THE UPPER DEVONIAN FOREST OF SEED FERNS IN EASTERN NEW YORK

BY WINIFRED GOLDRING

The "Gilboa trees" have been known to science for over half a century, but only within the last 3 years has it been discovered that New York actually had an extensive and very ancient fossil forest in its eastern domain. This forest remained hidden away in the Upper Devonian (Ithaca) rocks of Schoharie until 1869. In the fall of this year a great freshet swept the upper valley of the Schoharie in the vicinity of the village of Gilboa tearing out bridges, culverts and roadbeds, but greatly benefiting science by exposing in the bedrock standing stumps of trees.

The discovery of these trees was described in the Albany Argus of January 30, 1870, and in the 24th Report of the State Museum;[1] and was considered of so much importance that it was brought by Hall to the attention of the British Association for the Advancement of Science at the Brighton meeting in 1872.[2] Excavations were made during the year 1870 in the beds of sandstone containing these trees and five stumps and a number of fragments were taken out of this ancient forest, all at the same level in the rocks. The greater part of this material was brought to the State Museum where it has for some time constituted a remarkable exhibit of the ancient, extinct flora of the State.

The Gilboa collections were submitted to Sir William Dawson of Montreal for examination, and he determined the fossil trunks to be of two species, which he named Psaronius erianus and P. textilis. The trunks were noted as being in an upright position with their bases resting in and upon a soft shaly stratum, representing the bed of clay in which they appeared to have grown; and the facts of their occurrence led to the conclusion that "we had evidence of comparatively dry land on the eastern margin of the Devonian sea."[3] It was also inferred "that this area during the deposition of these beds was undergoing continuous oscillation of level, with a general downward movement." [3]

This Schoharie, or Gilboa, forest is the earliest recorded forest of the earth. The old locality had long since been covered up and the rocks at the level in which the trees were discovered did not outcrop

[1] Hall, James. 24th Rep't N. Y. State Cab. Nat. Hist., 1872, p. 15, 16.
[2] Rep't Brit. Assoc. Adv. Sci., 1872, v. 42, Trans., p. 103.
[3] Ref. cit., p. 103.

again in this area. Nothing more was heard of these fossil stumps until 1897 when Prosser,[4] then connected with the New York State Survey, reported finding some small specimens, from a higher horizon, lying loose at Manorkill falls about a mile south of Gilboa. Occasional attempts since then to rediscover this ancient forest were fruitless until the summer of 1920 when special effort was made to add to the collection of Devonian plant material already in the hands of the Museum. The effort to relocate the Schoharie forest or to find some additional evidence as to its extent led to the discovery of upright tree stumps not in the original locality but at the higher level, along the road in the vicinity of the lower falls of the Manorkill, a tributary of the Schoharie creek. These trees likewise were found with their bases resting in a bed of shale, greenish black in color. This second tree locality is at a level of 1120 feet A. T.; the old locality, on the same side of the Schoharie creek, just above the old Gilboa bridge, was at a level of 1020 feet A. T. Since 1920 the city of New York has been doing construction work at Gilboa, preparatory to impounding the waters of the Schoharie creek for the future use of its citizens. The resultant dam will drown the village of Gilboa and its vicinity, including the two above-mentioned fossil tree localities. In the course of quarrying in connection with the work on the dam the old locality, which is directly at the spot where the dam is being built, was uncovered and seven trees were found. In a quarry 2300 feet north (downstream) of the old locality trees were found at the 972-foot (one small specimen) and 960-foot levels. This quarry, known now as "Riverside quarry," has yielded the greatest number and also the largest stumps hitherto found. Eighteen specimens were taken from an area 50 feet square, not counting those destroyed in quarrying. One of the largest specimens of this group has a circumference at the base of approximately 11 feet (diameter approximately 3.5 feet), a height of 22 inches and a diameter at that height of 21½ inches; stumps of greater height, but of smaller girth have been obtained.

