Late Tertiary florule from the Douglass Creek Basin western Montana

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The University of Montana
A Late Tertiary Florule from the Douglass Creek Basin, Western Montana

by

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Approved by:

[Signatures]

Chairman, Board of Examiners

Dean, Graduate School

Date

May 25, 1972
ACKNOWLEDGEMENTS

The author is indebted to Dr. C. N. Miller, University of Montana, for his guidance and for supplying the bulk of the specimens; to Dr. J. A. Wolfe, U. S. G. S., for his help in identifications; to Dr. D. Alt, Dr. J. R. Habeck, and Dr. R. L. Konizeski, all University of Montana, for their criticism of the manuscript; and to Miss Elrena Erickson for typing the manuscript.
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<tr>
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</tr>
</tbody>
</table>
CHAPTER I

INTRODUCTION

Many Tertiary floras from the western United States have been reported, but few are located in the Rocky Mountain region. Most of the floras described have been from the basin-range province to the west, which had relatively uniform topography and climate prior to the uplift of the Cascades and Coast ranges.

This paper describes a late Tertiary florule from the Douglass Creek Basin in western Montana as interpreted from plant megafossils preserved as impressions in a coarse matrix. Specimens collected for this study were made by Dr. C. N. Miller, University of Montana, and Dr. H. F. Becker, The New York Botanical Garden, in the summer of 1967. Further collections were made by the author in the summer of 1971.

The florule was originally thought to be lowermost Oligocene (Chadronian) in age based on vertebrate and invertebrate evidence (Konizeski, 1961), but leaf margin analysis and comparison with other Tertiary Floras indicate a middle Oligocene to middle Miocene age for the florule since they represent cooler conditions than are thought to have existed during early Oligocene time.
CHAPTER II

PHYSICAL AND GEOLOGICAL ASPECTS OF THE DOUGLASS CREEK BASIN

Physical Aspects

The Douglass Creek Basin lies in Powell County in western Montana, about 8 miles northeast of Drummond (Fig. I). The basin is bordered by the Garnet Range on the west and south and by the continental divide about 25 miles to the east. The area is drained by Douglass, Sturgeon, Murray, Spring, Bear, Sheep, and Morris Creeks (Fig. II) which eventually unite with the Blackfoot and Clark Fork Rivers. The Douglass Creek Basin, itself, has an area of approximately 20 square miles and the altitude ranges from 5200 feet to 4550 feet at the drainage exit. In addition, irregular mountain slopes rise up to 1000 feet above the valley floor.

The present climate of the Douglass Creek Basin is semi-arid with mesic vegetation in the bottoms of the stream beds. The basin has an average growing season of 70 days with an average annual precipitation of about 17 inches--mostly in the winter as snow (Konizeski, 1961). Vegetation today on the upper and poorly drained slopes consists mainly of *Pseudotsuga menziesii* and small patches of *Populus tremuloides* on the more mesic upland slopes and hollows. Between the uplands and lower slopes is a zone of *Pinus ponderosa*, *Pseudotsuga*, and *Juniperus sp.* The well drained slopes, the majority of the basin, are covered by *Artemesia sp.* and various grasses. The bottomland vegetation consists mainly of *Populus tremuloides*, *P. trichocarpa*, and *Salix sp.*
Geological Aspects

From Precambrian to early upper Cretaceous times various sedimentary and igneous rocks were laid down, which now form the basement complex of the region. At early upper Cretaceous time the beds that had been deposited were thrust into great folds trending northwest to southeast and then granitic intrusions invaded the sedimentary strata. The surface was then thoroughly eroded. Subsequent structural stress, forming numerous depressions, was accompanied by general volcanic activity (Pardee, 1913). The primary volcanic activity consisted of extrusive lavas that filled the lower portions of the basins, remnants of which still exist in one part of the Douglass Creek Basin, and later eruptions covered the area with volcanic ash, which was washed into the valleys and deposited there. Deposition continued evidently well into Miocene time. At the end of this epoch the area was uplifted into a plateau with an approximate altitude of 7000 feet (Pardee, 1913) warping the deposits into broad synclines and monoclines. These beds dip generally, but not always, toward the centers of the basins (Pardee, 1913). The more severely deformed beds exhibit numerous small normal faults, while the less deformed beds exhibit few if any faults.

With this uplift, the rejuvenated streams rapidly eroded into the softer volcanic rocks and established their present channels. During the Pleistocene the Tertiary rocks were covered with a layer of alluvial gravel which now forms a thin veneer over the Tertiary basin fill in most places.
The valley fills are considered to be mainly Oligocene and Miocene in age by Pardee (1913) and of Oligocene age by Konizeski (1961) based on vertebrate and invertebrate evidence found at the base of the section in the Douglass Creek Basin. Work in southwest Montana (Kuenzi and Fields, 1971; Kuenzi and Richards, 1969) has determined that the basin fill sediments there are of Oligocene and Miocene-Pliocene age with an unconformity between the Oligocene sediments and the Miocene-Pliocene sediments. Due to the lack of evidence of this unconformity at the Douglass Creek Basin, I feel that the evidence from there cannot be extrapolated to the Douglass Creek Basin. However, their ages coincide with those given by Pardee and Konizeski. Rather than being of one age, however, these beds probably are time continuous and overlap two or more epochs.
CHAPTER III

FOSSIL LOCALITIES

The fossils were collected from two roadcuts along Montana highway 271 approximately 8 miles northeast of Drummond, Montana. The sites are in the southeast corner of Sec. 3, T 12 N, R 12 W, near the extreme south end of the basin near the headwaters of Sturgeon Creek (Fig. II). These correspond to Konizeski's (1961) fossil site number 5.

The plants are preserved in a reworked volcanic ash that was deposited in an apparent lacustrine environment. The beds range from blocky to thinly bedded to paper shale. Most of the fossils occurred in the blocky material with very few good specimens occurring in the thinly bedded material. The latter contains large numbers of ostracods and gastropods, which in some places make up the bulk of the rock. The beds dip south at approximately 20-25 degrees. Petrographic studies indicate the shales are made up of mainly montmorillonite clay with kaolinite and mica making up minor fractions of the rock.

Konizeski's (1961) measurements of the beds at the fossil locality are given below:

<table>
<thead>
<tr>
<th>feet</th>
<th>inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Limestone, light gray, marly; contains fish scales and teeth, pelecypods, myriad ostracodes..........................</td>
<td>1 3</td>
</tr>
<tr>
<td>Shale, chocolate brown, calcareous, laminated; contains two gypsum beds, myriads of ostracodes......................</td>
<td>1 6</td>
</tr>
</tbody>
</table>
Clay, olive, unctuous, bentonitic;

constituents montmorillonite (90 percent), gypsum (10 percent),
quartz (? percent).................................0 7

Shale, yellow brown; contains rare

(1-2 inch) argillaceous beds and

one (1 inch) gypsum bed............................6 8

Limestone, light brown, marly, thin-bedded; contains abundant ostracodes,
some gastropods....................................0 11

Shale, yellow brown, laminated; con-

stituents mixed-layered (Illite-

montmorillonite) (85 percent),
calcite (13 percent), quartz (1 percent), gypsum (? percent).....................13 8

Shale, chocolate brown, laminated;

contains plants, abundant ostracodes..............1 0

Limestone, chocolate brown, marly,

petroliferous........................................0 3

Limestone lens, yellow brown..........................0 4

Shale, ferruginous, thin bedded......................0 7

(Total section 25 feet, 11 inches)
DOUGLASS CREEK BASIN

Morris to Drummond fossil sites

Tertiary volcanics

Fig. II

(after Konizeski, 1961)
CHAPTER IV

COMPOSITION OF THE DOUGLASS CREEK FLORULAE

Systematic List

TRACHEOPHYTA

SPHENOPSIDA

Equisetineae

Equisetaceae

Equisetum sp.

PTEROPSIDA

Gymnospermae

Pinaceae

Abies laticarpa MacGinitie
Abies longirostris Knowlton
Abies spp.
Picea lahontensis MacGinitie
Picea magna MacGinitie
Pinus florissanti Lesquereux
Pinus monticolensis Berry
Pinus wheeleri Cockerell
Pinus spp.

Taxodiaceae

Sequoia affinis Lesquereux

Angiospermae (Monocotyledoneae)

Typhaceae

Typha sp.
Cyperaceae

*Cyperacites cf. lacustris* MacGinitie

Angiospermae (Dicotyledoneae)

Betulaceae

*Alnus helmvillensis* n. sp.

*Alnus relata* (Knowlton) Brown

Fagaceae

*Fagus drummondensis* n. sp.

*Quercus consimilis* Newberry

*Quercus convexa* Lesquereux

Ulmaceae

*Zelkova oregoniana* (Knowlton) Brown

*Ulmus* sp.

Berberidaceae

*Mahonia limirivuli* Becker

*Mahonia* spp.

Saxifragaceae

*Ribes auratum* Becker

Rosaceae

*Cercocarpus antiquus* Lesquereux

*Cercocarpus milleri* n. sp.

*Rosa hilliae* Lesquereux

*Amelanchier scudder* Cockerell

Anacardiaceae

*Astronium truncatum* (Lesquereux) MacG.
This florule consists of 14 families, 21 genera, and 25 identifiable species.

Since many of the species were based on single or very few specimens no quantitative study was made. The bulk of the specimens were of various conifer remains, particularly seeds and needles, which are produced in large numbers and could conceivably result in an over-representation of these plants.
TABLE I

NUMERICAL REPRESENTATION OF GENERA AND SPECIES IN THE DOUGLASS CREEK BASIN

<table>
<thead>
<tr>
<th>Family</th>
<th>Genera</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pinaceae</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Rosaceae</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Fagaceae</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Betulaceae</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Ulmaceae</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Berberidaceae</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Aceraceae</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Saxifragaceae</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Anacardiaceae</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Lauraceae</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Taxodiaceae</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Typhaceae</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Cyperaceae</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Equisetaceae</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
CHAPTER V

ECOLOGICAL ASPECTS OF THE DOUGLASS CREEK FLORULE

Due to the small numbers of plants represented in the Douglass Creek florule, only general ecological relationships can be interpreted.

The florule can be roughly divided into five floral zones according to Becker (1961):

HYDROSERE
   Cyperacites cf. lacustris
   Equisetum sp.
   Typha sp.

FLOOD PLAIN
   Alnus velata
   Acer cf. florissantii
   Rosa hilliae
   Zelkova oregontiana

DECIDUOUS FOREST
   Astronium truncatum
   Quercus consimilis

CONIFEROUS FOREST
   Abies laticarpa
   Abies longirostris
   Picea lahontensis
   Picea magna
   Pinus monticolensis
   Pinus wheeleri
   Sequoia affinis
XERIC ASSOCIATION

*Cercocarpus antiquus*

*Quercus convexa*

*Ribes auratum*

*Mahonia limirivuli*

*Amelanchier scudder*

The floristic association with the emphasis on the hydrosere and flood plain, and coniferous forest associations suggests a relatively high altitude cool-temperate habitat (sensu Wolfe and Hopkins, 1967) with the xeric association possibly existing on the west and south facing slopes. From the considerations of the presumed topography and flora at the time of deposition one would be prone to consider that the conifers were dominant on the majority of the slopes with the xeric association on the drier south and west facing slopes, and the hydric and flood plain plants either on the lake edge or in the streams draining into the lake.

