one of the most characteristic and easily recognizable types in the Homerian.

Spiraea hopkinsi closely resembles the extant *S. lindleyana* Wall. in all major features of the leaflets. In detail, however, the two species differ considerably in the nature of the nervilles, which are percurrent in *S. lindleyana*, and in the relationship of the teeth and sinuses. In the extant form, the sinuses appear as simple slits rather than being V-shaped as in the fossils.

This species is named in recognition of the invaluable assistance D. M. Hopkins has rendered to the study of the Kenai flora.

Occurrence: Homerian: 4129, 4131, 9361, 9366, 9844, 9853, 9868.
Holotype: USNM 42225.
Paratype: USNM 42226.

Spiraea weaveri Hollick

Plate 8, figure 4

Spiraea weaveri Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 124, pl. 70, fig. 7.

Discussion.—The generic reference of Hollick's type seems to be valid. The more recent collections from the Homer section contain an abundance of *Spiraea weaveri*, and at several localities leaves of this species represent more than 90 percent of the fossils collected. The range of variation in regard to number of teeth and secondary veins is considerable. The specimens from Houston, Alaska, are questionably referred to this species, for they have consistently small and few teeth and may represent an ancestral form.

Spiraea weaveri is closely related to an extant Alaskan species, *S. beauverdiana* Schn. Leaves of the latter species differ by having acute sinuses, whereas the sinuses in *S. weaveri* are typically narrowly arcuate.

Occurrence: Seldovian: 9365. Homerian: 4131, 9361, 9366, 9851, 9853. Clamgulchian: 9855.
Hypotype: USNM 42222.

LEGUMINOSAE

Cladrastis japonica (Tanai and Suzuki) Wolfe, new combination

Plate 8, figure 3

Nyssa japonica Tanai and Suzuki, 1963, Tertiary floras of Japan: Miocene floras, p. 146, pl. 24, figs. 1, 2, 5.
Cladrastis aniensis Huzioka, 1963, Tertiary floras of Japan: Miocene floras, p. 205, pl. 35, figs. 5, 6.
Tanai and Suzuki, 1963, Tertiary floras of Japan: Miocene floras, p. 132, pl. 23, figs. 1, 7.

Magnolia miocenica auct. non Hu and Chaney. Tanai and Suzuki, 1963, Tertiary floras of Japan: Miocene floras, p. 146 [part], pl. 24, fig. 5.

Discussion.—All the specimens on which the above citations are based have several characters in common: a broadly oval shape; acute to narrowly rounded base; narrowly rounded apex; 11–14 pairs of parallel secondary veins that, at the base, typically have a concave curvature towards the base; widely spaced percurrent nervilles; camptodrome secondary veins that loop close to the margin; one series of tertiary loops; an entire margin; and short (less than 0.2 cm) petiolules. In *Nyssa* and particularly in *N. aquatica* with which *N. japonica* was compared, the leaves typically have a petiole more than 2 cm long, widely spaced and undulating secondary veins, and at least two series of tertiary loops. All the variations shown by the Japanese material can be matched in a suite of leaves from locality 9844. Although the epithet "*aniensis*" is cited on page 132 of Tanai and Suzuki (1963), the epithet is not validated until page 205 of Huzioka (1963). The epithet "*japonica*" thus takes priority because it was first validated on page 146 of Tanai and Suzuki (1963).

Cladrastis japonica resembles the extant *C. lutea* in shape of leaflets and gross venation pattern. The primary difference between the two species is in the ultimate venation; the areoles in *C. lutea* leaflets are 0.4–0.5 mm across and are intruded by unbranching or once-branching veinlets. The Chuitna River specimens of *C. japonica* have areoles that are 0.5–0.7 mm across and are intruded by once- or twice-branching veinlets.

Occurrence: Seldovian: 9845. Homerian: 9361?, 9844.
Hypotype: USNM 42223.

ACERACEAE

Acer ezoanum Oishi and Huzioka

Plate 8, figure 6

Acer ezoanum Oishi and Huzioka, 1943, Hokkaido Imperial Univ, Fac. Sci. Jour., ser. 4, v. 7, p. 89, pl. 10, figs. 1–4; pl. 11, figs. 1–4; pl. 12, fig. 2.
Tanai and Suzuki, 1960, Hokkaido Univ. Fac. Sci. Jour., ser. 4, v. 10, p. 556, pl. 1, figs. 1, 2; pl. 2, figs. 1, 2; pl. 3, figs. 1–4; pl. 9, figs. 20–25. (See synonymy.)

Discussion.—The occurrence of *Acer ezoanum* in Alaska is noteworthy because of its common occurrence in early and middle Miocene floras in Japan. Many of the Japanese fossils referred to this species have been described and illustrated, and the Alaskan material falls well within the ranges of variation ascribed to *A. ezoanum.* Many of the Aaskan leaves have rudimentary sixth and seventh lobes, but some of the Japanese specimens figured by Tanai and Suzuki also have this feature.

Occurrence: Seldovian: 9848, 9858.
Hypotype: USNM 42224.

CORNACEAE

Cornus sp.

Plate 8, figure 1

Discussion.—The Kenai fossils may be conspecific with Tanai's *Neolitsea japonica* (Tanai, 1961, p. 337), but neither his figure nor description are adequate for comparison. The Kenai material is not Lauraceae, as indicated by the thin obcurrent nervilles. The profusely branching, freely ending veinlets, numerous intersecondaries, few secondaries, and nervilles typically perpendicular to the midrib indicate a close relationship to several extant species of *Cornus.*

Occurrence: Homerian: 9361, 9844, 9868.
Specimen: USNM 42221.

ERICACEAE

Rhododendron weaveri (Hollick) Wolfe, new combination

Plate 8, figures 7, 8

Lepargyraea weaveri Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 155, pl. 93, fig. 5.
Benzoin antiquum auct. non Heer. Hollick, 1936 [part], U.S. Geol. Survey Prof. Paper 182, p. 110, pl. 65, fig. 5.

Discussion.—The holotype of *Rhododendron weaveri* is not well preserved, but from its characteristics, it appears to be conspecific with the material of *Rhododendron* from the Chuitna River Homerian. On the basis of the often obovate shape, high angle of departure of the secondary veins, and the uniformly conspicuous secondary loops, *R. weaveri* is referrable to the subgenus *Azalea.*

The fossil species most similar to *Rhododendron weaveri* is "*Vaccinium*" *sophoroides* (Berry) Brown from the middle Miocene Latah Formation of Washington. The Alaskan leaves are typically more linear and have more numerous secondaries than *V. sophoroides*, which should be referred to *Rhododendron.*

Occurrence: Homerian: 4131, 9844, 9853.
Hyptotypes: USNM 42227, 42228.

