

THE FLORA OF THE ESMERALDA FORMATION IN WESTERN NEVADA

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INTRODUCTION

The beds to which the name Esmeralda formation was given comprise sandstones, shales, lacustral marls, with local fanglomerates and conglomerates on a large scale. These outcrop at intervals over a large area in the Great Basin of western Nevada. They were described by H. W. Turner in 1900, and their thickness was estimated as exceeding 14,000 feet. It was suggested that deposition may have covered parts of Miocene and Pliocene time, since the fossils, namely: Fresh-water mollusks, a fish, and fossil plants, were all from near the base of the formation.¹ The fossil plants were described by Knowlton² in the same report.

Fourteen species were recognized, and all but one of these were regarded as new. An additional small collection was made from these beds by S. H. Cathcart in 1924, and this forms the basis of the present paper. The Esmeralda flora as now revised comprises the following species:

REVISED FLORA OF THE ESMERALDA FORMATION

Pteridophyta.

Hydropterales.

Salviniaceae.

Azolla tertiaria Berry.

Polypodiales.

Polypodiaceae.

Dryopteris obscura Knowlton.

Spermatophyta.

Monocotyledonae.

Pandanales.

Typhacae.

Typha lesquereuxi Cockerell.

¹ Turner, H. W., U. S. Geol. Surv. 21st Ann. Rept., pt. 2, pp. 191-208, 1900. A preliminary account appeared in vol. 25 of the American Geologist in the same year.

² Knowlton, F. H., Idem., pp. 209-220, pl. 30.

Naiadales.

Naiadaceae.

Potamogeton knowltoni Berry.

Dicotyledonae.

Choripetalae.

Salicales.

Salicaceae.

Salix inquirenda Knowlton.*Salix knowltoni* Berry.*Salix* sp., Knowlton.*Salix* (?) sp., Knowlton.*Populus lacustris* (Knowlton) Berry.

Fagales.

Fagaceae.

Quercus simulata truncata Berry.*Quercus turneri* Knowlton.*Quercus argentum* Knowlton.

Ranales.

Ceratophyllaceae.

Ceratophyllum fossilium Berry.

Nymphaeaceae.

Castalia (?) sp., Berry.

Rosales.

Rosaceae.

Chrysoalanus pollardiana Knowlton.

Caesalpiniaceae.

Cercis (?) *nevadensis* Knowlton.

Sapindales.

Anacardiaceae.

Rhus (?) *nevadensis* Knowlton.

Sapindaceae.

Sapindus lancifolius Lesquereux.

Myrtales.

Hydrocaryaceae.

Trapa americana Knowlton.

Gamopetalae.

Ericales.

Vacciniaceae.

Vaccinium ellipticum Berry.*Vaccinium vacciniifolia* (Knowlton) Berry.

Rubiales (?).

Rubiaceae (?).

Cinchonidium (?) *turneri* Knowlton.

CHARACTER OF THE ESMERALDA FLORA

As shown in the foregoing list, this flora contains but 22 species. These represent 16 genera in 15 families and 12 orders. Two are Pteridophytes and the balance Spermatophytes. The seed plants represent 2 monocotyledons and 18 dicotyledons, there being no traces of conifers. Fifteen of the dicotyledons belong to the choripetalous division.

The flora is remarkable in containing representatives of six genera of hygrophilous plants, and since aquatic vegetation is largely conditioned by the presence or absence of water, it does not conform closely to life zones based upon terrestrial forms. Thus the following genera found in the Esmeralda formation, namely, *Azolla*, *Typha*, *Potamogeton*, and *Ceratophyllum* are all present in the present-day semiarid Upper Sonoran zone; *Castalia*, a genus tentatively recognized in the Esmeralda flora, occurs in the transition to the Hudsonian zone; and the sixth genus—*Trapa*—has been extinct in North America since the Pliocene.

These aquatic plants show conclusively the presence of a permanent water body in western Nevada in the Miocene, and this is reinforced by the presence in these deposits of the leaves of such stream and lakeside types as *Salix* and *Populus*, and mesophytic genera such as *Cercis*. This being so, the plants can not give us much definite information about the regional climate, beyond the fact that it was temperate and there was a sufficient source of supply to maintain permanent bodies of fresh water. The abundance of silicified wood, the presence of tree trunks said to be 6 to 8 feet in diameter, and the very considerable thickness of coal seams would seem to indicate a much greater humidity than prevails at the present time in this region, and perhaps justifies Turner's picture of the environment of Lake Esmeralda, as he christens it. This is rendered more probable by the wide distribution of diatomaceous beds throughout the Esmeralda formation. Frequently the matrix of the present collection is unusually rich in fresh-water diatoms.