Comparison of the floral list with present floras (Table II) indicates strongly a cool-temperate climate such as exists in the region today with a temperature range similar to the present but probably more humid as indicated by *Abies*, *Picea*, and *Sequoia*.

These assumptions are based on very broad generalities and this point must be remembered as many factors can be involved in a plant getting from the place of growth to the basin of deposition. Since many species are based on one specimen, ecological assumptions for the whole area based on the evidence of one specimen are at the very best quite suspect.
TABLE II

COMPARISON OF THE DOUGLASS CREEK FLORULE WITH LIVING FLORAS

<table>
<thead>
<tr>
<th>Douglass Creek Species</th>
<th>Closest living relative</th>
<th>W. U.S.</th>
<th>E. U.S.</th>
<th>Sw. U.S.</th>
<th>S.E. U.S.</th>
<th>Asia</th>
<th>S. Mexico</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abies laticarpa</td>
<td>A. magnifica</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abies longirostris</td>
<td>A. venusta</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Picea lahontensis</td>
<td>P. engelmanni</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Picea magna</td>
<td>P. noveitichii</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pinus florissanti</td>
<td>P. ponderosa</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pinus monticolensis</td>
<td>P. monticola</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pinus wheeleri</td>
<td>P. strobiformis</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sequoia affinis</td>
<td>S. sempervirens</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alnus relata</td>
<td>A. maritima</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A. japonica</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quercus consimilis</td>
<td>Q. stenophylla</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quercus convexa</td>
<td>Q. engelmanni</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Melkoava oregoniana</td>
<td>Z. serrata</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mahonia limirivuli</td>
<td>M. fortunei</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Ribes auratum</td>
<td>R. aureum</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cercocarpus antiquus</td>
<td>C. betuloides</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rosa hilliae</td>
<td>R. palustris</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amelanchier scudderi</td>
<td>A. alnifolia</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Astronium truncaturn</td>
<td>A. fraxinifolia</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acer cf. florissanti</td>
<td>A. rubrum</td>
<td>X</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Lindera coloradica</td>
<td>L. benzoin</td>
<td>X</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

|                | 11 | 3 | 1 | 1 | 4 | 1 |

15
CHAPTER VI

AGE OF THE FLORULE

The Douglass Creek beds were treated as lowermost Oligocene (Chadronian) by Konizeski (1961) based on vertebrate and invertebrate evidence, but the plants indicate cooler conditions than are generally thought to have existed in early Oligocene time.

Comparison of the Douglass Creek florule with other Tertiary floras (Table III) reveals the greatest overlap with the Ruby Valley Paper Shale flora (65%), the Beaverhead Basin flora (55%), and the Florissant flora of Colorado (45%) which are of middle to late Oligocene in age. These percentages sinclude such genera as *Equisetum, Typha*, and *Cyperacites*, which are common to all three floras. The Douglass Creek florule has an average of 31% of its species in common with all the Oligocene floras (8 mainly middle to upper), 19% in common with all the Miocene floras (5), 9% in common with the Eocene floras (3), and 3% in common with the Pliocene floras (2) compared. Becker's (1961) "paleobotanical triangulation" method would place the florule in the middle Oligocene to middle Miocene range.

Further evidence for this age range comes from a comparison of percentages of entire margined leaves (Bailey and Sinnott, 1915, 1916). Entire margined leaves are characteristic of woody dicots living in tropical, xeric-temperate, and arctic regions, that is, in regions of physiological aridity for the plant during most of its growing season (Wolfe and Hopkins, 1967). Conversely, non-entire leaves are found in more humid floras. This method is particularly useful because there are
no taxonomic considerations; only the type of margin is considered. The Douglass Creek Basin florule has an entire margin leaf percentage of approximately 12.5% which represents cool-temperate conditions according to Wolfe and Hopkins (1967). By examining Wolfe and Hopkin's graph (Fig. III) we see that the early to middle Oligocene floras plotted have an average percentage of entire margined leaves of about 60%. This curve takes a drastic drop to 25-30% in the middle Oligocene and remains more or less constant (varying between 25-40%) through the lower Pliocene. Although the Douglass Creek percentage is well below these percentages, one possible explanation for the discrepancy is the fact that the Douglass Creek florule is probably an upland flora while the majority of the floras plotted are from the basin-range province and tend to be low altitude floras (i.e. Eastern Oregon, Eastern Washington, and Nevada). While the floras of the Florissant beds and the Ruby Valley Paper Shale beds were not plotted by Wolfe and Hopkins, they show a 45% and 25% entire margin percentages respectively which fit into this graph nicely and further demonstrate that the graph is applicable to Rocky Mountain floras as well as those further west.

The wide discrepancy between the 12.5% entire margin percentage for the Douglass Creek Basin and the 60% entire margin percentage for the lower Oligocene definitely excludes the Douglass Creek florule from the lower Oligocene and would again tend to place it in the middle Oligocene to middle Miocene range. Thus by the two methods, "paleobotanical triangulation" and leaf margin analysis, an age of middle Oligocene to middle Miocene is indicated. Lacking stratigraphic evidence, no further age delineation can be made.
<table>
<thead>
<tr>
<th>Eocene</th>
<th>Republic</th>
<th>Green River</th>
<th>Mormon Crk.</th>
<th>Beaverhead Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
<tr>
<td>Douglas Creek</td>
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</tr>
<tr>
<td>Species</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Equisetum sp.</td>
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<tr>
<td>Abies laticarpa</td>
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<tr>
<td>Abies longirostris</td>
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<tr>
<td>Abies spp.</td>
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<tr>
<td>Picea l.</td>
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<tr>
<td>Picea magna</td>
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<td>Pinus florissanti</td>
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<td>Pinus wheeleri</td>
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<td>Pinus monticolensis</td>
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<tr>
<td>Pinus spp.</td>
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<td>Sequoia affinis</td>
<td></td>
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<td>Typha sp.</td>
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<td>Cyperacites cf. lacustris</td>
<td></td>
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Species with entire-margined leaves

Paleocene
Eocene
Oligocene
Miocene

cool temperate
warm temperate
sub-tropical

Fig. III
(after Wolfe & Hopkins, 1967)
CHAPTER VII
SYSTEMATIC DESCRIPTIONS

Type specimens are deposited in the University of Montana Paleontological Collection (U. Mont. P.C.).

Div. TRACHEOPHYTA
Sub. Div. SPHENOPSIDA
Class Equisetineae
Fam. Equisitaceae
Genus *Equisetum* Linnaeus

*Equisetum sp.*

(Plate 1, figs. 4-5)

Two specimens of *Equisetum* were found at the Douglass Creek locality. One is a piece of a rhizome 1.0 cm. long with a branch 1.5 cm. long with grooved ridges and furrows. Pointed leaves are whorled at the nodes. The second specimen is a single unbranched stem 5.0 cm. long with leaves whorled at the nodes. Absence of more diagnostic material makes it inadvisable to assign a specific name to these specimens. *Holotype* U. Mont. P.C. #814, P.C. #815.
Abies laticarpa MacGinitie

(Plate 1, fig. 10)

A seed 1.0 cm. long and 4 mm. wide and apically acute is referred to this species. The wing is 7 mm. long and 8 mm. wide at its widest point. The seed is similar to those described by MacGinitie in 1933 except for the fact that the seed is slightly smaller overall.

These seeds are generally considered to be closely related to *Abies magnifica* Murr whose present distribution is identical to its fossil distribution except for a small portion. Hypotype: U. Mont. P.C. #828.

Abies longirostris Knowlton

(Plate 1, figs. 6-8)

The seeds are 7 mm. long and 3-4 mm. wide, apically acute and broadening distally. Wings are 7-8 mm. long and 8 mm. wide at the widest point. The wing is constricted slightly where it joins the seed body.
The Douglass Creek specimens are very similar to the material of Becker (1969) and MacGinitie (1953).

This fruit is considered to be most closely related to the living Abies venusta Douglas. This fossil Abies appears to have been widely distributed during the Tertiary. Hypotype: U. Mont. P.C. #829, P.C. #830, P.C. #831.

Abies sp.

(Plate 1, figs. 11-16)

Six needles ranging in size from 12-16 mm. long and 2 mm. wide (one large specimen, though incomplete, is 25 mm. long) are referable to the genus Abies, but no further delineation is possible. Holotypes: U. Mont. P.C. #832, P.C. #833, P.C. #834, P.C. #835, P.C. #861, P.C. #879.

Genus Picea Link

Picea lahontensis MacGinitie

(Plate 1, fig. 17)


The seeds found in the Douglass Creek basin are referable to those specimens shown in Becker (1961, pl. 5, fig. 40) and those shown in MacGinitie's Florissant material (1953). The seeds are broadly wedge shaped and are 8 mm. long and 4-5 mm. wide at the widest point. The wing broadens and is obliquely rounded. The seed body is 2-4 mm. long and 2 mm. wide. Hypotype: U. Mont. P.C. #829.
*Picea magna* MacGinitie


The seeds are oval and 3-4 mm. long and 2-3 mm. wide. The wings are 7-8 mm. long and 4-5 mm. wide and broadly rounded at the end. Though somewhat smaller than MacGinitie's (1953) specimens, they are quite comparable.

These "snub nosed" seeds are readily distinguished and are very widely found in the Tertiary floras of Idaho and Oregon. They are thought to be most closely related to the living *Picea noeveitchii* Masters now living in the mountains of China. *Hypotypes*: U. Mont. P.C. #836, P.C. #837, P.C. #838, P.C. #839.

Genus *Pinus* Linnaeus

*Pinus florissanti* Lesquereux


Seeds referable to *Pinus florissanti* were found in the Douglass Creek Basin. The seeds are 5 mm. long and 3 mm. wide and the seed and wing is 2.5 cm. long which agrees with MacGinitie's material. No leaves or cones were found.

MacGinitie feels that *P. florissanti* is extremely close to the living *P. ponderosa*. *Hypotypes*: U. Mont. P.C. #867, P.C. #868.
Pinus monticolaensis Berry

(Plate 1, figs. 24-25)

Pinus monticolaensis Berry, 1929. U.S. Geol. Survey Prof. Paper 154, p. 238, pl. 49, fig. 8 only.

Pinus latahensis Berry, 1929, U.S. Geol. Survey Prof. Paper 154, p. 238, pl. 49, fig. 7.

One fascicle of five needles was found with needle length of 36 mm. which compares favorably with Becker's material (1961, pl. 8, fig. 8) except for its shorter size. Some of the needles in the Douglass Creek material appear to have broken off and this could account for the shorter length.