Vaccinium homerensis Wolfe, new name

Plate 8, figure 5

Grevillea alaskana Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 111, pl. 30, figs. 3–5.
Elaeocarpus alaskensis Hollick, 1936, U.S. Geol. Survey Prof. Paper 182, p. 143, pl. 80, fig. 5.
Benzoin antiquum auct. non Heer. Hollick, 1936 [part], U.S. Geol. Survey Prof. Paper 182, p. 119, pl. 65, figs. 2–4.

Discussion.—The irregularity of secondary venation, presence of some nervilles that parallel the midrib, and coriaceous texture indicate that these leaves are representatives of either *Ledum* or *Vaccinium.* In the former genus, the leaves have a pronounced marginal roll toward the underside, but this character is lacking in the fossils. Hence, these fossils are transferred to *Vaccinium.*

The epithet *alaskensis*, an orthographic variant of *alaskana*, has been used previously in *Vaccinium;* hence a new name is proposed.

Occurrence: Homerian: 4131, 5821, 9361, 9844, 9853.
Hypotype: USNM 42229.

FOSSIL-PLANT LOCALITIES

Description of some fossil-plant localities in the Chickaloon Formation

USGS Paleobotany locality	*Description of locality, collector, and year (if known)*
5892	Lat 61°40.3′ N., long 149°03.5′ W. North side of Alaska Railroad cut on north side of Matanuska River. About 1,500 ft above base of formation. Anchorage (C–6) quad. Martin, 1910; Hopkins and Wolfe, 1962.
9870	Lat 61°42.6′ N., long 149°05′ W. At new cut at old Baxter mine on east side of Moose Creek valley. Premier coal group. Anchorage (C–6) quad. Hopkins and Wolfe, 1962.
9871	Lat 61°45.2′ N., long 148°52.9′ W. Hanging wall of strip pit topographically high in Mrak mine. Stratigraphically below 9872. Anchorage (D–6) quad. Hopkins and Wolfe, 1962.
9872	Lat 61°44.9′ N., long 148°53.5′ W. Hanging wall of strip pit topographically lower than 9871 in Mrak mine. Stratigraphically above 9871. Anchorage (C–6) quad. Hopkins and Wolfe, 1962.
9873	Lat 61°44.8′ N., long 148°52.8′ W. Hanging wall of strip pit topographically lower than 9872 in Mrak mine. Stratigraphically above 9872. Anchorage (C–6) quad. Hopkins and Wolfe, 1962.
9874	Lat 61°38.3′ W., long 148°57.5′ W. West side of valley of Wolverine Creek. Anchorage (C–6) quad. Hopkins and Wolfe, 1962.
9877	Lat 61°48.0′ N., long 147°59.5′ W. North side of cut along old Glenn Highway. Anchorage (D–3) quad. Hopkins and Wolfe, 1962.
9881	Lat 61°44.4′ N., long 148°57.5′–148°58.4′ W. Collections from dumps of strip pits in Evan Jones mine. Between Premier (No. 5) and Jonesville (No. 3) coal groups. Anchorage (C–6) quad. Hopkins and Wolfe, 1962.

Description of megafossil-plant localities in the Kenai and Tsadaka Formations

USGS Paleobotany locality	*Description of locality, stage assignment, and collector and year (if known)*
3505	Chinitna Bay, near entrance to bay on north side. From sandstone at top of exposure above conglomerate. Seldovian(?). Stanton and Martin, 1904.
4129	At entrance to Troublesome Gulch. Seldovia (C–5) quad. Homerian. Weaver, 1906.
4130	0.5 mile south of town of Old Tyonek on sea cliff. Tyonek (A–4) quad. Homerian. Weaver, 1906.
4131	Near entrance to Fritz Creek, Kachemak Bay. Seldovia (C–4) quad. Homerian. Weaver, 1906.
5820	Bluff Point, 7 miles west of Homer, "30 ft. below Bradley coal" according to the specimen label, but F. F. Barnes informs us that the Cooper coal bed is the only named coal bed present at Bluff Point. Seldovia (C–5) quad. Homerian. Stone and Stanton, 1904.
5821	Talus on beach at Bluff Point about 1½ miles west of Cook Inlet Coal Field Company's mine. Seldovia (C–5) quad. Homerian. Stone and Stanton, 1904.
6061	2.5 miles southwest of Point Naskowhak. Seldovia (B–5) quad. Seldovian. Martin, 1911.
6063	From Cache Creek, 1.5 miles above Cache Creek Mining Company's camp. Talkeetna (B–2) quad. Seldovian. Capps, 1911.
6066	Mills Creek Basin, Chicago Gulch. Talkeetna (B–4) quad. Seldovian. Capps, 1911.
8380	Lat 61°41′ N., long 149°08′ W. Core material. Anchorage (C–6) quad. Seldovian. Waring and Davidson, 1932.
9359	Lat 61°42.1′ N., long 149°05.6′ W. West side of Tsadaka Canyon. Anchorage (C–6) quad. Seldovian. Barnes, Bender, and Brown, 1955; Hopkins and Wolfe, 1962.
9360	Lat 60°01.8′ N., long 151°42.1′ W. 0.75 mile south of mouth of Deep Creek. Kenai (A–5) quad. Clamgulchian. Bender and Brown, 1955.
9361	Lat 59°39.4′ N., long 151°26.3′ W. Sea cliff about 1 mile south of Millers Landing. Seldovia (C–4) quad. Homerian. Barnes, Bender, and Brown, 1955; Wolfe, 1962.
9364	Lat 61°39.8′ N., long 149°27.9′ W. On Coal Creek. Anchorage (C–7) quad. Seldovian. Barnes, Bender, and Brown, 1955.
9365	Lat 61°38.4′ N., long 149°50.8′ W. In Houston strip pit. Anchorage (C–8) quad. Seldovian. Barnes and Brown, 1955; Hopkins and Wolfe, 1962.
9366	Lat 59°40.3′ N., long 151°42.4′ W. 0.25 mile northwest of mouth of Diamond Creek. Seldovia (C–5) quad. Homerian. Bender and Brown, 1955.
9760	0.25 mile west of southern tip of Redoubt Point. Kenai (B–6) quad. Seldovian. Gulf Oil Corp.
9761	Cape Douglas. Afognak quad. Seldovian. Gulf Oil Corp.
9763	Lat 60°11.5′ N., long 150°28.5′ W. Sea Cliff north of Ninilchik. Clamgulchian. Gulf Oil Corp.
9844	Lat 61°07.1′ N., long 151°18.1′ W. South bank of Chuitna River. Tyonek (A–4) quad. Homerian. Barnes, 1961; Wolfe, 1962.
9845	Lat 61°18.9′ N., long 151°46.2′ W. Cliffs on south side of Capps Glacier. Tyonek (B–5) quad. Seldovian. Wolfe, 1962.
9846	Lat 61°16.7′ N., long 151°45.1′ W. West side of high hill. Tyonek (B–5) quad. Seldovian. Barnes, 1961; Wolfe, 1962.
9848	Lat 61°14.2′ N., long 151°14.7′ W. South bank of Beluga River. Tyonek (A–4) quad. Seldovian. Wolfe, 1962.