At all three tree horizons the stumps were found with their bases resting in and upon shale and in every case in an upright position with the trunk extending into the coarse sandstone above. The shale beds vary in thickness from 6 inches to 2 feet; at the lowest horizon, in the place in the quarry where the greatest number of stumps was obtained, the shale had a thickness of only 6 inches.

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[4] Prosser, Charles S., 17 Annual Rep't of N. Y. State Geol., for 1897 (1899), p. 211.

The small specimen found at the 972-foot level was in an upright position and rested upon a black shale layer, about an inch thick, which disappeared entirely a few feet from the stump. The presence of the black shale layer, in the vicinity of the stump would seem to indicate that it was found in the place of its growth; yet it is possible that it may have drifted in and been buried in the upright position in which it was found. At the middle horizon (the old locality) a stump was found 6 feet above the shale layer on which the other stumps that were found rested; but the specimen in this case did not rest upon a shale layer. The present Catskill mountains during this Upper Devonian period constituted the low shore of a shallow sea, the continental land lying off to the east. The coasts of those times were unstable, and it was along the borders of such a coast line that at least three successive forests of these trees reared themselves to great heights, were submerged, destroyed and buried.

With the recent additions to our collection, which we owe to the courtesy of the Commissioners of the New York Board of Water Supply and of Mr J. Waldo Smith, chief engineer, we now have a total of 40 stumps partial or complete, and a number of broken pieces. Taking into connection with these the specimens which have gone to other museums, the weathered stumps discarded, and those destroyed in blasting, the number of stumps taken from these primeval forests probably runs into the hundreds; and further quarrying is continually bringing more to light. The Riverside quarry will not be included in the area covered by the Gilboa dam, but its value as a fossil tree locality will be greatly lessened as soon as the quarrying operations in connection with the dam cease. Now that the rock layers containing the stumps have been located it is quite possible that they can be traced around the hills and found outcropping elsewhere. In the area known, the tree localities have been found stretching over a distance of something more than 1⅔ miles.*

As stated above, these ancient trees were described by Dawson as fern trees belonging to the genus Psaronius and represented by two species erianus and textilis.[5] In the report of the Geological Survey of Canada, 1871, P. textilis is noted as occurring at Gilboa and P. erianus in Madison county. In the 24th Report of the State Museum both are described as having been

* Notices of these recent occurrences have been mentioned in the later reports of the Director of the Museum, and an illustrated article entitled "The Oldest of the Forests" by John M. Clarke was published in the *Scientific Monthly*, January, 1921, pp. 83–91.

[5] Geol. Surv. Canada, 1871, p. 58, 59; Quart. Jour. Geol. Soc., 1871, 27:269; 1882, 37:307.

found in Schoharie county (Gilboa); and both species, in fact, are being obtained today from this area. The name Psaronius was inappropriately used for these trees, and indeed they belong to an entirely different group. The structure of Psaronius has been worked out in a most elaborate manner.[6] This genus contains a large number of species from the Permo-carboniferous strata, all of which agree in having a highly complex polystelic organization, comparable to that of the most highly differentiated fern stems of the present day. Psaronius, therefore, is a true fern, or Pteridophyte.

Even when it was definitely known that these trees did not belong with Psaronius, the problem of their relationship still remained, though it was recognized that the cortical structure bore a resemblance to that of Lyginodendron. The name Lyginodendron[7] was first given to a specimen that had nothing to do with the plant usually known as Lyginodendron oldhamium, described by Binney[8] as Dadoxylon oldhamium and placed in the genus Lyginodendron by Williamson.[9] This plant later was found to be a Pteridosperm and Potonié in 1899[10] proposed for it the now accepted name of Lyginopteris oldhamia. Gourlie's type specimen, Lyginodendron landsburgii, came from the Carboniferous rock of Ayrshire, Scotland and is the cast of a plant having in the outer cortex an irregular, anastomosing mechanical system of sclerenchyma plates. Potonié[11] proposed that the name Lyginodendron would serve a useful purpose for casts of stems similar to Gourlie's type but which can not be assigned to a definite systematic position. The largest example (100 cm long) of this Lyginodendron structure was noted by Seward[12] in a cast from the Upper Carboniferous near Harrogate. Nathorst[13] recently figured a similar cast from Spitzbergen, from the Culm, and has also described under the name of Lyginodendron sver-