Dicotyledonous leaves are prevailingly macerated, coriaceous forms, and are not abundant. Of the oaks, *Quescus turneri* suggests a chaparral form; and *Chrysobalanus*, *Rhus*, and *Sapindus* are all forms that are at home in a semiarid environment. The sparsity and in general broken character of these last-mentioned forms suggest that they may have been brought into the basin of sedimentation by streams, but the willow and *Cercis* leaves are equally rare and broken, so that the temptation to press the evidence further than is warranted must be resisted, and the conclusion is reached that the present flora does not furnish conclusive evidence regarding the regional environment.

AGE OF THE FLORA

The age of this flora can now be much more decisively indicated. Sixteen of the 22 species of plants recorded from the Esmeralda formation are not known in other areas and are therefore of slight value in correlation. The remainder show the following distribution:

	Florissant, Colo.	Mascall, Oreg.	Latah, Wash.	Payette, Idaho
<i>Typha lesquereuxi</i> , Cockerell.....	×		(?)	
<i>Salix inquirenda</i> Knowlton, (?).....		×	×	
<i>Salix knowltoni</i> Berry.....				×
<i>Quercus simulata truncata</i> Berry.....			(?)	×
<i>Sapindus lancifolius</i> Lesquereux.....	×			
<i>Trapa americana</i> Knowlton.....				×

The exact age of Florissant, the Mascall, Latah, and Payette formations has been the source of considerable differences of opinion in the past. Both the Florissant and Mascall beds are now generally considered to be middle Miocene, although Knowlton's latest unpublished opinion was that the Florissant flora was upper Miocene, and I think the evidence for this is reasonably conclusive. The Latah and Payette floras are similarly considered Miocene, although agreement has not been reached as to just what part of the Miocene they represent. After studying large recent collections from the Latah formation I have concluded that it is not older than middle Miocene and probably younger, so that the Esmeralda flora seems to me to show conclusively that it is not older than middle Miocene and is almost certainly upper Miocene. This conclusion from the plant evidence coincides with J. W. Gidley's age determination of the Esmeralda vertebrates.

Phylum PTERIDOPHYTA

Order HYDROPTERALES

Family SALVINIACEAE

Genus AZOLLA Lamarck

AZOLLA TERTIARIA, new species

Plate 1, figs. 9, 10

The basis of this species is a considerable number of whole plants and scattered plant fragments at certain horizons in the clay where they are preserved as impressions. The plant body in the best-preserved examples is about a centimeter in diameter and consists of a flat branched stem covered with tiny oval leaves somewhat variable in shape, slightly under a millimeter in length, generally crowded and imbricated, becoming densely so around the periphery where they are more rounded and distinctly concavo-convex.

The certain remains of sporocarps have not been detected because of the poorness of preservation, but certain parts of the fossils distinctly suggest that they represent microsporocarps since they show impressions of small globular bodies that resemble microsporangia, although they may be massulae.

It is most unfortunate that this interesting form which looks so convincing to the naked eye fails to fulfill its promise of detail when magnified. I am quite sure that it is an *Azolla*, and it is of especial interest since no fossil species of this genus, except the remains of an existing species in the European Pleistocene, have been known until recently. Last year Reid and Chandler³ described the very complete remains of a species, *Azolla prisca*, from the Oligocene of the Isle of Wight, in which they were able to make out, most conclusively, most of the details of organization. It was this discovery and the resemblance of the Esmeralda fossils to the English material which convinced me of the nature of the former.

Occurrence.—Coal prospect 4 miles southeast of Morgan Ranch and 15 miles west of Hawthorne, Mineral County, Nev.

Holotype.—Cat. No. 37299, U.S.N.M.

Order POLYPODIALES

Genus DRYOPTERIS Adanson

DRYOPTERIS OBSCURA (Knowlton) Berry

Gleichenia (?) *obscura* KNOWLTON, U. S. Geol. Surv. 21st Ann. Rept., pt. 2, p. 210, pl. 30, figs. 1-4, 1901.