9849---------- Lat 61°15.1′ N., long 151°14.4′ W. North bank of Beluga River. Tyonek (B–4) quad. Seldovian. Wolfe, 1962.

9850---------- Lat 61°25.6′ N., long 151°31.2′ W. East bank of Coal Creek. Tyonek (B–5) quad. Seldovian. Wolfe, 1962.

9851---------- Lat 59°38.6′ N., long 151°35.1′ W. In sea cliffs west of Homer. Seldovia (C–5) quad. Homerian. Wolfe, 1962.

9852---------- Lat 59°43.2′ N., long 151°49.4′ W. ¼ mile south of Mutnala Gulch in sea cliffs. Seldovia (C–5) quad. Homerian. Wolfe, 1962.

9853---------- Lat 59°40.9′ N., long 151°22.6′ W. Just west of mouth of Fritz Creek. Seldovia (C–4) quad. Homerian. Wolfe, 1962.

9854---------- Lat 59°45.1′ N., long 151°10.2′ W. ⅓ mile west of mouth of Eastland Creek. Seldovia (C–4) quad. Clamgulchian. Wolfe, 1962.

9855---------- Lat 59°44.0′ N., long 151°12.4′ W. ¼ mile west of mouth of Cottonwood Creek. Seldovia (C–4) quad. Clamgulchian. Wolfe, 1962.

9856---------- Lat 59°23.7′ N., long 151°53.7′ W. North side of Coal Cove on Port Graham, probably the "Sinus Anglorum" (English Bay) locality of Heer. Seldovia (B–6) quad. Seldovian. Hopkins, Schmidt, and Wolfe, 1962.

9857---------- Lat 59°25.0′ N., long 151°53.1′ W. 0.6 mile south of Point Pogibshi. Seldovia (B–6) quad. Seldovian. Hopkins, Schmidt, and Wolfe, 1962.

9858---------- Lat 59°28.3′ N., long 151°40.6′ W. 0.7 mile east of Seldovia Point. Seldovia (B–5) quad. Seldovian. Hopkins, Schmidt, and Wolfe, 1962.

9859---------- Lat 59°49.2′ N., long 151°07.4′ W. East bank of Swift Creek. Seldovia (D–4) quad. Clamgulchian. Hopkins and Wolfe, 1962.

9860---------- Lat 60°15.2′ N., long 151°23.5′ W. Sea Cliffs 0.9 mile north of Clam Gulch. Kenai (B–4) quad. Clamgulchian. Hopkins and Wolfe, 1962.

9861---------- Lat 60°15.7′ N., long 151°23.3′ W. Sea Cliffs 1.5 miles north of Clam Gulch. Kenai (B–4) quad. Clamgulchian. Hopkins and Wolfe, 1962.

9862---------- Lat 60°12.5′ N., long 151°25.5′ W. Sea Cliffs 2.4 miles south of Clam Gulch. Kenai (A–4) quad. Clamgulchian. Hopkins and Wolfe, 1962.

9863---------- Lat 61°19.1′ N., long 149°36.5′ W. South bank of Eagle River. Anchorage (B–7) quad. Seldovian. Hopkins and Wolfe, 1962.

9864---------- Lat 61°18.7′ N., long 149°34.8′ W. South bank of Eagle River. Anchorage (B–7) quad. Seldovian. Hopkins and Wolfe, 1962.

9865---------- Lat 61°39.4′ N., long 149°27.8′ W. North bank of Little Susitna River. Anchorage (C–7) quad. Seldovian. Hopkins and Wolfe, 1962.

9866---------- Lat 61°41.7′ N., long 149°14.7′ W. West bank of Little Susitna River. Anchorage (C–6) quad. Seldovian. Hopkins and Wolfe, 1962.

9867---------- Lat 62°29.4′ N., long 150°58.7′ W. South side of Cache Creek opposite mouth of Rambler Creek. Talkeetna (B–2) quad. Seldovian. Hopkins and Wolfe, 1962.

9868---------- Lat 62°29.9′ N., long 150°56.9′ W. South side of Cache Creek. Talkeetna (B–2) quad. Homerian. Hopkins and Wolfe, 1962.

9883---------- Near mouth of Happy Creek. Seldovia (D–5) quad. Clamgulchian. Benninghof, 1955.

9884---------- North of Harriet Point. Sec. 13, T. 5 N., R. 18 W. Kenai (C–6) quad. Seldovian. Shell Oil Co.

9885---------- North of Harriet Point. Sec. 25, T. 5 N., R. 18 W. Kenai (B–6) quad. Seldovian. Shell Oil Co.

9886---------- North of Harriet Point. Sec. 15, T. 4 N., R. 18 W. Kenai (B–6) quad. Seldovian. Shell Oil Co.

9887---------- Near Redoubt Point. Sec. 33, T. 3 N., R. 18 W. Kenai (B–6) quad. Seldovian. Shell Oil Co.

9937---------- Lat 61°18.4′ N., long 151°46.5′ W. Cliffs on south side of Capps Glacier. Tyonek (B–5) quad. Seldovian. British Petroleum Co., 1962.

9945---------- On Harriet Creek, 21.85 miles east and 30.15 miles north of southwest corner of Kenai, 1 : 250,000 quad. Kenai (B–6) quad. Seldovian. Mobil Oil Co.

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[Italic numbers indicate major references and descriptions]

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PLATES 1–8

PLATE 1

[All figures natural size]

FIGURE 1. *Carya antiquora* Newberry. (p. B8).
Hypotype, USNM 42183; loc. 9881.

2. *Cocculus flabella* (Newberry) Wolfe. (p. B9).
Hypotypes, USNM 42282, 42286; loc. 9881.