One reason for placing this five needle fascicle in P. monticolaensis is that seeds referable to this species were also found in the Douglass Creek florule and therefore substantiate the presence of P. monticolaensis in the Douglass Creek Basin. The seed and wing is 18 mm. long and 6 mm. wide at the widest point. The seed body itself is 5 mm. long and 4 mm. wide and agrees favorably with Becker's (1961) material. Hypotypes:

Pinus wheeleri Cockerell

(Plate 1, figs. 22-23)


A fascicle of five needles with needle length of 31 mm. (incomplete) was found that is similar to MacGinitie's specimen (1933, pl. 18, fig. 11). The needles appear to be robust and the short shoot is pronounced.

MacGinitie feels that P. wheeleri is synonmous with P. monticolaensis and P. tulameenensis, but the author feels there is enough justification for keeping these as separate species.

A seed of P. wheeleri was found that is quite similar to those pictured in Becker (1969, pl. 6, figs. 22, 23). The nutlet is small (3 mm. long and 2 mm. wide) and the wing is long and narrow—15 mm. long and 5.5 mm wide. Hypotypes: U. Mont. P.C. #840, P.C. #841.

Pinus spp.

(Plate 1, figs. 29-32)

Species A: Whole and partial fascicles of Pinus were found with 2-3 needles per fascicle. The needles are up to 27 mm. and 0.5 mm. wide for a complete specimen. One incomplete specimen is 24 mm. long and 0.5 mm.
wide. They differ in length from Becker's specimens (1969, pl. 9, figs. 2, 9) and appear to be more delicate.

Species B: One fascicle containing 2 needles is 32 mm. (incomplete) and 2 mm. wide and appears quite robust. It bears close resemblance to MacGinitie's *Pinus wheeleri* except for the 2 needles, possible the other 2 needles were lost in transport.

Species C: A branch with many needles was found, but it is impossible to determine the number of needles per fascicle. It bears close resemblance to MacGinitie's *Pinus hirbeabi* except for its shorter length. It also appears close to *Pinus tulameenensis* Penhallow as pictured in Arnold (1955). Needles range in length from 25-35 mm. and small short shoots are evident on the stem of the specimen. *Holotypes:* U. Mont. P.C. #869, P.C. #870, P.C. #877, P.C. #871.
Fam. Taxodiaceae
Genus. *Sequoia* Endlicher

*Sequoia affinis* Lesquereux

(Plate 2, figs. 1-3)


*Glyptostrobus europaeus* Berry, (not Brongiart), U.S. Geol. Survey Prof. Paper 185, p. 103, (*Sequoia affinis* Lesquereux only), 1934.

*Sequoia affinis* Lesquereux by H. V. Smith, Amer. Midland Naturalist, vol. 25, p. 493, pl. 2, figs. 1, 6, 1941. --Chaney, Trans. Amer. Philos. Soc., new ser., vol. 40, pt. 3, p. 231, pl. 1, fig. 2; pl. 3, figs. 2-4; pl. 4, figs. 3, 4, 7; pl. 6, fig. 6; pl. 7, figs. 7-9;
pl. 8, figs. 10; pl. 12, figs. 3, 4. 1951.


The leaves are linear. The maximum length of the leaves is about 7-10 mm. Leaves are both appressed and apparently two ranked. Ovulate cones are small, ovoid, and about 1 cm. in diameter.

The Douglass Creek material is comparable for all intents and purposes with the material from Florissant. Both the leaves and cones are very similar. It is very difficult to distinguish sterile foliage of *Glyptostrobus* and *Sequoia*, but on the basis of cones, the author feels that the Douglass Creek material is *S. affinis*. *S. affinis* makes up the greatest number of specimens in the Douglass Creek florate. The distribution of *S. affinis* is widespread during the Oligocene and the reader is referred to Chaney's monograph on the fossil species of *Sequoia*, *Taxodium*, *Metasequoia*, and *Glyptostrobus*. (1951). Hypotypes: U. Mont. P.C. #855, P.C. # 872, P.C. #876.
Fam. Typhaceae

Genus. Typha Linnaeus

Typha sp.

(Plate 1, fig. 3)

Fossils representing Typha are represented by numerous impressions with parallel venation, ranging in size from 11 cm. long and 5 mm. wide to 4.5 cm. long and 3 cm. wide. The specimens are too poorly preserved to be assigned to the specific level. *Holotype:* U. Mont. P.C. #812.
Fam. Cyperaceae

Genus. Cyperacites Schimper

Cyperacites cf. lacustris MacGinitie

(Plate 1, fig. 9)


The specimens of Cyperacites found at Douglass Creek are comparable to the specimens found at Florissant. Most of them are small fragments, but fit within the sizes given by MacGinitie. Roots diverge from nodes which are 3-7 mm. apart. There are possibly more than one species represented here, but preservation is not sufficient to delineate them further. Hypotype: U. Mont. P.C. #813.
Fam. Betulaceae

Genus. *Alnus* Ehrhart

*Alnus relata* (Knowlton) Brown

(Plate 2, figs. 5-7)


The leaves are lanceolate to elliptical. The apices are acute to rounded (damaged?) and the base is slightly rounded. The blade is 4.2 - 4.5 cm. long and 1.8 - 2.0 cm. wide. The petiole is 0.8 cm. long. Six to seven pairs of secondary veins diverge at an angle of approximately 60° and curve toward the apex and are opposite to alternate. Tertiary venation is not preserved. Secondary veins enter the teeth directly where visible. The margin is serrate.

This species contains many forms of what appear to be a single species (Becker, 1961). The Douglass Creek specimens fit very well into the general description given by Becker (1961) for this species. Many specimens from the Douglass Creek Basin were preserved only sufficiently to be positively identified as *A. relata*, but only two or three were preserved sufficiently to be described and photographed.


*Alnus helmwillensis* sp. nov.

(Plate 2, fig. 4)

The leaf is obovate and approximately 3.5 cm. long and 2.3 cm. wide at the widest point. The petiole is 1.0 cm. long. The base is
acute and the margin is serrate with numerous teeth. The tip has been damaged, but appears to have been acute to rounded. Five pairs of secondary veins diverge alternately at an angle of about 50° and are craspedomous. Tertiary venation is not preserved. The midvein is robust as are the secondaries. Holotype: U. Mont. P.C. #851.
Fam. Fagaceae

Genus. *Quercus* Linnaeus

*Quercus consimilis* Newberry

(Plate 2, figs. 9-11, 13, 14; Plate 3, fig. 1)

1898. U.S. Geol. Surv. Mon. 31, p. 71, pl. 43, figs. 2-5.—Brown,

24, p. 285; pl. 6, fig. 2; pl. 7, figs. 3, 4; pl. 8, figs. 1-5;
pl. 9, figs. 4, 5; pl. 10, figs. 4, 5; pl. 17, fig. 1; pl. 20, fig. 5.

The Douglass Creek specimens are very similar to Beckers material
(1961, pl. 17, figs. 4-7) but tend to be 2-3 cm. shorter. They agree
in length with Graham's Sucker Creek flora (1965). The Douglass Creek
specimens range in length from 4-6.7 cm. while Becker's specimens are
generally in the 9-10 cm. range. Other than this size difference, the
Douglass Creek material is quite similar to the Ruby Valley material.

#821, P.C. #856.

*Quercus convexa* Lesquereux

(Plate 2, fig. 12; Plate 3, figs. 2, 4)

no. 2, 4, pl. 1, figs. 13-17; 1883. U.S. Geol. Surv. Terr. Rept.,
vol. 8, p. 265, pl. 45b, figs. 5, 6.—Axelrod, 1939. Carn. Inst. Wash.
Pub. 516, p. 95, pl. 7, figs. 3-7; 1950. Carn. Inst. Wash. Pub. 590,
The leaves are obovate to oblong. One entire specimen is 3.5 cm. long and 1.5 cm. wide at its widest point. The leaf base is acute to cuneate and the apex is obtuse to mucronate. The leaves have entire margins, pronounced midribs and the secondary veins are alternate to subopposite. These specimens are very similar to the Ruby Valley material of Becker (1961), but as in the case of *Quercus consimilis* are generally 1.0 to 2.0 cm. shorter. **Hypotypes:** U. Mont. P.C. #822, P.C. #823, P.C. #824.

*Fagus drummondensis* sp. nov.

(Plate 2, fig. 8)

The leaf of this species of *Fagus* is elliptical and 8.5 cm. long by 3.7 cm. wide. The petiole is 0.6 cm. long and the base is acute. The apex appears damaged, but appears to have been acute to acuminate. 12 pairs of secondary veins diverge suboppositely to alternately at angles of approximately 35-40° and are craspedromous. The margin is crenate to serrate and the teeth recurve strongly toward the apex. Tertiary venation is net. **Holotype:** U. Mont. P.C. #852.
Fam. Ulmaceae

Genus. *Zelkova* Spach

*Zelkova oregoniana* (Knowlton) Brown

*(Plate 3, fig. 6)*


The leaf is lanceolate and is 5.1 cm. long and 2.0 cm. wide at its widest point. The base is rounded and is highly asymmetrical. The apex is acuminate. The petiole is 0.8 cm. long and robust as is the primary vein. Approximately 14-16 secondary veins diverge suboppositely at angles of about 75° and are craspedromous. The margin is highly eroded, but appears to have been serrate to crenate. Tertiary venation is not preserved.

Becker's specimens of *Z. oregoniana* have only 6-10 pairs of secondary veins, but Wolfe (1964) describes a specimen with 14-16 pairs of secondary veins and his figures are comparable to the Douglass Creek specimen. *Zelkova* seems to have had its greatest range during Oligocene and Miocene times, but since then it has steadily decreased its range.

**Hypotype:** U. Mont. P.C. #853.

Genus. *Ulmus* Linnaeus

*Ulmus sp.*

*(Plate 3, fig. 3)*

A small leaf fragment was found that should probably be placed in this genus. The leaf fragment is 3.4 cm. long and 1.8 cm. wide. The
base is obtuse and the overall leaf appears to be oval. The margin is serrate, and the secondary veins diverge at an angle of about 45° and sometimes bifurcate before entering a tooth, but only in a few instances. The petiole is 5 mm. long and appears to be robust.

The specimen bears close resemblance to the *Ulmus* species pictured by MacGinitie (1953), but due to the fragmentary nature of the Douglass Creek specimen the author feels that it is inadvisable to assign it to a species. *Holotype:* U. Mont. P.C. #849.
Fam. Berberidaceae
Genus. *Mahonía* Nuttall

*Mahonía limirivuli* Brown ex Becker

(Plate 3, fig. 5)

*Mahonia limirivuli* Brown ex Becker, 1962. Bull. Torrey Bot. Club, vol. 82, no. 2, p. 117, fig. 3 (fig. 4 is a reconstruction of fig. 3).

*Mahonia grantiana* Brown ex Becker. Ibid., p. 116, fig. 1.

The leaf is elongate, inequalateral, and slightly curved. The specimen is 3.5 cm. long and 1.7 cm. wide at its widest point. The apex is acuminate and the base is concavely rounded. Marginal teeth are 10 in number and are approximately 5 mm. long and directed upward and are spinose. The very weak primary vein and secondary veins are very indistinct.

This specimen is very close to Becker's (1961 pl. 25, fig. 13) specimen, being slightly smaller and having more teeth. Becker's specimens have teeth numbers ranging from 2-6 so 10 is within reason for this species. Therefore the author feels that this specimen fits well within the possible morphologic range for this species. *Hypotype*: U. Mont. P.C. #873.