Dryopteris (?) *gleichenoides* KNOWLTON, U. S. Geol. Surv. 21st Ann. Rept., pt. 2, p. 211, pl. 30, figs. 5-7.

These two nominal species of ferns are clearly different parts of the pinnae of a single botanical species. They are not represented in the recent collections studied by me. In the absence of fruiting characters the reference to *Dryopteris* is not conclusive, although their form and venation suggest such a reference. They are certainly not related to *Gleichenia* aside from the improbability of the occurrence of this genus in Nevada in Miocene time associated with a flora such as that indicated by the other Esmeralda plants.

³ Reid, E. M., and Chandler, M. E. J., The Bembridge flora, p. 40, figs. 2, 3, pl. 1, figs. 14-24, 1926.

Phylum SPERMATOPHYTA

Order PANDANALES

Family TYPHACEAE

Genus TYPHA Linnaeus

TYPHA LESQUEREUXI Cockerell

Plate 1, figs. 13-15

Typha latissima LESQUEREUX, U. S. Geol. Surv. Terr. Rept., vol. 8 (Cretaceous and Tertiary floras), p. 141, pl. 23, figs. 4, 4a, 1883.—PENHALLOW, Tert. Pl. British Columbia Rept., p. 93, 1908.

Typha lesquereuxi COCKERELL, Torrey Bot. Club. Bull., vol. 33, p. 307, 1906; Univ. Colorado Studies, vol. 3, p. 175, 1906.—KNOWLTON, U. S. Nat. Mus. Proc., vol. 51, p. 251, 1916.

Spathyema? nevadensis KNOWLTON, U. S. Geol. Surv. 21st Ann. Rept., pt. 2, p. 211, pl. 30, figs. 17, 18, 1900.

There are numerous fragmentary leaves of this genus in the Esmeralda formation. Associated with these are numerous flattened rhizomes, with rootlet scars, which I have tentatively considered to represent the same species, although they might, perhaps, equally well be considered to be the rhizomes of some large semiaquatic grass. Their precise identification is not so important as the fact that they undoubtedly represent the peculiar fragments from these beds which Knowlton called *Spathyema* (?) *nevadensis* and thought were fragments of a spadix of some monocotyledonous plant.

The present leaves are referred to the same species as those from Florissant, Colo., with which they are in entire agreement, although it is obvious that the leaves of *Typha* show no trustworthy specific characters.

The genus embraces about a dozen existing species of marsh and aquatic plants, widely distributed in temperate and tropical regions. There are two species in eastern North America, and one survives on the Pacific slope in California.

A variety of uncertainly identified leaf fragments from the mid-Cretaceous upward have been referred to *Typha*. More recently Reid and Chandler⁴ have described characteristic fruits and seeds associated with leaves from the Oligocene of southern England.

Occurrence.—Coal prospect 4 miles southeast of Morgan Ranch and 15 miles west of Hawthorne, Mineral County, Nev.

Plesiotypes.—Cat. No. 37,300, U.S.N.M.

⁴ Reid, E. M., and Chandler, M. E. J., The Bembridge flora.

Order NAIADALES

Family NAIADACEAE

Genus POTAMOGETON Linnaeus

POTAMOGETON KNOWLTONI, new species

Plate 1, figs. 5-8

I have referred to a single botanical species the abundant leaves and fruits of an unusually well preserved *Potamogeton*, a description of which Doctor Knowlton was contemplating publishing at the time of his death. This may appropriately be named in his honor and may be described as follows:

Floating leaves narrowly to broadly elliptical in outline, narrowly to broadly rounded distad; the entire margins decurring proximad to the broad flat petioles, which are sometimes preserved for lengths of 6 centimeters. These leaves range in size from 2.5 by 0.6 centimeters to 5 by 2.25 centimeters, average sized specimens being shown in the accompanying figures. The petioles, which are about 2 millimeters wide, consist of a central, fairly stout vascular strand, bordered throughout by the winged margins extending downward from the leaf lamina and these show three or four thin parallel vascular strands on each side. The mid vein of the lamina is about twice as thick as the laterals. These are four to nine in number on each side, diverging in the base and converging in the tip at about equally acute angles. They are usually simple and acrodrome and approximately equally spaced, but occasionally one will fork a considerable distance above the base. In the better preserved material each alternate lateral is thinner than its adjacent fellows. All are connected by thin obliquely transverse veinlets.