3. *Trochodendroides serrulata* (Ward) Wolfe. (p. B10).
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4. *Dicotylophyllum richardsoni* (Heer) Wolfe. (p. B12).
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5. *Dennstaedtia americana* Knowlton. (p. B8).
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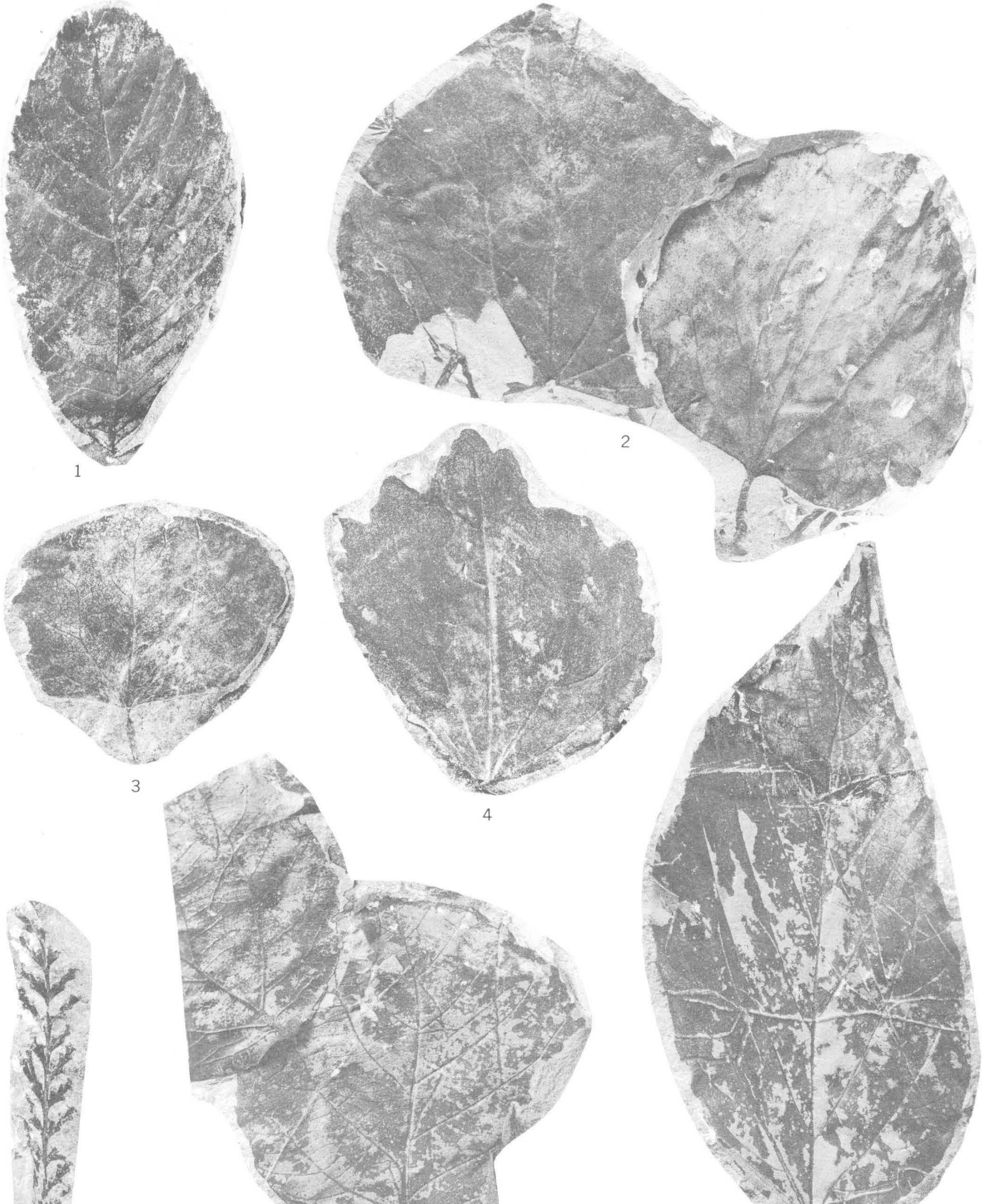
Hypotypes, USNM 42283, 42284; loc. 9870.

7. *Hamamelites inaequalis* (Newberry) Brown. (p. B10).
Hypotype, USNM 42188; loc. 9870.



FLORA OF THE CHICKALOON FORMATION

PLATE 2

[All figures natural size]

FIGURE 1. *Dicotylophyllum flexuosa* (Newberry) Wolfe. (p. B11).
Hypotype, USNM 42191; loc. 9881.

2. *Dicotylophyllum alaskana* (Hollick) Wolfe. (p. B11).
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3. "*Sapindus*" *affinis* Newberry. (p. B11).
Hypotype, USNM 42189; loc. 9881.

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5. "*Planera*" *microphylla* Newberry. (p. B9).
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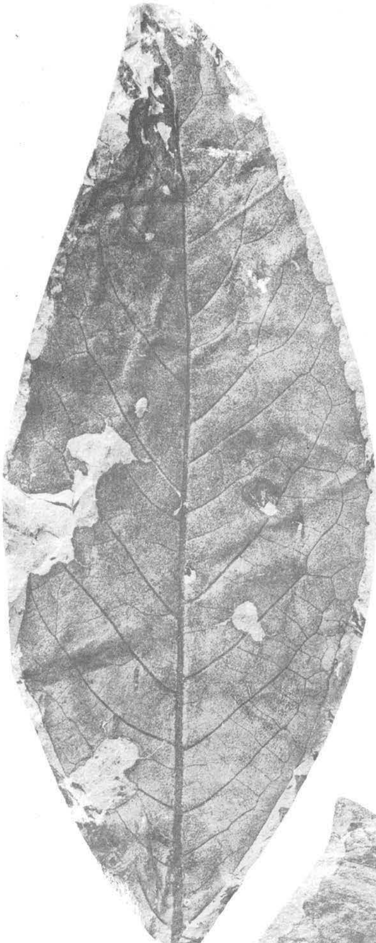

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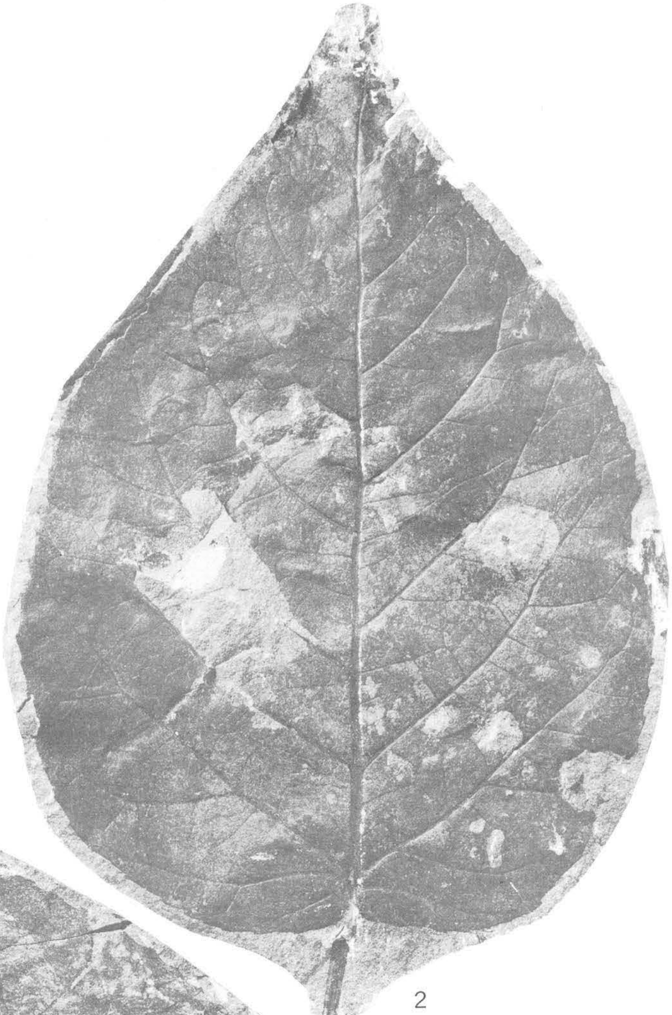