*Mahonia spp.*

(Plate 3, figs. 7-8)

Another specimen possibly referable to *M. limirivuli* is very poorly preserved and appears to have been badly battered before preservation so that the author feels that this specimen can best be called *Mahonía sp.*
One other specimen is also too poorly preserved to be assigned a definite species name, but the general outline of the leaf suggests that it is closest to *M. simplex* (Newberry) Arnold, but the author prefers to leave it at *Mahonia* sp. for the present. *Holotypes*: U. Mont. P.C. #874, P.C. #875.
Fam. Saxifragaceae

Genus. Ribes Linnaeus

Ribes auratum Becker

(Plate 3, figs. 9-10)

Ribes auratum Becker. 1961, Geol. Soc. Amer. Mem. 82, p. 70, pl. 20, fig. 13.

The leaf is broadly obovate and is three lobed. The base is cuneate to acute. The leaves are 1.5 to 2.0 cm. long and 1.5 to 2.3 cm. wide at their widest points. The venation is palmate and the secondary veins are distinctly upward curving and craspadromous. The petiole is 7 mm. long.

Except for the slightly larger size and being more acute at the base, the Douglass Creek specimens are comparable to Becker's specimens (1961). The author feels that specimens from the Douglass Creek Basin fit within the limits of this species. Hypotypes: U. Mont. P.C. #846, P.C. #847.
Fam. Rosaceae

Genus. Cercocarpus Humboldt, Bonpland, et Kunth

Cercocarpus antiquus Lesquereux

(Plate 3, fig. 12)


One poorly preserved specimen evidently belongs to this species. The leaf is 2.6 cm. long and 8 mm. wide. It is lanceolate and the margins tend to be parallel and decurrent to the base of the petiole. Secondary veins, though very poorly preserved, are sharply ascending. Though smaller than Becker's material, I feel that it is still within the limits of this species. Hypotype: U. Mont. P.C. #848.

Cercocarpus milleri sp. nov.

(Plate 3, fig. 11)

The leaf is 4.2 cm. long and 1.7 cm. wide. The leaf is oblong with a rounded apex and an acute base. 6-9 pairs of secondaries arise at an angle of about 45° and go to the serrate margin—each ending in a tooth. The teeth are 18 in number and are quite pronounced. The petiole is approximately 0.8 cm. long. Tertiary venation is not preserved.
Description of this leaf was quite difficult since evidently two leaves of the same species were superimposed prior to fossilization.

*Holotype:* U. Mont. P.C. #860.

**Genus. Rosa Linnaeus**

*Rosa hilliae* Lesquereux

(Plate 3, figs. 14-19)


Several rosaceous leaves of unknown species identity are placed in this form genus (MacGinitie, 1953). The leaves range in length from 1-2.4 cm. for complete specimens and one incomplete specimen is 2.7 cm. long. Widths range from 1-2 cm. (the 2 cm. size is for the incomplete specimen). The margins are serrate and all have distinct petioles which average about 0.5 cm. in length.

The number of specimens of *R. hilliae* collected at the Douglass Creek Basin was second only to the number of specimens of *Sequoia affinis* collected. *Hypotypes:* U. Mont. P.C. #861, P.C. #862, P.C. #863, P.C. #864, P.C. #865, P.C. #866.
Genus. *Amelanchier* Medicus

*Amelanchier scudderi* Cockerell

(Plate 3, fig. 13)


*Amelanchier peritula* Cockerell, 1908, Bull. Amer. Mus. Nat. Hist., vol. 24, p. 95, pl. 6, fig. 6.


The leaf is obovate to ovate, length is 3.5 cm., width is 2.2 cm. at the widest point. The apex is broadly rounded and the assumed acute apex is missing. The base is cuneate and the margin is coarsely serrate in the upper two-thirds of the leaf. The teeth are broadly triangular with terminal apiculation. Six pairs of opposite or subopposite secondary veins diverge at an angle of approximately 45°. Branches of the secondary veins enter the marginal teeth. Tertiary venation is not preserved.

The Douglass Creek specimen is similar to the Florissant specimen (MacGinitie, 1953, pl. 50, fig. 2) except for a possible missing apical point on the Douglass Creek specimen. *Hypotype:* U. Mont. P.C. #816.
Fam. Anacardiaceae

Genus. Astronium Jacquin

Astronium truncatum (Lesquereux) MacGinitie

(Plate 3, fig. 20)

Astronium truncatum (Lesquereux) MacGinitie, 1953, Carn. Inst. Wash. pub. 599, p. 133, pl. 38, figs. 1, 2; pl. 48, fig. 5.


A single calyx was found at Douglass Creek that is identical to that found at Florissant (MacGinitie, 1953). The calyx consists of five oblong sepals, 10-13 mm. long and 5-6 mm. wide. They are distinctly veined. A scar 2 mm. in diameter in the center of the calyx shows the point of seed attachment. Hypotype: U. Mont. P.C. #811.
**Fam. Aceraceae**

**Genus. Acer Linnaeus**

*Acer cf. florissanti* Kirchner

(Plate 4, fig. 1)

*Acer florissanti* Kirchner, 1898, Trans. Acad. Sci. St. Louis, vol. 8, p. 181, pl. 11, fig. 1.

*Acer mysticum* Kirchner, *ibid.*, p. 181, pl. 11, fig. 2.


*Acer florigerum* Cockerell, *ibid.*, p. 66, fig. 1c.


One badly eroded leaf 4.0 cm. long by 3.0 cm. wide is tentatively assigned to this species. It is palmately veined with three very distinct veins. Secondary veins arise at right angles from the primary veins. The specimen appears to have been three lobed, but it has been badly eroded so as to obscure this feature.

Except for a slightly different base (the Douglass Creek specimen has an acute base, while the Florissant specimen has a rounded base) the Douglass Creek specimen is quite comparable to MacGinitie's specimen (1953, pl. 58, fig. 2). Since the Douglass Creek specimen was poorly preserved, this could account for the apparent change in basal morphology.

**Hypotype:** U. Mont. P.C. #857.
Acer sp.

(Plate 4, fig. 2)

One very poorly preserved samara has enough preservation to be placed in this genus. The samara is 2.8 cm. long and approximately 6-8 mm. wide and is thickened along the upper edge of the wing.

_Holotype:_ U. Mont. P.C. #850.

The Douglass Creek specimens consist of one complete specimen 4 cm. long and 1.8 cm. wide, and two partial specimens, one of which is comparable to the complete specimen and the other is larger being 3.5 cm. long and 2.8 cm. wide and appears to be within the size range of MacGinitie's specimen (1953). The margins are entire and the preserved apices are rounded. The base is acute and the petiole is short (0.5 cm.) and slender. The midribs are pronounced but are slender and gently tapering. 5-7 pairs of secondary veins diverge irregularly at an angle of about 50°, open distally. Some secondary veins branch well within the margin and all the secondary veins are camptodromus. Tertiary venation is not preserved.

Incertae Cedis

*Panax andrewsii* Cockerell

(Plate 4, figs. 6-7)


The Douglass Creek specimens are obovate, 3-5 cm. long and 1.9 cm. wide. The bases are cordate and the apices are rounded. These specimens are comparable to MacGinitie's specimens (1953). The margins are serrate and the petiole is short, 2 mm. long.

MacGinitie feels that this *Panax* is not really a *Panax* but since the Douglass Creek specimens are relatively well preserved they are included in the flora and the name *Panax andrewsii* is retained.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

Plant impressions representing 14 families, 21 genera, and 25 identifiable species, three of which are new, form the basis for this report. They come from beds in western Montana that were originally thought to be lowermost Oligocene (Chadronian) on the basis of vertebrate and invertebrate remains (Konizeski, 1961). Comparison of these plant fossils with those of other Tertiary localities and analysis of their leaf margins indicate an age of middle Oligocene to middle Miocene.

The animal remains were collected from localities some distance from the plant localities and these beds dip away from the vertebrate beds toward the plant beds. These beds could have undergone constant deposition from Eocene through middle Miocene (Pardee, 1913) and so Konizeski's vertebrates, evidently located near the base of the section, could be lowermost Oligocene while the plant beds, located seemingly near the top of the section, could be the middle Oligocene to middle Miocene age indicated by the plants. Thus, it is likely that these beds could span this broad spectrum of Tertiary time.

While this florule is relatively small, it is important in providing our first source of information about vegetation of this time in western Montana.
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Soc. Amer., vol. 80, no. 2, pp. 315-320.


EXPLANATION OF PLATE I

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1-2. Fossil sites.

3. Typha sp. ........................................29
   Holotype: U. Mont. P.C. #812

4-5. Equisetum sp. ................................20
   Holotypes: U. Mont. P.C. #814, P.C. #815

6-8. Abies longirostris Knowlton ................21
   Hypotypes: U. Mont. P.C. #829, P.C. #830,
              P.C. #831

9. Cyperacites cf. lacustris ....................30
   Holotype: U. Mont. P.C. #813

10. Abies laticarpa MacGinitie ....................21
    Hypotype: U. Mont. P.C. #828

11-16. Abies spp. ..................................22
   Holotypes: U. Mont. P.C. #832, P.C. #833,
              P.C. #834, P.C. #835, P.C. #861, P.C. #879

17. Picea lahontensis MacGinitie .................22
    Hypotype: U. Mont. P.C. #829

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    Hypotypes: U. Mont. P.C. #836, P.C. #837,
               P.C. #838, P.C. #839

22-23. Pinus wheeleri Cockerell ................25
    Hypotypes: U. Mont. P.C. #841, P.C. #840

24-25. Pinus monticolensis Berry ................24
    Hypotypes: U. Mont. P.C. #842, P.C. #843

26. Unidentified Pinus seed
    Holotype: U. Mont. P.C. #878

27-28. Pinus florissanti Lesquereux .............23
    Hypotypes: U. Mont. P.C. #867, P.C. #868

29-32. Pinus spp. ................................25
   Holotypes: U. Mont. P.C. #869, P.C. #870
             P.C. #871, P.C. #877
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    Hypotypes: U. Mont. P.C. #855, P.C. #872,
               P.C. #876

4. *Alnus helmwillensis* sp. nov. ............... 31
    Holotype: U. Mont. P.C. #851

5-7. *Alnus relata* (Knowlton) Brown ............. 31
    Hypotypes: U. Mont. P.C. #854, P.C. #858,
               P.C. #859

8. *Fagus drummondensis* sp. nov. ............... 34
    Holotype: U. Mont. P.C. #852

9-11, 13, 14. *Quercus consimilis* Newberry ...... 33
    Hypotypes: U. Mont. P.C. #817, P.C. #818,
               P.C. #819, P.C. #820, P.C. #821

12. *Quercus convexa* Lesquereux ................. 33
    Hypotype: U. Mont. P.C. #822
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Figures - All figs. IX.