The leaves are present in abundance in the clays and are strikingly similar to the floating leaves of a number of still existing American species such as *Potamogeton nuttalli* Chamisso and Schlechtendal, which, however, has shorter petioles, and *Potamogeton faxoni* Morong. Species of *Potamogeton* are wide-ranging and variable in their foliar characters, and no especial significance, either systematic or ecologic, can be attached to the above comparisons.

The associated fruits, of which four or five specimens have been detected among the leaves, are compressed as preserved in the clays, about 3 millimeters in length and 2 millimeters in maximum diameter. The exocarp is rather delicate and frequently incompletely preserved, with a smooth surface. The ventral margin appears to have normally been nearly straight or slightly excavated, although

it is somewhat rounded in the second specimen figured. It is produced into a short and stout recurved style. There is a more or well-developed sinus at the base resulting in a blunt point on the ventral side and a more prominent and sharper point on the dorsal side. The dorsal margin or keel is smooth and nearly semicircular in profile. The endocarp or seed was obviously crustaceous, since it usually stands out sharply and distinctly from the collapsed exocarp. It is pronouncedly campylotropous, the radicular end, twice the diameter of the much curved distal end lying close to the basal sinus and toward the dorsal margin. In the second, and what is believed to be the more typical, form figured a portion of the resistant seed coat offset and reversed along the upper dorsal margin.

These fruits are much like those of a large number of existing species of *Potamogeton* without being significantly like any particular one.

The genus contains about 70 widely distributed existing species of temperate regions. It is not infrequent in the geological record, although few fossil species are as well preserved as the present one. Upwards of 50 fossil species have been described ranging in age from the Upper Cretaceous to the Pleistocene, and the genus is very well represented by still existing species at the latter horizon. A characteristic species, *Potamogeton ripleysensis* Berry,⁵ from the Ripley Upper Cretaceous of western Tennessee is quite similar in its foliage to the present Esmeralda form.

Occurrence.—Coal prospect 4 miles southeast of Morgan Ranch and 15 miles west of Hawthorne, Mineral County, Nev.

Cotypes.—Cat. No. 37301, U.S.N.M.

Order SALICALES

Family SALICACEAE

Genus SALIX Linnaeus

SALIX INQUIRENDA Knowlton (?)

Salix inquirenda KNOWLTON, U. S. Geol. Surv. Prof. Paper 140, p. 32, pl. 11, figs. 1, 2, 1926.

Salix angusta AL BRAUN, KNOWLTON. U. S. Geol. Surv. 21st Ann. Rept., pt. 2, p. 212, pl. 30, fig. 22, 1901.

Knowlton referred a fragment of a small willow leaf from the Esmeralda formation to *Salix angusta* Al. Braun—a European Tertiary form. The fact that it has been recorded from as various western American horizons as the Mesaverde, Lance, Green River,

⁵ Berry, Edward W., The flora of the Ripley formation: U. S. Geol. Surv. Prof. Paper 136, p. 34, pl. 3, fig. 5; pl. 23, figs. 1-3, 1925.

and Mascall formations is in itself sufficient evidence of the vagueness of such long-range identifications. There can not be the slightest doubt but that this Esmeralda willow is a different species from Braun's European form.

In a recent study of the flora of the Latah formation of eastern Washington I have referred exactly similar small *Salix* leaves to the normally larger *Salix inquirenda*, and since the Esmeralda and Latah formations are not especially remote geographically and are of approximately the same age, I have made a similar disposition of this Esmeralda form.

SALIX KNOWLTONI, new species

Plate 2, fig. 1

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

This species was described from the Payette formation of Idaho as a *Myrica*, which it is not. It is represented in the Esmeralda formation by numerous fragments, which show it to have been a linear-lanceolate, entire margined *Salix*.

Occurrence.—Coal prospect 4 miles southeast of Morgan Ranch and 15 miles west of Hawthorne, Mineral County, Nev.

Holotype.—Cat. No. 37302, U.S.N.M.

Genus POPULUS Linnaeus

POPULUS LACUSTRIS (Knowlton) Berry

Ficus lacustris KNOWLTON, U. S. Geol. Surv. 21st Ann. Rept., pt. 2, p. 215, pl. 30, fig. 26, 1901.

The single incomplete specimen which is the type and only known specimen of this species has no features warranting it reference to the genus *Ficus*. On the other hand, so far as they are shown the form, margin, and venation are characteristic of the genus *Populus*, to which I have accordingly transferred it.