[6] Corda, Göppert, Stenzel, Solms-Laubach, etc. in Germany; Zeiller, Renault, Pelourde, etc. in France (*see* Scott, D. H., Studies in Fossil Botany, pt 1, 3d. ed., 1920, p. 270-78).
Derby, Orville A., Observations on the Stem Structure of Psaronius Brasiliensis. Amer. Jour. Sci., ser. 4, 1914, 63:489-97.
[7] Gourlie, W., Proc. Phil. Soc. Glasgow, 1844, 1:105.
[8] Proc. Lit. Phil. Soc. Manchester, 1866, 5:113.
[9] Phil. Trans. Roy. Soc., 1873, 163:404.
[10] Lehrbuch der Pflanzenpalaeontologie, p. 171.
[11] Ref. cited.
[12] Seward, A. C., Fossil Plants, 1917, 3:37.
[13] Nathorst, A. G., Zur Fossilen Flora der Polarländer. Teil 1, Nachträge zur Pälaozoischen Flora Spitzbergens, pl. 7, fig. 1. Stockholm 1914.

drupi[14] impressions of a cortical reticulum from the Upper Devonian of Ellesmere Land.

As pointed out by Seward,[15] this type of cortex is not confined to a single genus of plants, nor even to a single group, since it is found in Pteridosperms and also occurs in some Paleozoic lycopodiaceous stems, and therefore can not be considered a safe criterion of botanical affinity. The name Lyginodendron is nothing more than a form name, therefore; and can serve only as a convenient catch-all for plants of unknown affinities.

Fortunately during the same summer that the Manorkill (1120-foot level) tree horizon was located, while operations were under way for the removal of the new stumps, through the keen observation of Dr Rudolf Ruedemann who was on the look-out for seeds in Upper Devonian rocks, there was discovered partly buried in the bed of the Schoharie creek, a loose block of shale covered with fructifications. The slab was traced to its source at the south side of the lower falls of the Manorkill about 15 feet above the base of the falls and 100 feet below the tree horizon. At this time a few specimens were obtained. Later in that same season and again in the summer of 1922 that and other localities were worked and reworked until a fair-sized collection has been obtained containing seeds (megasporangia), male fructifications, pieces of foliage and roots. Besides these Gilboa trees, occurring in large numbers, only specimens of a Protolepidodendron have been found, and these not in abundance; also the shale layer in which the fruiting bodies were found is at the same level (1020 feet) as the shale layer in which rested the bases of the stumps of the first-discovered locality. The above facts leave no doubt that the fruiting bodies, foliage and roots, occurring so frequently wherever the shale layers in question can be worked, belong to the Gilboa trees.

The presence of seed ferns in the Upper Devonian rocks has long been predicted. Back in 1912 Johnson of the Royal College of Science for Ireland, Dublin, found in the Upper Devonian beds at Kiltorcan, County Kilkenny, impressions indicating the presence of the seeds and microsporangia of a Devonian plant, suggesting that heterospory was already well pronounced at this epoch. The specimens were reserved for description in the hope that specimens showing the parentage of the seed would turn up. With this hope unful-

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[14] Die Oberdevonische Flora des Ellesmere-landes. Report 2d Norwegian Arctic Exped. "Fram" 1898–1902. No. 1, 1904, p. 11, 12, pl. 1, fig. 1; pl. 2, figs. 1, 2.