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   Hypotype: U. Mont. P.C. #856

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5. Mahonia limirivuli Becker ............................................ 37
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    Holotype: U. Mont. P.C. #860

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6-7. *Panax andrewsii* Cockerell ........ .......... ........ .......... .47
   Hypotypes: U. Mont. P.C. #844, P.C. #845

8. Unidentified Fish scale.
   Holotype: U. Mont. P.C. #880
A Late Tertiary Florule from the

Douglass Creek Basin, Western Montana

by

Christopher P. Person

B.S., University of Oregon, 1970

Presented in partial fulfillment of the
requirements for the degree of

Master of Arts

UNIVERSITY OF MONTANA

1972

Approved by:

Chairman, Board of Examiners

Dean, Graduate School

May 25, 1972
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CHAPTER I

INTRODUCTION

Many Tertiary floras from the western United States have been reported, but few are located in the Rocky Mountain region. Most of the floras described have been from the basin-range province to the west, which had relatively uniform topography and climate prior to the uplift of the Cascades and Coast ranges.

This paper describes a late Tertiary florule from the Douglass Creek Basin in western Montana as interpreted from plant megafossils preserved as impressions in a coarse matrix. Specimens collected for this study were made by Dr. C. N. Miller, University of Montana, and Dr. H. F. Becker, The New York Botanical Garden, in the summer of 1967. Further collections were made by the author in the summer of 1971.

The florule was originally thought to be lowermost Oligocene (Chadronian) in age based on vertebrate and invertebrate evidence (Konizeski, 1961), but leaf margin analysis and comparison with other Tertiary Floras indicate a middle Oligocene to middle Miocene age for the florule since they represent cooler conditions than are thought to have existed during early Oligocene time.
CHAPTER II

PHYSICAL AND GEOLOGICAL ASPECTS OF THE DOUGLASS CREEK BASIN

Physical Aspects

The Douglass Creek Basin lies in Powell County in western Montana, about 8 miles northeast of Drummond (Fig. I). The basin is bordered by the Garnet Range on the west and south and by the continental divide about 25 miles to the east. The area is drained by Douglass, Sturgeon, Murray, Spring, Bear, Sheep, and Morris Creeks (Fig. II) which eventually unite with the Blackfoot and Clark Fork Rivers. The Douglass Creek Basin, itself, has an area of approximately 20 square miles and the altitude ranges from 5200 feet to 4550 feet at the drainage exit. In addition, irregular mountain slopes rise up to 1000 feet above the valley floor.

The present climate of the Douglass Creek Basin is semi-arid with mesic vegetation in the bottoms of the stream beds. The basin has an average growing season of 70 days with an average annual precipitation of about 17 inches--mostly in the winter as snow (Konizeski, 1961).

Vegetation today on the upper and poorly drained slopes consists mainly of Pseudotsuga menziesii and small patches of Populus tremuloides on the more mesic upland slopes and hollows. Between the uplands and lower slopes is a zone of Pinus ponderosa, Pseudotsuga, and Juniperus sp. The well drained slopes, the majority of the basin, are covered by Artemesia sp. and various grasses. The bottomland vegetation consists mainly of Populus tremuloides, P. trichocarpa, and Salix sp.
Geological Aspects

From Precambrian to early upper Cretaceous times various sedimentary and igneous rocks were laid down, which now form the basement complex of the region. At early upper Cretaceous time the beds that had been deposited were thrust into great folds trending northwest to southeast and then granitic intrusions invaded the sedimentary strata. The surface was then thoroughly eroded. Subsequent structural stress, forming numerous depressions, was accompanied by general volcanic activity (Pardee, 1913). The primary volcanic activity consisted of extrusive lavas that filled the lower portions of the basins, remnants of which still exist in one part of the Douglass Creek Basin, and later eruptions covered the area with volcanic ash, which was washed into the valleys and deposited there. Deposition continued evidently well into Miocene time.

At the end of this epoch the area was uplifted into a plateau with an approximate altitude of 7000 feet (Pardee, 1913) warping the deposits into broad synclines and monoclines. These beds dip generally, but not always, toward the centers of the basins (Pardee, 1913). The more severely deformed beds exhibit numerous small normal faults, while the less deformed beds exhibit few if any faults.

With this uplift, the rejuvenated streams rapidly eroded into the softer volcanic rocks and established their present channels. During the Pleistocene the Tertiary rocks were covered with a layer of alluvial gravel which now forms a thin veneer over the Tertiary basin fill in most places.
The valley fills are considered to be mainly Oligocene and Miocene in age by Pardee (1913) and of Oligocene age by Konizeski (1961) based on vertebrate and invertebrate evidence found at the base of the section in the Douglass Creek Basin. Work in southwest Montana (Kuenzi and Fields, 1971; Kuenzi and Richards, 1969) has determined that the basin fill sediments there are of Oligocene and Miocene-Pliocene age with an unconformity between the Oligocene sediments and the Miocene-Pliocene sediments. Due to the lack of evidence of this unconformity at the Douglass Creek Basin, I feel that the evidence from there cannot be extrapolated to the Douglass Creek Basin. However, their ages coincide with those given by Pardee and Konizeski. Rather than being of one age, however, these beds probably are time continuous and overlap two or more epochs.
Fig. I
CHAPTER III

FOSSIL LOCALITIES

The fossils were collected from two roadcuts along Montana highway 271 approximately 8 miles northeast of Drummond, Montana. The sites are in the southeast corner of Sec. 3, T 12 N, R 12 W, near the extreme south end of the basin near the headwaters of Sturgeon Creek (Fig. II). These correspond to Konizeski's (1961) fossil site number 5.

The plants are preserved in a reworked volcanic ash that was deposited in an apparent lacustrine environment. The beds range from blocky to thinly bedded to paper shale. Most of the fossils occurred in the blocky material with very few good specimens occurring in the thinly bedded material. The latter contains large numbers of ostracods and gastropods, which in some places make up the bulk of the rock. The beds dip south at approximately 20-25 degrees. Petrographic studies indicate the shales are made up of mainly montmorillonite clay with kaolinite and mica making up minor fractions of the rock.

Konizeski's (1961) measurements of the beds at the fossil locality are given below:

<table>
<thead>
<tr>
<th></th>
<th>feet</th>
<th>inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limestone, light gray, marly; contains fish scales and teeth, pelecypods, myriad ostracodes</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Shale, chocolate brown, calcareous, laminated; contains two gypsum beds, myriads of ostracodes</td>
<td>1</td>
<td>6</td>
</tr>
</tbody>
</table>
Clay, olive, unctuous, bentonitic;
    constituents montmorillonite (90 percent), gypsum (10 percent),
    quartz (? percent)...........................................0 7

Shale, yellow brown; contains rare
    (1-2 inch) argillaceous beds and
    one (1 inch) gypsum bed....................................6 8

Limestone, light brown, marly, thin-bedded; contains abundant ostracodes,
    some gastropods.............................................0 11

Shale, yellow brown, laminated; constituents mixed-layered (Illite-
    montmorillonite) (85 percent),
    calcite (13 percent), quartz (1 percent), gypsum (? percent)..............13 8

Shale, chocolate brown, laminated;
    contains plants, abundant ostracodes......................1 0

Limestone, chocolate brown, marly,
    petroliferous..............................................0 3

Limestone lens, yellow brown................................0 4

Shale, ferruginous, thin bedded..............................0 7

(Total section 25 feet, 11 inches)
DOUGLASS CREEK BASIN

Morris to Drummond fossil sites

Tertiary volcanics

Fig. II (after Konizeski, 1961)
CHAPTER IV

COMPOSITION OF THE DOUGLASS CREEK FLORULE

Systematic List

TRACHEOPHYTA

SPHENOPSIDA

Equisetineae

Equisetaceae

Equisetum sp.

PTEROPSIDA

Gymnospermae

Pinaceae

Abies laticarpa MacGinitie
Abies longirostris Knowlton
Abies spp.
Picea lahontensis MacGinitie
Picea magna MacGinitie
Pinus florissanti Lesquereux
Pinus monticolensis Berry
Pinus wheeleri Cockerell
Pinus spp.

Taxodiaceae

Sequoia affinis Lesquereux

Angiospermae (Monocotyledoneae)

Typhaceae

Typha sp.
Cyperaceae

*Cyperacites cf. lacustris* MacGinitie

Angiospermae (Dicotyledeneae)

Betulaceae

*Alnus helmwillensis* n. sp.

*Alnus relata* (Knowlton) Brown

Fagaceae

*Fagus drummondensis* n. sp.

*Quercus consimilis* Newberry

*Quercus convexa* Lesquereux

Ulmaceae

*Zelkova oregoniana* (Knowlton) Brown

*Ulmus* sp.

Berberidaceae

*Mahonia limirivuli* Becker

*Mahonia* spp.

Saxifragaceae

*Ribes auratum* Becker

Rosaceae

*Cercocarpus antiquus* Lesquereux

*Cercocarpus milleri* n. sp.

*Rosa hilliae* Lesquereux

*Amelanchier scudderi* Cockerell

Anacardiaceae

*Astronium truncatum* (Lesquereux) MacG.
This florule consists of 14 families, 21 genera, and 25 identifiable species. Since many of the species were based on single or very few specimens no quantitative study was made. The bulk of the specimens were of various conifer remains, particularly seeds and needles, which are produced in large numbers and could conceivably result in an over-representation of these plants.
<table>
<thead>
<tr>
<th>Family</th>
<th>Genera</th>
<th>Species</th>
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<tbody>
<tr>
<td>Pinaceae</td>
<td>3</td>
<td>7</td>
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<tr>
<td>Rosaceae</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Fagaceae</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Betulaceae</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Ulmaceae</td>
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</tr>
<tr>
<td>Berberidaceae</td>
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<tr>
<td>Aceraceae</td>
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<td>Saxifragaceae</td>
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<td>Anacardiaceae</td>
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<td>Lauraceae</td>
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<td>Taxodiaceae</td>
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<tr>
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<td>Cyperaceae</td>
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</tr>
<tr>
<td>Equisetaceae</td>
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</table>
CHAPTER V

ECOLOGICAL ASPECTS OF THE DOUGLASS CREEK FLORULE

Due to the small numbers of plants represented in the Douglass Creek florule, only general ecological relationships can be interpreted.

The florule can be roughly divided into five floral zones according to Becker (1961):

HYDROSERE

Cyperacites cf. lacustris
Equisetum sp.
Typha sp.

FLOOD PLAIN

Alnus relata
Acer cf. florissanti
Rosa hilliae
Zelkova oregoniana

DECIDUOUS FOREST

Astronium truncatum
Quercus consimilis

CONIFEROUS FOREST

Abies laticarpa
Abies longirostris
Picea lahontensis
Picea magna
Pinus monticолensis
Pinus wheeleri
Sequoiа affinis
XERIC ASSOCIATION

_Cercocarpus antiquus_

_Quercus convexa_

_Ribes auratum_

_Mahonia limirivuli_

_Amelanchier scudderi_

The floristic association with the emphasis on the hydrosere and flood plain, and coniferous forest associations suggests a relatively high altitude cool-temperate habitat (sensu Wolfe and Hopkins, 1967) with the xeric association possibly existing on the west and south facing slopes. From the considerations of the presumed topography and flora at the time of deposition one would be prone to consider that the conifers were dominant on the majority of the slopes with the xeric association on the drier south and west facing slopes, and the hydric and flood plain plants either on the lake edge or in the streams draining into the lake.