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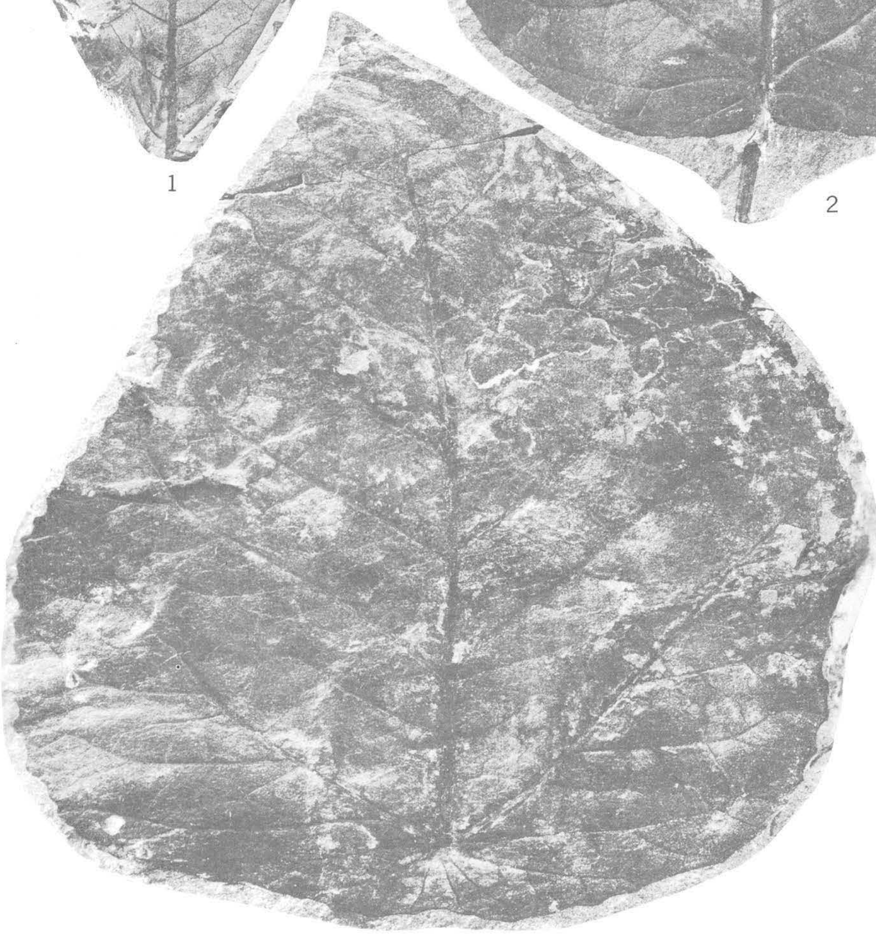

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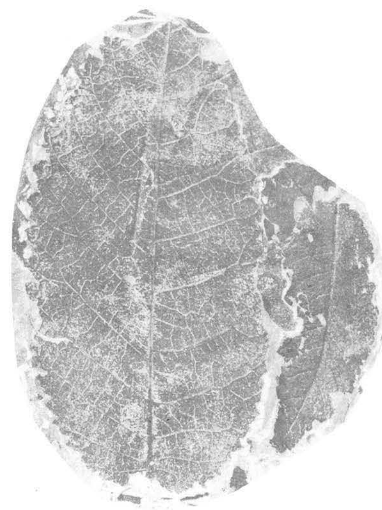

5

FLORA OF THE CHICKALOON FORMATION

PLATE 3

[All figures natural size]

FIGURE 1. *Populus kenaiana* Wolfe. (p. B12).
Hypotype, USNM 42264; loc. 9858.

2. *Salix confirmata* (Hollick) Wolfe. (p. B14).
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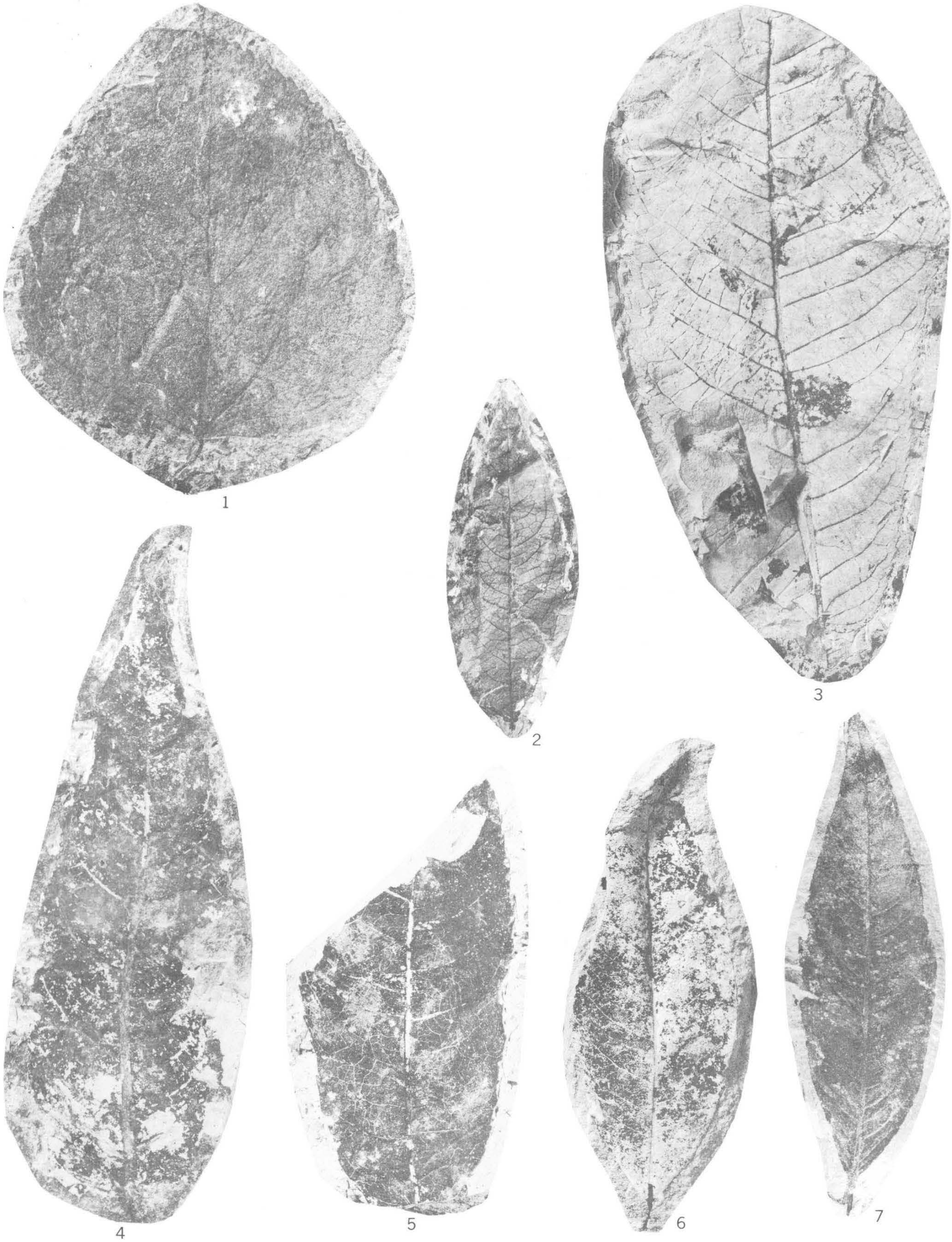

FLORA OF THE KENAI FORMATION

PLATE 4

[All figures natural size]

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1. Holotype, USNM 42200; loc. 9844.
2. Paratype, USNM 42201; loc. 9844.