[15] Ref. cited; also 1910, 2:220.

filled, in 1917 he published a short description of this material under the name of Spermolithus devonicus.[16] For this country, Mr David White,[17] paleobotanist of the United States Geological Survey, discovered in 1900 the seeds of Aneimites (Adiantites), whose fern nature had hitherto been unquestioned, in the lower Pottsville (lower Pennsylvanian) of West Virginia; and this occurrence gave us the hope of finding seeds or forerunners of seeds in our Upper Devonian plant beds in New York.

Study of all the Gilboa material collected has shown that this Upper Devonian tree, while of simpler organization, bears a strong resemblance to the Carboniferous Lyginopteris and, with it, belongs among the seed ferns (Pteridospermophyta; Cycadofilicales of some). The generic name Eospermatopteris is here proposed to include the two species of Gilboa trees.

Seed ferns must have had their origin in primitive ferns earlier than the Upper Devonian. The climax of their development occurred in the Pennsylvanian and early Permian; but, beyond the Paleozoic, none are as yet known.

Eospermatopteris gen. nov.

Eos-*dawn*; sperma-*seed;* pteris-*fern.*

Stumps and trunks. Plates 2, 3, 4 and 7 will give a very good idea of the size and shape of the stumps of these trees, and the lower surface of the bases is well shown in plate 5. In the forty more or less complete stumps which the Museum has obtained there is great variability in size and some variability in shape. The bases are bulbous, as might be expected of trees growing under swampy conditions, in some cases more spreading than in others. The height at which the trunks were broken off above the base varies from 1 foot 4 inches in the case of some of the smaller stumps to about 3 feet and slightly over in the case of the largest stumps. The circumference at the spreading part of the base varies from 3 feet 10 inches in the smallest specimen (height 2 feet) to 11 feet in the largest specimen, which has a diameter of 21½ inches at a height of 22 inches. Others of the largest stumps show circumferences between 8½ feet and 11 feet and have diameters up to 2 feet at heights varying from 20 inches to 2 feet. One of these large stumps shows very slight spreading at the base. With a base having a circumference of 8½ feet (diameter 32 inches) the trunk at the height

[16] Johnson, Thomas, Sci. Proc. Roy. Dublin Soc. 1917, 15, no. 23:218, 219, pl. 11, figs. 4–6, pl. 12, figs. 1, 2.

[17] White, David, Smith. Misc. Coll., pt. 3, 1904, 47:322–31, pls. 17, 18.

of 23 inches still has a diameter of 2 feet. In other cases, the narrowing from the bulbous base to the trunk is more rapid and more striking. One stump standing 3 feet high has a circumference at the base of 10½ feet (diameter 40 inches) and at a height of 2 feet a circumference of 6 feet 3 inches (diameter 23.8 inches); another, about 3 feet high has a circumference at the base of 9 feet (diameter 34 inches); at the top of 3 feet 1 inch (diameter 11.7 inches). In both these cases the narrowing is gradual. In two of the most recently acquired specimens, in fact the best specimens we have, the narrowing is very strikingly, in one case very abruptly, shown. One has a height of 3 feet and a circumference at the base of 6 feet 3 inches (diameter approximately 23.8 inches), but at a height of 14 inches, a circumference only of 4 feet 3 inches (diameter approximately 16 inches), while at the top the circumference is about 3 feet (*see* plate 3). Another has a height of 34 inches and a circumference at the base of 7 feet 6 inches (diameter approximately 25.4 inches); at the height of 14 inches a circumference of 6 feet 5 inches; at the height of 24 inches, a circumference of 4 feet 4 inches; at the height of 34 inches a circumference of 36½ inches (diameter 11.6 inches). This last example (plate 4) shows a case of very gradual narrowing of the trunk; the preceding example shows an abrupt change from the enlarged base to the trunk.