Comparison of the floral list with present floras (Table II) indicates strongly a cool-temperate climate such as exists in the region today with a temperature range similar to the present but probably more humid as indicated by _Abies, Picea,_ and _Sequoia._

These assumptions are based on very broad generalities and this point must be remembered as many factors can be involved in a plant getting from the place of growth to the basin of deposition. Since many species are based on one specimen, ecological assumptions for the whole area based on the evidence of one specimen are at the very best quite suspect.
<table>
<thead>
<tr>
<th>Douglass Creek Species</th>
<th>Closest living relative</th>
<th>W. U.S.</th>
<th>E. U.S.</th>
<th>SW. U.S.</th>
<th>SE. U.S.</th>
<th>Asia</th>
<th>S. Mexico</th>
</tr>
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<tbody>
<tr>
<td>Abies laticarpa</td>
<td>A. magnifica</td>
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<tr>
<td>Abies longirostris</td>
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<tr>
<td>Picea lahontensis</td>
<td>P. engelmanni</td>
<td>X</td>
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<td></td>
</tr>
<tr>
<td>Picea magna</td>
<td>P. noeveitchii</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Pinus florissanti</td>
<td>P. ponderosa</td>
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<td>Pinus monticoculensis</td>
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<td>Pinus wheeleri</td>
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CHAPTER VI

AGE OF THE FLORULE

The Douglass Creek beds were treated as lowermost Oligocene (Chadronian) by Konizeski (1961) based on vertebrate and invertebrate evidence, but the plants indicate cooler conditions than are generally thought to have existed in early Oligocene time.

Comparison of the Douglass Creek florule with other Tertiary floras (Table III) reveals the greatest overlap with the Ruby Valley Paper Shale flora (65%), the Beaverhead Basin flora (55%), and the Florissant flora of Colorado (45%) which are of middle to late Oligocene in age. These percentages include such genera as *Equisetum*, *Typha*, and *Cyperacites*, which are common to all three floras. The Douglass Creek florule has an average of 31% of its species in common with all the Oligocene floras (8 mainly middle to upper), 19% in common with all the Miocene floras (5), 9% in common with the Eocene floras (3), and 3% in common with the Pliocene floras (2) compared. Becker's (1961) "paleobotanical triangulation" method would place the florule in the middle Oligocene to middle Miocene range.

Further evidence for this age range comes from a comparison of percentages of entire margined leaves (Bailey and Sinnott, 1915, 1916). Entire margined leaves are characteristic of woody dicots living in tropical, xeric-temperate, and arctic regions, that is, in regions of physiological aridity for the plant during most of its growing season (Wolfe and Hopkins, 1967). Conversely, non-entire leaves are found in more humid floras. This method is particularly useful because there are
no taxonomic considerations; only the type of margin is considered. The Douglass Creek Basin florule has an entire margin leaf percentage of approximately 12.5% which represents cool-temperate conditions according to Wolfe and Hopkins (1967). By examining Wolfe and Hopkin's graph (Fig. III) we see that the early to middle Oligocene floras plotted have an average percentage of entire margined leaves of about 60%. This curve takes a drastic drop to 25-30% in the middle Oligocene and remains more or less constant (varying between 25-40%) through the lower Pliocene. Although the Douglass Creek percentage is well below these percentages, one possible explanation for the discrepancy is the fact that the Douglass Creek florule is probably an upland flora while the majority of the floras plotted are from the basin-range province and tend to be low altitude floras (i.e. Eastern Oregon, Eastern Washington, and Nevada). While the floras of the Florissant beds and the Ruby Valley Paper Shale beds were not plotted by Wolfe and Hopkins, they show a 45% and 25% entire margin percentages respectively which fit into this graph nicely and further demonstrate that the graph is applicable to Rocky Mountain floras as well as those further west.

The wide discrepancy between the 12.5% entire margin percentage for the Douglass Creek Basin and the 60% entire margin percentage for the lower Oligocene definitely excludes the Douglass Creek florule from the lower Oligocene and would again tend to place it in the middle Oligocene to middle Miocene range. Thus by the two methods, "paleobotanical triangulation" and leaf margin analysis, an age of middle Oligocene to middle Miocene is indicated. Lacking stratigraphic evidence, no further age delineation can be made.
### Douglass Creek Species

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Species with entire-margined leaves

Fig. III

(after Wolfe & Hopkins, 1967)
Type specimens are deposited in the University of Montana Paleontological Collection (U. Mont. P.C.).

Div. TRACHEOPHYTA
Sub. Div. SPHENOPSIDA
Class Equisetineae
Fam. Equisitaceae
Genus *Equisetum* Linnaeus

*Equisetum sp.*

(Plate 1, figs. 4-5)

Two specimens of *Equisetum* were found at the Douglass Creek locality. One is a piece of a rhizome 1.0 cm. long with a branch 1.5 cm. long with grooved ridges and furrows. Pointed leaves are whorled at the nodes. The second specimen is a single unbranched stem 5.0 cm. long with leaves whorled at the nodes. Absence of more diagnostic material makes it inadvisable to assign a specific name to these specimens. *Holotype* U. Mont. P.C. #814, P.C. #815.
Sub. Div. PTEROPSIDA

Class Gymnospermae

Fam. Pinaceae

Genus Abies Miller

Abies laticarpa MacGinitie

(Plate 1, fig. 10)

pl. 3, fig. 1.

A seed 1.0 cm. long and 4 mm. wide and apically acute is referred to
this species. The wing is 7 mm. long and 8 mm. wide at its widest point.
The seed is similar to those described by MacGinitie in 1933 except for
the fact that the seed is slightly smaller overall.

These seeds are generally considered to be closely related to Abies
magnifica Murr whose present distribution is identical to its fossil

Abies longirostris Knowlton

(Plate 1, figs. 6-8)

Abies longirostris Knowlton, 1923. U.S. Geol. Survey Prof. Paper 131,
p. 187.—MacGinitie, 1953. Carn. Inst. Wash. Pub. 599, p. 82, pl. 18,
fig. 8.

The seeds are 7 mm. long and 3-4 mm. wide, apically acute and
broadening distally. Wings are 7-8 mm. long and 8 mm. wide at the widest
point. The wing is constricted slightly where it joins the seed body.
The Douglass Creek specimens are very similar to the material of Becker (1969) and MacGinitie (1953).

This fruit is considered to be most closely related to the living Abies venusta Douglas. This fossil Abies appears to have been widely distributed during the Tertiary. Hypotype: U. Mont. P.C. #829, P.C. #830, P.C. #831.

Abies sp.

(Plate 1, figs. 11-16)

Six needles ranging in size from 12-16 mm. long and 2 mm. wide (one large specimen, though incomplete, is 25 mm. long) are referable to the genus Abies, but no further delineation is possible. Holotypes: U. Mont. P.C. #832, P.C. #833, P.C. #834, P.C. #835, P.C. #861, P.C. #879.

Genus Picea Link

Picea lahontensis MacGinitie

(Plate 1, fig. 17)


The seeds found in the Douglass Creek basin are referable to those specimens shown in Becker (1961, pl. 5, fig. 40) and those shown in MacGinitie's Florissant material (1953). The seeds are broadly wedge shaped and are 8 mm. long and 4-5 mm. wide at the widest point. The wing broadens and is obliquely rounded. The seed body is 2-4 mm. long and 2 mm. wide. Hypotype: U. Mont. P.C. #829.
Picea magna MacGinitie (Plate 1, figs. 18-21)


The seeds are oval and 3-4 mm. long and 2-3 mm. wide. The wings are 7-8 mm. long and 4-5 mm. wide and broadly rounded at the end. Though somewhat smaller then MacGinitie's (1953) specimens, they are quite comparable.

These "snub nosed" seeds are readily distinguished and are very widely found in the Tertiary floras of Idaho and Oregon. They are thought to be most closely related to the living Picea noveveitchii Masters now living in the mountains of China. Hypotypes: U. Mont. P.C. #836, P.C. #837, P.C. #838, P.C. #839.

Genus Pinus Linnaeus

Pinus florissanti Lesquereux (Plate 1, figs. 27-28)


Seeds referable to Pinus florissanti were found in the Douglass Creek Basin. The seeds are 5 mm. long and 3 mm. wide and the seed and wing is 2.5 cm. long which agrees with MacGinitie's material. No leaves or cones were found.

MacGinitie feels that P. florissanti is extremely close to the living P. ponderosa. Hypotypes: U. Mont. P.C. #867, P.C.#868.
Pinus monticolensis Berry
(Plate 1, figs. 24-25)

Pinus monticolensis Berry, 1929. U.S. Geol. Survey Prof. Paper 154, p. 238, pl. 49, fig. 8 only.

Pinus latahensis Berry, 1929, U.S. Geol. Survey Prof. Paper 154, p. 238, pl. 49, fig. 7.

One fascicle of five needles was found with needle length of 36 mm. which compares favorably with Becker's material (1961, pl. 8, fig. 8) except for its shorter size. Some of the needles in the Douglass Creek material appear to have broken off and this could account for the shorter length.

One reason for placing this five needle fascicle in P. monticolensis is that seeds referable to this species were also found in the Douglass Creek florule and therefore substantiate the presence of P. monticolensis in the Douglass Creek Basin. The seed and wing is 18 mm. long and 6 mm. wide at the widest point. The seed body itself is 5 mm. long and 4 mm. wide and agrees favorably with Becker's (1961) material. Hypotypes: U. Mont. P.C. #842, P.C. #843.
Pinus wheeleri Cockerell

(Plate 1, figs. 22-23)


A fascicle of five needles with needle length of 31 mm. (incomplete) was found that is similar to MacGinitie's specimen (1933, pl. 18, fig. 11). The needles appear to be robust and the short shoot is pronounced.

MacGinitie feels that P. wheeleri is synonymous with P. monticolensis and P. tulameenensis, but the author feels there is enough justification for keeping these as separate species.

A seed of P. wheeleri was found that is quite similar to those pictured in Becker (1969, pl. 6, figs. 22, 23). The nutlet is small (3 mm. long and 2 mm. wide) and the wing is long and narrow--15 mm. long and 5.5 mm wide. Hypotypes: U. Mont. P.C. #840, P.C. #841.

Pinus spp.

(Plate 1, figs. 29-32)

Species A: Whole and partial fascicles of Pinus were found with 2-3 needles per fascicle. The needles are up to 27 mm. and 0.5 mm. wide for a complete specimen. One incomplete specimen is 24 mm. long and 0.5 mm.
wide. They differ in length from Becker's specimens (1969, pl. 9, figs. 2, 9) and appear to be more delicate.

Species B: One fascicle containing 2 needles is 32 mm. (incomplete) and 2 mm. wide and appears quite robust. It bears close resemblance to MacGinitie's *Pinus wheeleri* except for the 2 needles, possible the other 2 needles were lost in transport.