Order FAGALES

Family FAGACEAE

Genus QUERCUS Linnaeus

QUERCUS SIMULATA TRUNCATA, new variety

Plate 2, fig. 3

Leaves of various sizes, represented in the Esmeralda formation by several fragments and by the single complete leaf figured. This differs from the type, which came from the Payette formation near

Marsh, Idaho,⁶ merely in its more truncate base, a feature of doubtful value. Since, however, the numerous leaves of what has been considered by Knowlton⁷ to be this species in the Latah formation of Washington fail to show the basal features of this *Esmeralda* form, I have felt constrained to give it a varietal name.

Occurrence.—Coal prospect 4 miles southeast of Morgan Ranch and 15 miles west of Hawthorne, Mineral County, Nev.

Holotype.—Cat. No. 37303, U.S.N.M.

Order RANALES

Family CERATOPHYLLACEAE

Genus CERATOPHYLLUM Linnaeus

CERATOPHYLLUM FOSSILIUM, new species

Plate 1, figs. 2-4

Nut or achene moderately compressed, elliptical in profile, highly but variably spined over much of the surface. The style is persistent and becomes a beak, which in one specimen is preserved for a length of 5 millimeters. The margin is narrowly winged and bears a variable number of spines of various lengths; some mere mucronate teeth, others long and slenderly incurved or recurved. The basal spine on each side, usually termed spurs, are invariably present and well developed and in instances are preserved for a length of 4 millimeters. Four specimens have been available for study, and these are rather uniform in size and form but show considerable variation in the degree of development of the marginal spines. The average length of the four fruits is extremely close to 6 millimeters, and the maximum width ranges from 3.5 to 4 millimeters. The fossil is thus well within the limits of size of the nuts of the existing species. The beak, spurs, and those spines which are developed beyond the tooth stage become exceedingly slender distad, and in no case is it certain that their delicate tips have been fossilized. This is all the more probable since in those existing species which are spinose the beak and spurs are relatively longer than they are in the fossil. Three of the four specimens are figured to show the variations exhibited. All three contain lignified portions of the original fruit showing that it was decidedly resistant and that, allowing for compression during fossilization, it has retained a thickness of

⁶ Knowlton, F. H., The fossil plants of the Payette formation: U. S. Geol. Surv. 18th Ann. Rept., pt. 3, p. 728, pl. 101, figs. 3, 4; pl. 102, figs. 1, 2, 1898.

⁷ Knowlton, F. H., Flora of the Latah formation of Spokane, Wash., and Coeur d'Alene, Idaho: U. S. Geol. Surv. Prof. Paper 140, p. 38, pl. 22, figs. 3, 4, 1926.

slightly under 1 millimeter. The fourth specimen is an impression and the punctate surface of the matrix shows that the surfaces of the fruit were spinose. The clays are in places packed with the macerated slender linear plant tissues which, in part at least, are believed to represent the foliage of *Ceratophyllum*. In some cases these are seen to be dichotomously forked, and I have illustrated two of the clearer of these objects. (Cat. No. 37309, U.S.N.M.) They are obviously incomplete, as is definitely shown by the larger of the two, in which the artist has attempted to indicate the disintegration of the more delicate distal portions of the leaf as it is preserved in the clay.

The existing hornwort is a gregarious, completely submerged aquatic of ponds and slow streams, which is of rather unusual botanical interest, since it is one of the few aquatic vascular plants which has altogether lost the habit of aerial pollination. In *Ceratophyllum* the pollen is carried to the surface by the buoyant stamens which then dehisce, and the released pollen sinks slowly through the water until it comes in contact with the stigmas of the ovulate flower. This represents possibly the highest degree of aquatic specialization in a descendant of a terrestrial ancestor and is correlated with rootlessness and the entire loss of vascular tissue in the stem.

Ceratophyllum is practically cosmopolitan in the existing floras, occurring on all of the continents (except Antarctica) and on oceanic islands such as the Bermudas and Fijis, which raises interesting questions with respect to its means of dispersal and possible antiquity. The fruits sink at once and the plant is soon killed by sea water or exposure to the atmosphere, so that currents can hardly be the agents of dispersal over great distances, which would seem to have been due to the transportation of the seeds by wading birds.