3, 4, 8. *Salix kachemakensis* Wolfe. (p. B14).
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4. Paratype, USNM 42196; loc. 9853.
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5. *Salix alaskana* Hollick. (p. B13).
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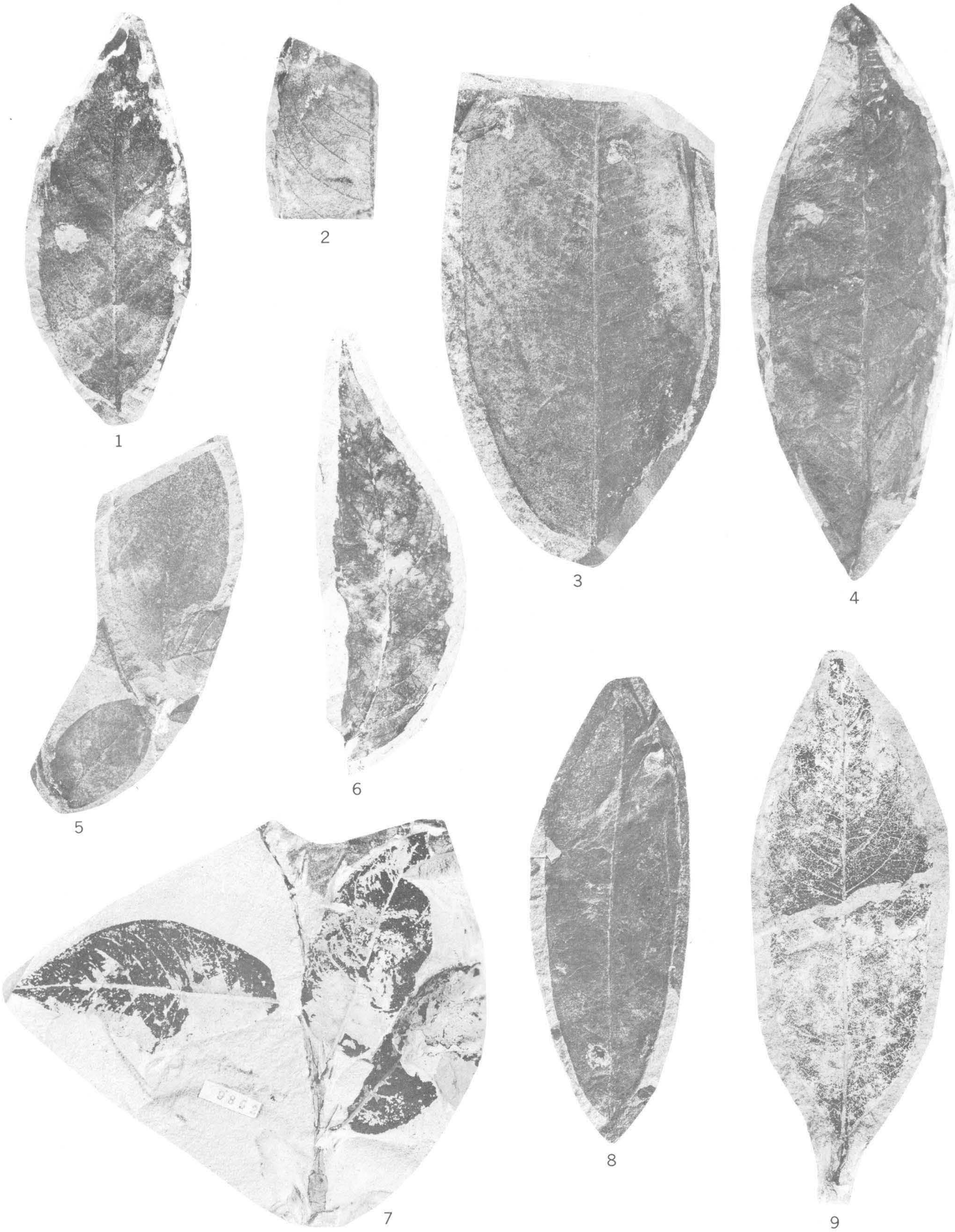

FLORA OF THE KENAI FORMATION

PLATE 5

[All figures natural size]

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Holotype, USNM 42003; loc. 9862.

2, 6. *Corylus chuitensis* Wolfe. (p. B23).
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3, 4. *Alnus evidens* (Hollick) Wolfe. (p. B18).
3. Hypotype, USNM 42275; loc. 9359.
4. Hypotype, USNM 42276; loc. 9887.