Parts of the trunk, above the heights shown in the stumps, have been found infrequently and in a flattened condition. The Museum has two of these specimens, one over 4 feet long and the other over 3 feet long. In the case of the latter, which was taken from the underside of an overhanging ledge, as much again of the trunk had been broken away and lost; and, beyond the section obtained, the trunk continued into the solid rocks with little, if any, diminution in width. Another specimen, too poor to be removed from the rock, shows some 12 feet of slender trunk which must represent a portion near the top of a large trunk or the trunk of a very small tree. Among the Carboniferous seed ferns some were of the "scrambler" type, with long slender stems climbing among other plants; some were herbaceous, and others were tall and stout like the tree ferns. The Carboniferous Lyginopteris belongs to the "scrambler" type, but Eospermatopteris of the Upper Devonian belongs to the type with tall, stout trunks. The largest of these trees must have reached heights of at least 30 to 40 feet. As yet the Museum has not located any specimens of the trunk showing the attachment of the petioles of the frond; but about 1870 or 1871 a Mr Lockwood of Gilboa found the upper part of one of these trunks, with its leaf-scars preserved and petioles attached. This specimen, figure 1, in the collection of Professor J. S. Newberry, was described by Dawson,[18] under the name Caulopteris lockwoodi, as probably the

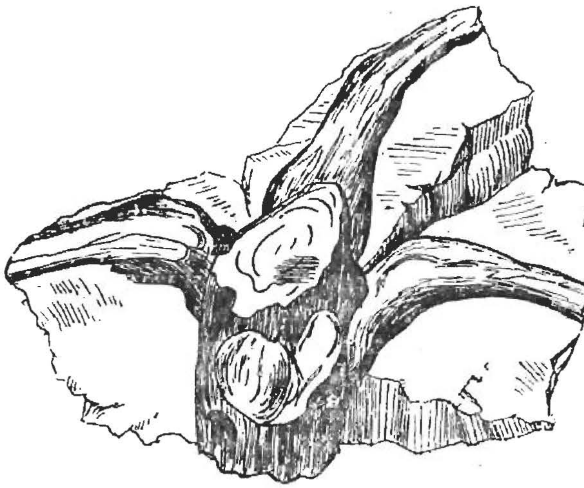

Fig. 1 Portion of trunk of Eospermatopteris (Caulopteris lockwoodi Dawson) showing attachment of the petioles and the leaf-scars. (Reduced; after Dawson, 1871.)

upper part of one or the other of his species of Psaronius found in the same bed. Dawson's description is as follows:

Trunk from 2 to 3 inches in diameter, rugose longitudinally. Leaf-scars broad, rounded above, and radiatingly rugose, with an irregular scar below, arranged spirally in about five ranks; vascular bundles not distinctly preserved. Petioles slender, much expanded at the base, dividing at first in a pinnate manner, and afterwards dichotomously. Ultimate pinnae with remains of numerous, apparently narrow pinnules.

The character of the fronds led Dawson to believe that the plant approached in that respect to the cyclopterids of the subgenus Aneimites. Today we know that both Eospermatopteris (Dawson's Psaronius) and Aneimites are both seed ferns belonging to the important phylum Pteridospermophyta.

The outer cortex is the only structure of the stumps and trunks of these trees that is to any extent preserved. The interior structures

[18] Dawson, Sir J. W., Jour. Geol. Soc., 1871, 27:269-71; Geol. Surv. Canada, 1871, Fossil Plants, p. 59 (figured only).