The systematic position of the genus has also been a mooted point which seems now to be fairly well settled as a much reduced relative of the Cambombaceae.

Systematists recognize from one to three existing species based on the presence or absence of the marginal wing and basal spurs, but it must be admitted that a great variability in these features prevails. In North America *Ceratophyllum demersum* Linnaeus is found in appropriate environments everywhere except in the far northern part. Although the in general great geographical range of most aquatics is fully recognized it would seem that cosmopolitanism would demand some specific differentiation. The geological history of *Ceratophyllum* is exceedingly obscure.

The known geological occurrences of *Ceratophyllum* at pre-Pleistocene horizons have been few and unconvincing. Ettingshausen recorded some stem nodes and very indefinite fruits from the supposed

Cretaceous of Australia as *Ceratophyllum australe*, but these are hardly convincing enough to have any weight.⁸ This same author identified equally indefinite leaf fragments and stem nodes from the Miocene of Leoben and Schönegg in Styria as *Ceratophyllum tertiarium*.⁹ Saporta described some stem impressions with verticillate leaves from the Aquitanian of France as *Ceratophyllum aquaticum*.¹⁰ Certain spiny fruits from the lower Eocene of Tennessee have been described by the present writer (*Ceratophyllum incertum* Berry *MS.*) which if actually related to *Ceratophyllum* are by far the oldest record of the genus.

During the Pleistocene numerous occurrences of fruits not to be distinguished from the variations seen in the fruits of the existing plant have been recorded from Canada and the United States, England, and Germany.

Occurrence.—Coal prospect 4 miles southeast of Morgan Ranch and 15 miles west of Hawthorne, Mineral County, Nev.

Cotypes.—Cat. No. 37304, U.S.N.M.

Family NYMPHAEACEAE?

Genus CASTALIA? Salisbury

CASTALIA? sp.

Plate 1, fig. 1

Small elliptical, equilateral, and apparently somewhat compressed seeds with a dense coat, about 3.25 millimeters long and 2.5 millimeters in width. There are several of these seeds in the collection. Their preservation does not disclose features sufficient to substantiate their supposed affinity, and they are therefore tentatively identified.

The genus *Oastalia* has about 30 existing species of large aquatic herbs, widely distributed in fresh water but absent on the present Pacific slope, although present in eastern Asia. It is present in the former region in the earlier Tertiary but has not been detected in the Miocene or later epochs.

Occurrence.—Coal prospect 4 miles southeast of Morgan Ranch and 15 miles west of Hawthorne, Mineral County, Nev. (Cat. No. 37305, U.S.N.M.)

⁸ Ettingshausen, C. von, Kreideflora von Australien. Denkschr. K. Akad. Wiss., vol. 62, p. 14, pl. 1, figs. 14, 15, 1895.

⁹ Ettingshausen, C. von, Fossile Flora von Schonegg in Steiermark. Denkschr. K. Akad. Wiss., vol. 57 (Foss. Fl. Schönegg, pt. 1), p. 87 (27), pl. 3, figs. 4-15, 1890.

¹⁰ Saporta, Gaston de, Recher. Végét. niv. Aquitanien de Manosque. Mém. Soc. Géol. France, vol. 2, p. 19, pl. 2, figs. 8-10, 1891.

Order SAPINDALES

Family SAPINDACEAE

Genus SAPINDUS Linnaeus

SAPINDUS LANCIFOLIUS Lesquereux

Plate 2, fig. 2

Sapindus lancifolius LESQUEREUX, U. S. Geol. Surv. Terr. Rept., vol. 8 (Cretaceous and Tertiary floras), p. 182, pl. 32, figs. 3-6, pl. 37, fig. 9, 1883.—KNOWLTON, U. S. Nat. Mus. Proc., vol 51, p. 283, 1916.

This species was described from Florissant, Colo., to which locality it has hitherto been confined. Similar leaflets are present in the Esmeralda formation, the only observable difference being the shorter petiolule of the latter. It is undoubtedly a *Sapindus* and not sufficiently distinct from the Florissant form to warrant considering it to represent a different species.

The genus is an old one, found throughout North America in the older Tertiary and abundant at Florissant and in the Mascall beds of Oregon during the Miocene. The existing species number about 40, widely distributed through the Tropics of both Hemispheres, most abundant in the Asiatic region, and extending for considerable distances into the temperate zone, as in the case of the three species found in the United States, one of which (*Sapindus drummondii* Hooker and Arnott) is found as far north as southern Kansas, New Mexico, and Arizona.