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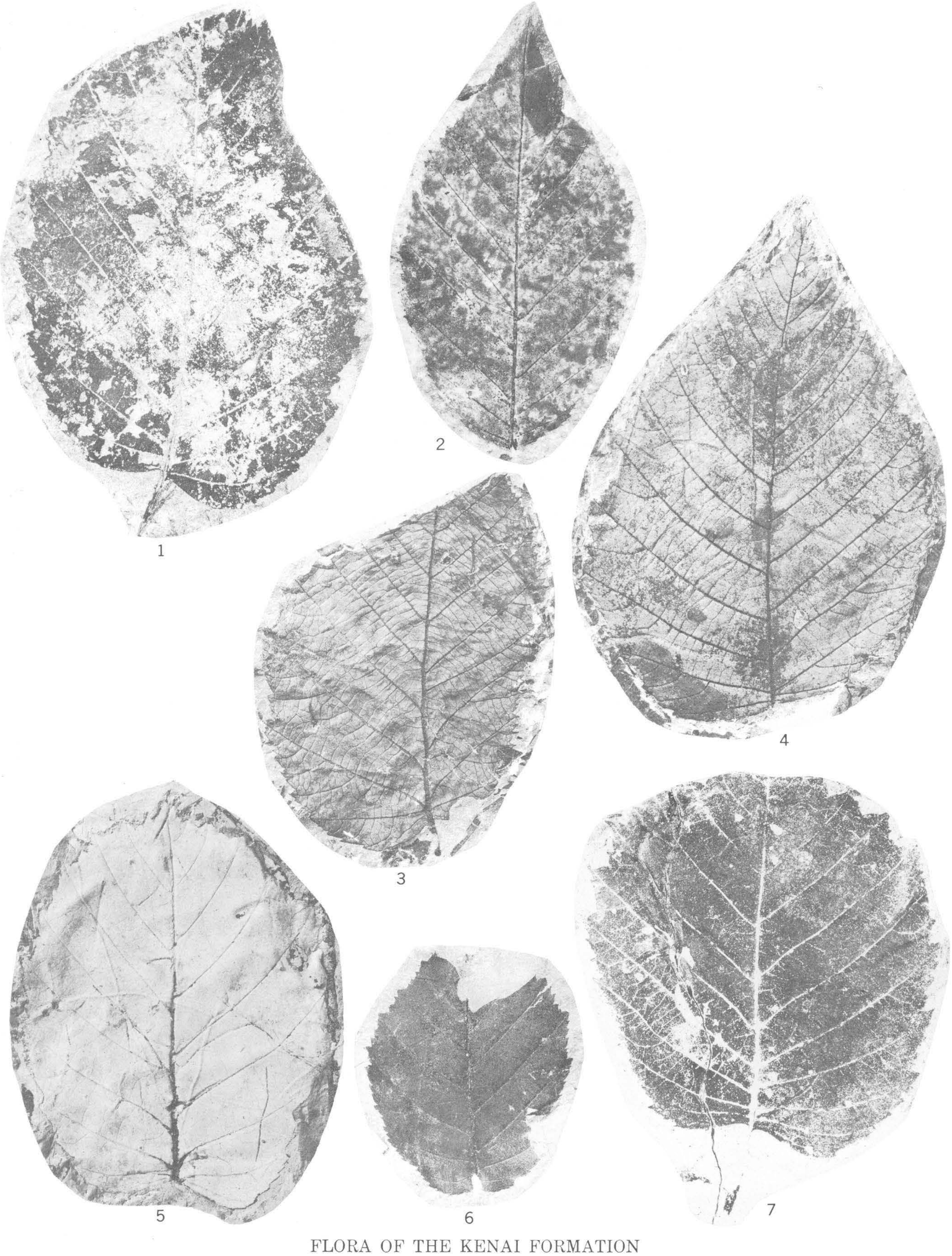
5. Paratype, USNM 42277; loc. 9845.
7. Holotype, USNM 42202; loc. 9845.



FLORA OF THE KENAI FORMATION

PLATE 6

[All figures natural size]

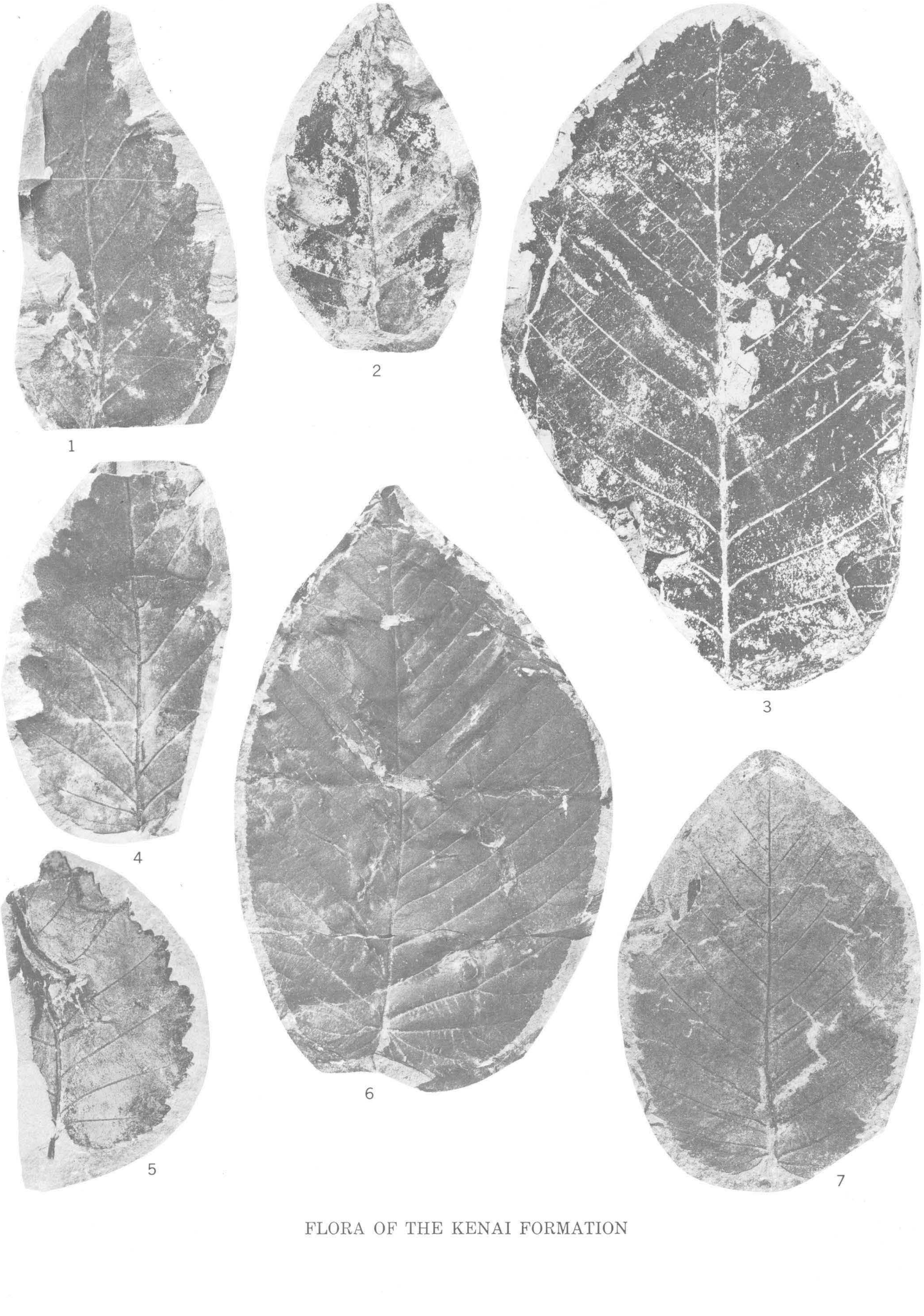
FIGURES 1, 4. *Alnus cappsi* (Hollick) Wolfe. (p. B19)
1. Hypotype, USNM 42205; loc. 9365.
4. Hypotype, USNM 42206; loc. 9365.

2, 5. *Alnus corylina* Knowlton and Cockerell. (p. B19)
Hypotypes, USNM 42208, 42207; loc. 9844.

3. *Carpinus cappsensis* Wolfe. (p. B22)
Holotype, USNM 42213; loc. 9845.

6. *Carpinus seldoviana* Wolfe. (p. B23).
Holotype, USNM 42212; loc. 9858.

7. *Carpinus cobbi* Wolfe. (p. B23).
Holotype, USNM 42214; loc. 9361.