Species C: A branch with many needles was found, but it is impossible to determine the number of needles per fascicle. It bears close resemblance to MacGinitie's *Pinus hambeehi* except for its shorter length. It also appears close to *Pinus tulameenensis* Penhallow as pictured in Arnold (1955). Needles range in length from 25-35 mm. and small short shoots are evident on the stem of the specimen. **Holotypes:** U. Mont. P.C. #869, P.C. #870, P.C. #877, P.C. #871.
Fam. Taxodiaceae

Genus. *Sequoia* Endlicher

*Sequoia affinis* Lesquereux

(Plate 2, figs. 1-3)


*Glyptostrobus europaeus* Berry, (not Brongiart), U.S. Geol. Survey Prof. Paper 185, p. 103, (*Sequoia affinis* Lesquereux only), 1934.

*Sequoia affinis* Lesquereux by H. V. Smith, Amer. Midland Naturalist, vol. 25, p. 493, pl. 2, figs. 1, 6, 1941. --Chaney, Trans. Amer. Philos. Soc., new ser., vol. 40, pt. 3, p. 231, pl. 1, fig. 2; pl. 3, figs. 2-4; pl. 4, figs. 3, 4, 7; pl. 6, fig. 6; pl. 7, figs. 7-9;
pl. 8, figs. 10; pl. 12, figs. 3, 4. 1951.


The leaves are linear. The maximum length of the leaves is about 7-10 mm. Leaves are both appressed and apparently two ranked. Ovulate cones are small, ovoid, and about 1 cm. in diameter.

The Douglass Creek material is comparable for all intents and purposes with the material from Florissant. Both the leaves and cones are very similar. It is very difficult to distinguish sterile foliage of *Glyptostrobus* and *Sequoia*, but on the basis of cones, the author feels that the Douglass Creek material is *S. affinis*. *S. affinis* makes up the greatest number of specimens in the Douglass Creek florule. The distribution of *S. affinis* is widespread during the Oligocene and the reader is referred to Chaney's monograph on the fossil species of *Sequoia, Taxodium, Metasequoia*, and *Glyptostrobus*. (1951). Hypotypes: U. Mont. P.C. #855, P.C. # 872, P.C. #876.
Fam. Typhaceae

Genus. *Typha* Linnaeus

*Typha* sp.

(Plate 1, fig. 3)

Fossils representing *Typha* are represented by numerous impressions with parallel venation, ranging in size from 11 cm. long and 5 mm. wide to 4.5 cm. long and 3 cm. wide. The specimens are too poorly preserved to be assigned to the specific level. *Holotype*: U. Mont. P.C. #812.
Fam. Cyperaceae

Genus. *Cyperacites* Schimper

*Cyperacites* cf. *lacustris* MacGinitie

(Plate 1, fig. 9)


The specimens of *Cyperacites* found at Douglass Creek are comparable to the specimens found at Florissant. Most of them are small fragments, but fit within the sizes given by MacGinitie. Roots diverge from nodes which are 3-7 mm. apart. There are possibly more than one species represented here, but preservation is not sufficient to delineate them further. Hypotype: U. Mont. P.C. #813.

The leaves are lanceolate to elliptical. The apices are acute to rounded (damaged?) and the base is slightly rounded. The blade is 4.2 - 4.5 cm. long and 1.8 - 2.0 cm. wide. The petiole is 0.8 cm. long. Six to seven pairs of secondary veins diverge at an angle of approximately 60° and curve toward the apex and are opposite to alternate. Tertiary venation is not preserved. Secondary veins enter the teeth directly where visible. The margin is serrate.

This species contains many forms of what appear to be a single species (Becker, 1961). The Douglass Creek specimens fit very well into the general description given by Becker (1961) for this species. Many specimens from the Douglass Creek Basin were preserved only sufficiently to be positively identified as A. relata, but only two or three were preserved sufficiently to be described and photographed.


Alnus helmwillensis sp. nov.

(Plate 2, fig. 4)

The leaf is obovate and approximately 3.5 cm. long and 2.3 cm. wide at the widest point. The petiole is 1.0 cm. long. The base is
acute and the margin is serrate with numerous teeth. The tip has been
damaged, but appears to have been acute to rounded. Five pairs of
secondary veins diverge alternately at an angle of about 50° and are
craspedomous. Tertiary venation is not preserved. The midvein is
robust as are the secondaries. Holotype: U. Mont. P.C. #851.
Quercus consimilis Newberry

(Plate 2, figs. 9-11, 13, 14; Plate 3, fig. 1)

1898. U.S. Geol. Surv. Mon. 31, p. 71, pl. 43, figs. 2-5.--Brown,

24, p. 285; pl. 6, fig. 2; pl. 7, figs. 3, 4; pl. 8, figs. 1-5;
pl. 9, figs. 4, 5; pl. 10, figs. 4, 5; pl. 17, fig. 1; pl. 20, fig. 5.

The Douglass Creek specimens are very similar to Beckers material
(1961, pl. 17, figs. 4-7) but tend to be 2-3 cm. shorter. They agree
in length with Graham's Sucker Creek flora (1965). The Douglass Creek
specimens range in length from 4-6.7 cm. while Becker's specimens are
generally in the 9-10 cm. range. Other than this size difference, the
Douglass Creek material is quite similar to the Ruby Valley material.

#821, P.C. #856.

Quercus convexa Lesquereux

(Plate 2, fig. 12; Plate 3, figs. 2, 4)

no. 2, 4, pl. 1, figs. 13-17; 1883. U.S. Geol. Surv. Terr. Rept.,
vol. 8, p. 265, pl. 45b, figs. 5, 6.--Axelrod, 1939. Carn. Inst. Wash.
Pub. 516, p. 95, pl. 7, figs. 3-7; 1950. Carn. Inst. Wash. Pub. 590,
The leaves are obovate to oblong. One entire specimen is 3.5 cm. long and 1.5 cm. wide at its widest point. The leaf base is acute to cuneate and the apex is obtuse to mucronate. The leaves have entire margins, pronounced midribs and the secondary veins are alternate to subopposite. These specimens are very similar to the Ruby Valley material of Becker (1961), but as in the case of Quercus consimilis are generally 1.0 to 2.0 cm. shorter. Hypotypes: U. Mont. P.C. #822, P.C. #823, P.C. #824.

*Fagus drummondensis* sp. nov.

(Plate 2, fig. 8)

The leaf of this species of *Fagus* is elliptical and 8.5 cm. long by 3.7 cm. wide. The petiole is 0.6 cm. long and the base is acute. The apex appears damaged, but appears to have been acute to acuminate. 12 pairs of secondary veins diverge suboppositely to alternately at angles of approximately 35-40° and are craspedromous. The margin is crenate to serrate and the teeth recurve strongly toward the apex. Tertiary venation is net. Holotype: U. Mont. P.C. #852.
Fam. Ulmaceae

Genus. Zelkova Spach

Zelkova oregoniana (Knowlton) Brown

(Plate 3, fig. 6)


The leaf is lanceolate and is 5.1 cm. long and 2.0 cm. wide at its widest point. The base is rounded and is highly asymmetrical. The apex is acuminate. The petiole is 0.8 cm. long and robust as is the primary vein. Approximately 14-16 secondary veins diverge suboppositely at angles of about 75° and are craspedromous. The margin is highly eroded, but appears to have been serrate to crenate. Tertiary venation is not preserved.

Becker's specimens of Z. oregoniana have only 6-10 pairs of secondary veins, but Wolfe (1964) describes a specimen with 14-16 pairs of secondary veins and his figures are comparable to the Douglass Creek specimen. Zelkova seems to have had its greatest range during Oligocene and Miocene times, but since then it has steadily decreased its range.


Genus. Ulmus Linnaeus

Ulmus sp.

(Plate 3, fig. 3)

A small leaf fragment was found that should probably be placed in this genus. The leaf fragment is 3.4 cm. long and 1.8 cm. wide. The
base is obtuse and the overall leaf appears to be oval. The margin is serrate, and the secondary veins diverge at an angle of about 45° and sometimes bifurcate before entering a tooth, but only in a few instances. The petiole is 5 mm. long and appears to be robust.

The specimen bears close resemblance to the *Ulmus* species pictured by MacGinitie (1953), but due to the fragmentary nature of the Douglass Creek specimen the author feels that it is inadvisable to assign it to a species. *Holotype:* U. Mont. P.C. #849.
Fam. Berberidaceae

Genus. *Mahonía* Nuttall

*Mahonía limirivuli* Brown ex Becker

(Plate 3, fig. 5)

*Mahonía limirivuli* Brown ex Becker, 1962. Bull. Torrey Bot. Club, vol. 82, no. 2, p. 117, fig. 3 (fig. 4 is a reconstruction of fig. 3).

*Mahonía grantiana* Brown ex Becker. Ibid., p. 116, fig. 1.

The leaf is elongate, inequalateral, and slightly curved. The specimen is 3.5 cm. long and 1.7 cm. wide at its widest point. The apex is acuminate and the base is concavely rounded. Marginal teeth are 10 in number and are approximately 5 mm. long and directed upward and are spinose. The very weak primary vein and secondary veins are very indistinct.

This specimen is very close to Becker's (1961 pi. 25, fig. 13) specimen, being slightly smaller and having more teeth. Becker's specimens have teeth numbers ranging from 2-6 so 10 is within reason for this species. Therefore the author feels that this specimen fits well within the possible morphologic range for this species. Hypotype: U. Mont. P.C. #873.

*Mahonía spp.*

(Plate 3, figs. 7-8)

Another specimen possibly referable to *M. limirivuli* is very poorly preserved and appears to have been badly battered before preservation so that the author feels that this specimen can best be called *Mahonía sp.*
One other specimen is also too poorly preserved to be assigned a definite species name, but the general outline of the leaf suggests that it is closest to *M. simplex* (Newberry) Arnold, but the author prefers to leave it at *Mahonia sp.* for the present. *Holotypes:* U. Mont. P.C. #874, P.C. #875.
Fam. Saxifragaceae

Genus. *Ribes* Linnaeus

*Ribes auratum* Becker

(Plate 3, figs. 9-10)

*Ribes auratum* Becker. 1961, Geol. Soc. Amer. Mem. 82, p. 70, pl. 20, fig. 13.

The leaf is broadly obovate and is three lobed. The base is cuneate to acute. The leaves are 1.5 to 2.0 cm. long and 1.5 to 2.3 cm. wide at their widest points. The venation is palmate and the secondary veins are distinctly upward curving and craspadromous. The petiole is 7 mm. long.

Except for the slightly larger size and being more acute at the base, the Douglass Creek specimens are comparable to Becker's specimens (1961). The author feels that specimens from the Douglass Creek Basin fit within the limits of this species. *Hypotypes:* U. Mont. P.C. #846, P.C. #847.
Fam. Rosaceae

Genus. Cercocarpus Humboldt, Bonpland, et Kunth

*Cercocarpus antiquus* Lesquereux

(Plate 3, fig. 12)


One poorly preserved specimen evidently belongs to this species. The leaf is 2.6 cm. long and 8 mm. wide. It is lanceolate and the margins tend to be parallel and decurrent to the base of the petiole. Secondary veins, though very poorly preserved, are sharply ascending. Though smaller than Becker's material, I feel that it is still within the limits of this species. *Hypotype:* U. Mont. P.C. #848.