Occurrence.—Coal prospect 4 miles southeast of Morgan Ranch and 15 miles west of Hawthorne, Mineral County, Nev.

Plesiotypes.—Cat. No. 37306, U.S.N.M.

Order MYRTALES

Family HYDROCARYACEAE

Genus TRAPA Linnaeus

TRAPA AMERICANA Knowlton

Plate 2, figs. 5, 6

Trapa americana KNOWLTON, U. S. Geol. Surv. 18th Ann. Rept., pt. 3, p. 733, pl. 102, fig. 7a, 1898.

Trapa? occidentalis Knowlton, U. S. Geol. Surv. 18th Ann Rept., pt 3, p. 734, pl. 102, fig. 7b, 1898.

This species was described by Knowlton from the Payette formation near Idaho City, Idaho. He fancied that he had representatives of two distinct species, but in the light of the abundant remains now

found in the Esmeralda formation, which are of all sizes and of every conceivable shape and attitude due to their compression in the clays after having been rendered slightly plastic by maceration there can be no doubt but that only a single species is represented.

There are three species of *Trapa* in the existing flora, none of which is native to the Western Hemisphere, although the European species is more or less naturalized in the northeastern United States. *Trapa natans* Linnaeus, which normally has four horns, is now endemic in central and southern Europe, although during the Pleistocene it was abundant in England, Scandinavia, Denmark, and Russia. The two existing Asiatic species—*Trapa bicornis* Linnaeus and *Trapa bispinosa* Roxburg—of eastern and southern Asia and Africa are normally two-horned.

Considerable of the geological history of the genus is known. Rosettes supposed to represent floating leaves, but of doubtful identity, are widespread in the Rocky Mountain region of North America in formations of late Upper Cretaceous to early Eocene age (*Trapa ? microphylla* Lesquereux, *Trapa ? cuneata* Knowlton). The oldest fruits are relatively small ones from the lower Eocene (Wilcox) of the Mississippi embayment. There is a two-horned species in the Upper Eocene of Alaska and western Canada, an Oligocene species in Saxony, several Miocene species in Japan, Europe, and the western United States, and a fine Pliocene species from southern Alabama, marking the latest known occurrence of the genus in North America.

Occurrence.—Coal prospect 4 miles southeast of Morgan Ranch and 15 miles west of Hawthorne, Mineral County, Nev.

Plesiotypes.—Cat. No. 37307, U.S.N.M.

Order ERICALES

Family VACCINIACEAE

Genus VACCINIUM Linnaeus

VACCINIUM ELLIPTICUM, new species

Plate 2, fig. 4

Leaves small, elliptical in outline. Margins entire. Texture coriaceous. Apex full and evenly rounded. Base less full and conceivably narrowed if there was material of this form to show variations. Length 1.25 centimeters. Maximum width 8 millimeters. Mid vein stout, immersed, becoming thin distad. Secondaries thin, three or four ascending pairs, camptodrome.

The species is based upon the single small leaf figured, which shows the features of this genus. It may have been carried into the basin

of sedimentation from higher levels, since it is both tiny and coriaceous. The genus has not before been found in the later Tertiary of western North America, although it occurs in the Pleistocene of that region, as well as in the existing flora of the Pacific slope from Alaska southward. The modern species are shrubs or small trees, about 125 in number, and holarctic in their distribution, occurring also in the Southern Hemisphere, and from their present distribution obviously of ancient lineage, although their geological history is very imperfectly known. The present species is not unlike some of the leaves of the wide-ranging existing *Vaccinium uliginosum* Linnaeus and *Vaccinium vitis-idaea* Linnaeus.

Occurrence.—Coal prospect 4 miles southeast of Morgan Ranch and 15 miles west of Hawthorne, Mineral County, Nev.

Holotype.—Cat. No. 37308, U.S.N.M.

VACCINIUM VACCINIFOLIA (Knowlton) Berry

Salix vaccinifolia KNOWLTON, U. S. Geol. Surv. 21st Ann. Rept., pt. 2, p. 212, pl. 30, figs. 8, 20, 1901.

These small, entire, subcoriaceous leaves are not those of a willow, and I have therefore transferred them to the genus *Vaccinium*, which they resemble in size, texture, margins, and venation.