FLORA OF THE KENAI FORMATION

PLATE 7

[All figures natural size]

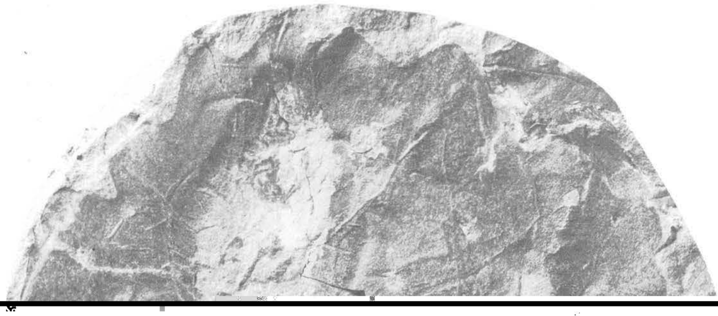
FIGURE 1. *Cocculus auriculata* (Heer) Wolfe. (p. B24).
Hypotype, USNM 42278; loc. 9858.

2, 6. *Alnus cappsi* (Hollick) Wolfe. (p. B19).
2. Hypotype, USNM 42259; loc. 9365.
6. Hypotype, USNM 42260; loc. 9365.

3. *Alnus fairi* (Knowlton) Wolfe. (p. B17).
Hypotype, USNM 42210; loc. 9365.

4. *Alnus healyensis* Wolfe. (p. B17).
Hypotype, USNM 42209; loc. 9850.

5. *Alnus largei* (Knowlton) Wolfe. (p. B16).
Hypotype, USNM 42211; loc. 9850.



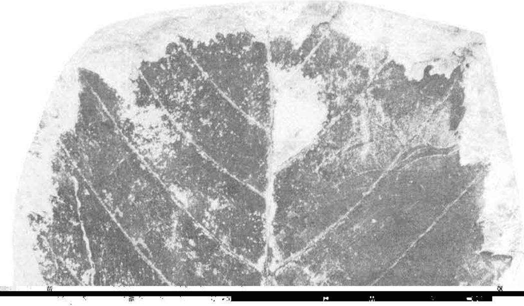
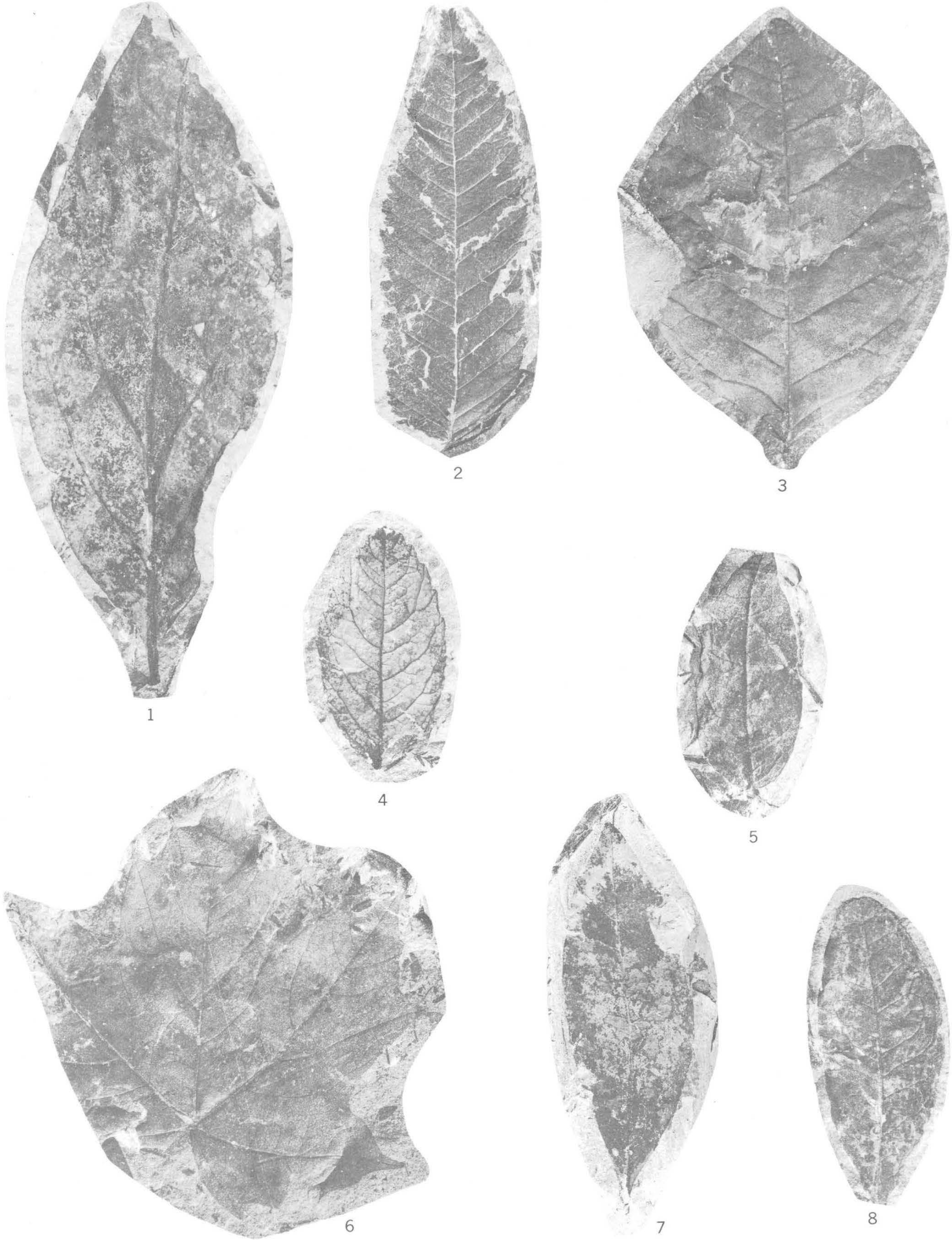


PLATE 8

[All figures natural size]

FIGURE 1. *Cornus* sp. USNM 42221; loc. 9844. (p. B25).
2. *Spiraea hopkinsi* Wolfe. (p. B24).
Holotype, USNM 42225; loc. 9361.
3. *Cladrastis japonica* (Tanai and Suzuki) Wolfe. (p. B24).
Hypotype, USNM 42223; loc. 9844.
4. *Spiraea weaveri* Hollick. (p. B24).
Hypotype, USNM 42222; loc. 9366.
5. *Vaccinium homerensis* Wolfe. (p. B25).
Hypotype, USNM 42229; loc. 9844.
6. *Acer ezoanum* Oishi and Huzioka. (p. B25).
Hypotype, USNM 42224; loc. 9858.
7, 8. *Rhododendron weaveri* (Hollick) Wolfe. (p. B25).
Hypotypes, USNM 42227, 42228; loc. 9844.



FLORA OF THE KENAI FORMATION