*Cercocarpus milleri* sp. nov.

(Plate 3, fig. 11)

The leaf is 4.2 cm. long and 1.7 cm. wide. The leaf is oblong with a rounded apex and an acute base. 6-9 pairs of secondaries arise at an angle of about 45° and go to the serrate margin—each ending in a tooth. The teeth are 18 in number and are quite pronounced. The petiole is approximately 0.8 cm. long. Tertiary venation is not preserved.
Description of this leaf was quite difficult since evidently two leaves of the same species were superimposed prior to fossilization.

*Holotype: U. Mont. P.C. #860.*

Genus. *Rosa* Linnaeus

*Rosa hilliae* Lesquereux

(Plate 3, figs. 14-19)


Several rosaceous leaves of unknown species identity are placed in this form genus (MacGinitie, 1953). The leaves range in length from 1-2.4 cm. for complete specimens and one incomplete specimen is 2.7 cm. long. Widths range from 1-2 cm. (the 2 cm. size is for the incomplete specimen). The margins are serrate and all have distinct petioles which average about 0.5 cm. in length.

The number of specimens of *R. hilliae* collected at the Douglass Creek Basin was second only to the number of specimens of *Sequoia affinis* collected. *Hypotypes:* U. Mont. P.C. #861, P.C. #862, P.C. #863, P.C. #864, P.C. #865, P.C. #866.
Genus. *Amelanchier* Medicus

*Amelanchier scudderi* Cockerell

(Plate 3, fig. 13)


*Amelanchier peritula* Cockerell, 1908, Bull. Amer. Mus. Nat. Hist., vol. 24, p. 95, pl. 6, fig. 6.


The leaf is obovate to ovate, length is 3.5 cm., width is 2.2 cm. at the widest point. The apex is broadly rounded and the assumed acute apex is missing. The base is cuneate and the margin is coarsely serrate in the upper two-thirds of the leaf. The teeth are broadly triangular with terminal apiculation. Six pairs of opposite or subopposite secondary veins diverge at an angle of approximately 45°. Branches of the secondary veins enter the marginal teeth. Tertiary venation is not preserved.

The Douglass Creek specimen is similar to the Florissant specimen (MacGinitie, 1953, pl. 50, fig. 2) except for a possible missing apical point on the Douglass Creek specimen. *Hypotype:* U. Mont. P.C. #816.
Fam. Anacardiaceae

Genus. Astronium Jacquin

*Astronium truncatum* (Lesquereux) MacGinitie

(Plate 3, fig. 20)

*Astronium truncatum* (Lesquereux) MacGinitie, 1953, Carn. Inst. Wash. pub. 599, p. 133, pl. 38, figs. 1, 2; pl. 48, fig. 5.


A single calyx was found at Douglass Creek that is identical to that found at Florissant (MacGinitie, 1953). The calyx consists of five oblong sepals, 10-13 mm. long and 5-6 mm. wide. They are distinctly veined. A scar 2 mm. in diameter in the center of the calyx shows the point of seed attachment. *Hypotype*: U. Mont. P.C. #811.
Fam. Aceraceae

Genus. *Acer* Linnaeus

*Acer cf. florissanti* Kirchner

(Plate 4, fig. 1)

*Acer florissanti* Kirchner, 1898, *Trans. Acad. Sci. St. Louis*, vol. 8, p. 181, pl. 11, fig. 1.

*Acer mysticum* Kirchner, *ibid.*, p. 181, pl. 11, fig. 2.


*Acer florigerum* Cockerell, *ibid.*, p. 66, fig. 1c.


One badly eroded leaf 4.0 cm. long by 3.0 cm. wide is tentatively assigned to this species. It is palmately veined with three very distinct veins. Secondary veins arise at right angles from the primary veins. The specimen appears to have been three lobed, but it has been badly eroded so as to obscure this feature.

Except for a slightly different base (the Douglass Creek specimen has an acute base, while the Florissant specimen has a rounded base) the Douglass Creek specimen is quite comparable to MacGinitie's specimen (1953, pl. 58, fig. 2). Since the Douglass Creek specimen was poorly preserved, this could account for the apparent change in basal morphology.

Acer sp.

(Plate 4, fig. 2)

One very poorly preserved samara has enough preservation to be placed in this genus. The samara is 2.8 cm. long and approximately 6-8 mm. wide and is thickened along the upper edge of the wing.

Holotype: U. Mont. P.C. #850.
Fam. Lauraceae

Genus. *Lindera* Thunberg

*Lindera coloradica* MacGinitie

(Plate 4, figs. 3-5)


The Douglass Creek specimens consist of one complete specimen 4 cm. long and 1.8 cm. wide, and two partial specimens, one of which is comparable to the complete specimen and the other is larger being 3.5 cm. long and 2.8 cm. wide and appears to be within the size range of MacGinitie's specimen (1953). The margins are entire and the preserved apices are rounded. The base is acute and the petiole is short (0.5 cm.) and slender. The midribs are pronounced but are slender and gently tapering. 5-7 pairs of secondary veins diverge irregularly at an angle of about 50°, open distally. Some secondary veins branch well within the margin and all the secondary veins are camptodromus. Tertiary venation is not preserved.

Incertae Cedis

*Panax andrewsii* Cockerell

(Plate 4, figs. 6-7)


The Douglass Creek specimens are obovate, 3-5 cm. long and 1.9 cm. wide. The bases are cordate and the apices are rounded. These specimens are comparable to MacGinitie's specimens (1953). The margins are serrate and the petiole is short, 2 mm. long.

MacGinitie feels that this *Panax* is not really a *Panax* but since the Douglass Creek specimens are relatively well preserved they are included in the flora and the name *Panax andrewsii* is retained.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

Plant impressions representing 14 families, 21 genera, and 25 identifiable species, three of which are new, form the basis for this report. They come from beds in western Montana that were originally thought to be lowermost Oligocene (Chadronian) on the basis of vertebrate and invertebrate remains (Konizeski, 1961). Comparison of these plant fossils with those of other Tertiary localities and analysis of their leaf margins indicate an age of middle Oligocene to middle Miocene.

The animal remains were collected from localities some distance from the plant localities and these beds dip away from the vertebrate beds toward the plant beds. These beds could have undergone constant deposition from Eocene through middle Miocene (Pardee, 1913) and so Konizeski's vertebrates, evidently located near the base of the section, could be lowermost Oligocene while the plant beds, located seemingly near the top of the section, could be the middle Oligocene to middle Miocene age indicated by the plants. Thus, it is likely that these beds could span this broad spectrum of Tertiary time.

While this florule is relatively small, it is important in providing our first source of information about vegetation of this time in western Montana.
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EXPLANATION OF PLATE I

Figures - All figs. IX.

1-2. Fossil sites.

3. Typha sp. .......................................................... 29
   Holotype: U. Mont. P.C. #812

4-5. Equisetum sp. .................................................. 20
   Holotypes: U. Mont. P. C. #814, P. C. #815

6-8. Abies longirostris Knowlton .................................. 21
   Hypotypes: U. Mont. P. C. #829, P. C. #830, P. C. #831

9. Cyperacites cf. lacustris ..................................... 30
   Holotype: U. Mont. P.C. #813

10. Abies laticarpa MacGinitie .............................. 21
    Hypotype: U. Mont. P.C. #828

11-16. Abies spp. .................................................. 22

17. Picea lahontensis MacGinitie ............................... 22
    Hypotype: U. Mont. P.C. #829

18-21. Picea magna MacGinitie .................................. 23

22-23. Pinus wheeleri Cockerell .................................. 25
    Hypotypes: U. Mont. P.C. #841, P.C. #840

24-25. Pinus monticolaensis Berry. .............................. 24
    Hypotypes: U. Mont. P.C. #842, P.C. #843

26. Unidentified Pinus seed
    Holotype: U. Mont. P.C. #878

    Hypotypes: U. Mont. P.C. #867, P.C. #868

29-32. Pinus spp. .................................................. 25
    Holotypes: U. Mont. P.C. #869, P.C. #870, P.C. #871, P.C. #877
EXPLANATION OF PLATE II

Figures - All figs. IX.

1-3. *Sequoia affinis* Lesquereux .................. 27
    Hypotypes: U. Mont. P.C. #855, P.C. #872,
                P.C. #876

4. *Alnus helmillosensis* sp. nov. ................. 31
    Holotype: U. Mont. P.C. #851

5-7. *Alnus retata* (Knowlton) Brown ............... 31
    Hypotypes: U. Mont. P.C. #854, P.C. #858,
                P.C. #859

8. *Fagus drummondensis* sp. nov. .................. 34
    Holotype: U. Mont. P.C. #852

9-11, 13, 14. *Quercus corporalis* Newberry ........ 33
    Hypotypes: U. Mont. P.C. #817, P.C. #818,
                P.C. #819, P.C. #820, P.C. #821

12. *Quercus convexa* Lesquereux ................... 33
    Holotype: U. Mont. P.C. #822
EXPLANATION OF PLATE III

Figures - All figs. IX.

1. Quercus consimilis Newberry ......................... 33
   Hypotype: U. Mont. P.C. #856

2, 4. Quercus convexa Lesquereux ......................... 33
   Hypotypes: U. Mont. P.C. #823, P.C. #824

3. Ulmus sp. ........................................... 35
   Holotype: U. Mont. P.C. #849

5. Mahonia limirivuli Becker ......................... 37
   Hypotype: U. Mont. P.C. #873

6. Zelkova oregoniana (Knowlton) Brown ......................... 35
   Hypotype: U. Mont. P.C. #853

7-8. Mahonia spp. ........................................... 37
   Holotypes: U. Mont. P.C. #874, P.C. #875

9-10. Ribes auratum Becker ......................... 39
   Hypotypes: U. Mont. P.C. #846, P.C. #847

11. Ceroocarpus milleri sp. nov. ......................... 40
    Holotype: U. Mont. P.C. #860

12. Ceroocarpus antiquus Lesquereux ......................... 40
    Hypotype: U. Mont. P.C. #848

13. Amelanchier scudderi Cockerell ......................... 42
    Hypotype: U. Mont. P.C. #816

14-19. Rosa hiliacea Lesquereux ......................... 41
    Hypotypes: U. Mont. P.C. #861, P.C. #862,
                P.C. #863, P.C. #864, P.C. #865, P.C. #866

20. Astronium truncatum (Lesquereux) MacGinitie ........ 43
    Hypotype: U. Mont. P.C. #811
EXPLANATION OF PLATE IV

Figures - All figs. IX.

1. *Acer cf. florissanti* Kirchner ........................................... .44
   Hypotype: U. Mont. P.C. #857

2. *Acer sp.* (samara) ............................................................. .45
   Holotype: U. Mont. P.C. #850

3-5. *Lindera coloradica* MacGinitie ........................................ .46
   Hypotypes: U. Mont. P.C. #825, P.C. #826, P.C. #827

6-7. *Panax andrewsii* Cockerell ............................................ .47
   Hypotypes: U. Mont. P.C. #844, P.C. #845

8. Unidentified Fish scale.
   Holotype: U. Mont. P.C. #880