EXPLANATION OF PLATES

PLATE 1

FIG. 1. *Castalia* (?) sp. seed, $\times 2$.

2-4. *Ceratophyllum fossilium* Berry, natural size.

5-8. *Potamogeton knowltoni* Berry.

Figs. 5, 6. Leaves, natural size.

7, 8. Fruits $\times 5$.

9, 10. *Azolla tertiaria* Berry.

Fig. 9. Plant natural size.

10. Same $\times 6$.

11, 12. Leaves referred to *Ceratophyllum*.

Fig. 11, $\times 2$; Fig. 12, $\times 3$.

13-15. Rhizomes referred to *Typha*.

Figs. 13, 14, natural size; Fig. 15, $\times 2$.

PLATE 2

FIG. 1. *Salix knowltoni* Berry.

2. *Sapindus lancifolius* Lesquereux.

3. *Quercus simulata truncata* Berry.

4. *Vaccinium ellipticum* Berry, $\times 2$.

5, 6. *Trapa americana* Knowlton, $\times 2$.

7. An alga, *Fontinalis* or submerged foliage, $\times 2$.





1



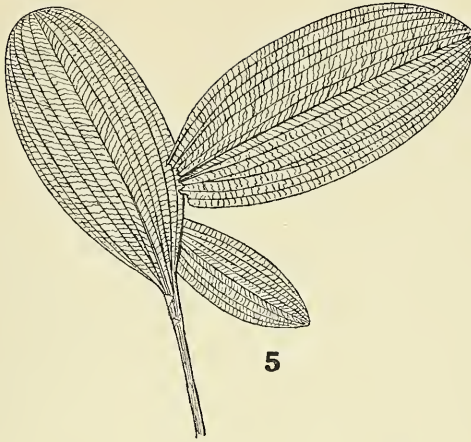
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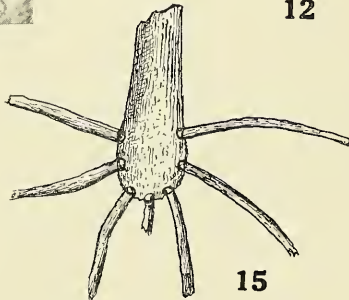
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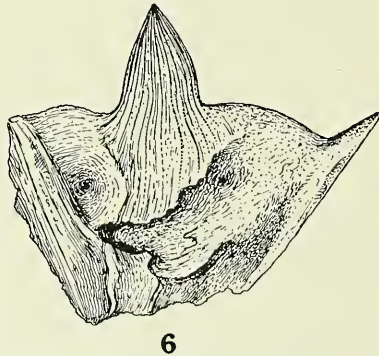
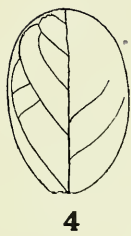
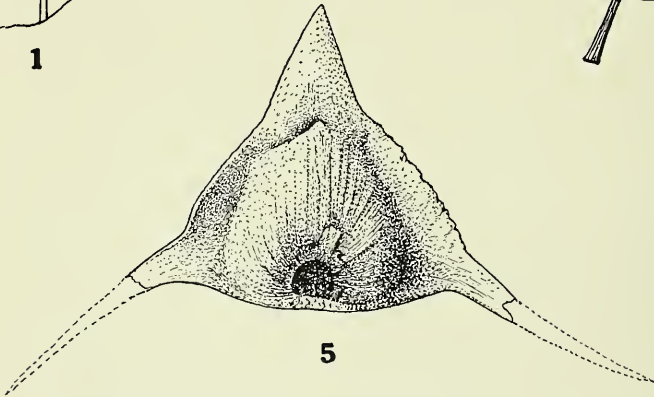
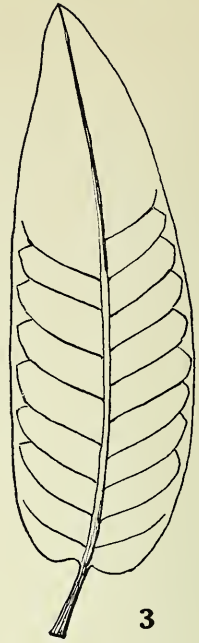
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FLORA OF THE ESMERALDA FORMATION

FOR EXPLANATION OF PLATE SEE PAGE 15



FLORA OF THE ESERALDA FORMATION

FOR EXPLANATION OF PLATE SEE PAGE 15