have been washed out and the cavity left filled with sand which has helped preserve the shape of the stumps in fossilization. The outer cortex, as in Lyginopteris, consists of interlacing strands of sclerenchyma tissue, forming a network (plate 6) or more or less parallel (plate 7). The cellular tissue which in the living trees occupied the space between the sclerenchyma strands is here replaced by sandstone. In a transverse section of the stem of Lyginopteris and the allied genus, Heterangium, the sclerenchyma appears in the form of dark radial bands, but in Eospermatopteris it appears in the form of dots or short thick irregular lines, irregularly scattered. This zone of the outer cortex varies from an inch or less to several inches in thickness depending upon the size of the stumps. In the majority of cases, the outside of the outer cortex is missing, but it is very well shown in several cases. The outer surface is marked with shallow ridges and furrows in some cases, giving the effect of a bark; in other cases the outer surface is only irregularly furrowed and wrinkled or even just roughened some of which is undoubtedly due to shrinkage in preservation. But in either case the outer surface appears to be composed of layers of sclerenchyma forming a kind of bark, which in the living tree undoubtedly had a covering of ramentum or fibers. The underside of the base of the stumps is quite strikingly furrowed in a radiate manner (plate 5) and in some specimens a depression is seen at the center. The base as well as the sides has the outer zone or covering of sclerenchyma layers above which is the zone several inches thick, varying according to the size of the stumps, of interlacing sclerenchyma strands.

The interior structure of the trunk of Eospermatopteris for the present must remain unknown. There seems to be sufficient reason to believe that it belongs to the Lyginopterideae; but whether it has a stele occupied entirely by the primary wood, with no pith, as in Heterangium[19] or whether it has the large pith which is a constant feature of Lyginodendron[19] can not be determined from the material at hand. A transverse section of one of the smaller trunks shows toward the center an irregular, thin ring of sclerenchyma tissue and within this ring and to some extent outside are irregularly scattered strands of sclerenchyma tissue. The

[19] Williamson, W. C., Phil. Trans. Roy. Soc., 1873, 163:377–408, pls. 22–31. Williamson, W. C. and Scott, D. H., Phil. Trans. Roy. Soc. (B), 1895, 186:703–779, pls. 18–29.
See Seward, A. C., Fossil Plants, 1917, v. 3, ch. 29; *see* Scott, D. H., Studies in Fossil Botany, Pt. II, 1909, ch. 10.

scattered sclerenchyma strands may be due entirely to some maceration before preservation; but the ring itself appears to be a definite zone, part of the missing central cylinder. Transverse sections of larger trunks were made, but nothing was found. Success in this line, I believe, can only be attained when we find a petiole or rachis of a frond preserved in such a condition that thin sections can be made for study.

Roots. Though we have a number of specimens of roots, none of the stumps taken out have any roots attached. For this reason it has been suggested that the stumps perhaps may not have grown in the place in which they were found. There is one trunk now, still in place in the quarry at Gilboa at this time of writing, which shows the roots spreading outward in the shale layer (lowest horizon) in which the stumps rest; roots were likewise observed in the shale layer of the highest horizon from which stumps were taken. These observations taken into consideration with the upright position of all the stumps found, the successive tree horizons with the bases of the stumps in each case resting in and upon a shale layer, representing the clay bed in which the trees are believed to have grown, would all seem to indicate that the forest was destroyed and the stumps buried *in situ*.

Eospermatopteris apparently had no large heavy roots. None have been found and there certainly is nothing about the stumps themselves that would suggest that any might be expected. All the roots found, in their flattened condition, measure between one quarter of an inch or less and half an inch across; but they are not preserved in a condition which permits of their being studied structurally. Numerous long, strap like rootlets, as shown in text figure 2 and plate 8, radiate from the roots, but do not appear to have any regular arrangement. These rootlets, as preserved, measure on the average ⅛ of an inch or less across and there is little, if any, variation in width. Some of the rootlets measure up to 6 inches in length as far as preserved, and there is no indications that this is anywhere near the tip. With a root system such as this, I think the bases of these trees must have been buried to some height in the sediments to give adequate foothold.

Foliage. The fronds of Eospermatopteris are tripinnate; they were at least 6 feet long, and, judging from the fragments of main rachises collected, in the larger specimens they must have been considerably longer. One specimen (figure 3) shows an impression of a main rachis 25 inches long which is apparently at considerable distance from both the tip and the petiole, probably near the middle of the frond, for two of the primary division measure, the one 15 inches, the other which is not fully preserved 12 inches. The impression of the main rachis, at its widest part, measures three-eights of an inch across, the primary divisions one-eighth to

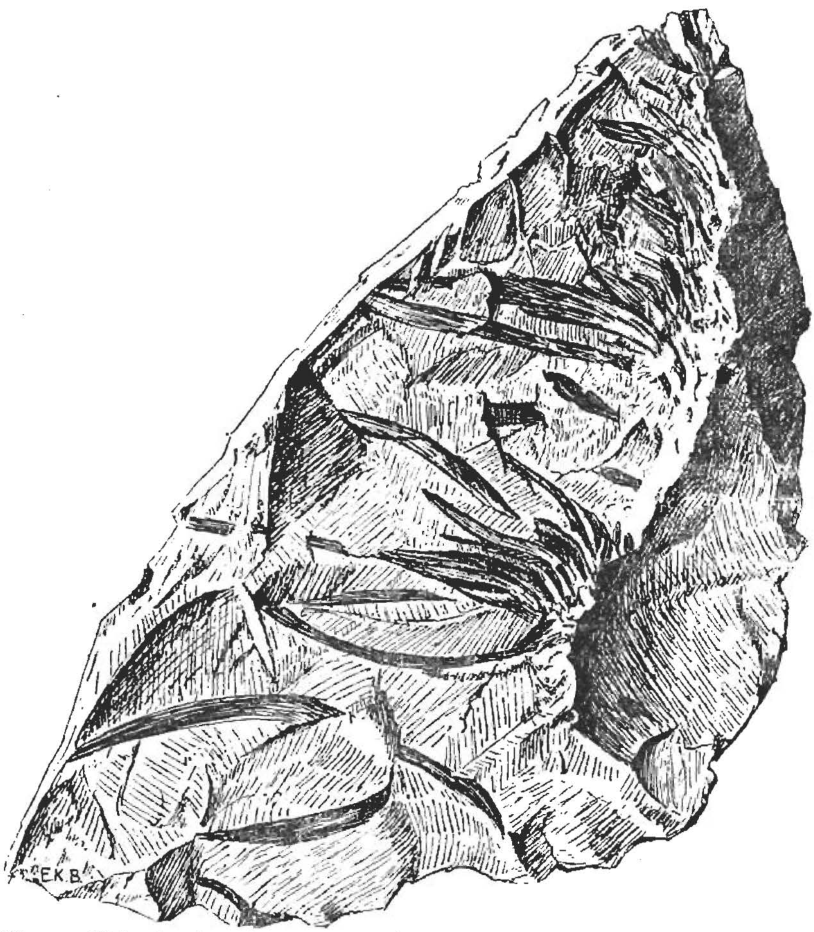

Fig. 2 Slab showing the strap-like, radiating rootlets of Eospermatopteris. (Slightly reduced)

three-sixteenths of an inch. The impression of another main rachis measures 30 inches and apparently not half of the total length is shown (*see* plate 9). The impression of this main rachis is between one-half and five-eighths of an inch in width; of its primary divisions about three-sixteenths of an inch. Both the primary and secondary divisions are alternately arranged; no indication has been found of the occurrence of dichtomous divisions in the upper part of the fronds, as mentioned by Dawson (*see* page 57) under his description of Caulopteris lockwoodi. This specimen of "Caulopteris lockwoodi" is the only clue we have as to the character of the petioles and the arrangement of the fronds upon the trunk. The petioles are described as slender and much expanded at the base and spirally arranged in about five ranks (*see* figure 1). Many of

Fig. 3 Part of main rachis and lateral branches of the frond of Eospermatopteris. The slab has a greatest width and length of 2 feet.

the impressions of the frond stems show a central groove or depression with a flattened area on each side (plate 10, figure 4) from which branch off the next smaller divisions and, on the ultimate pinnae, the pinnules. This depression is probably the impression left by the central woody strand or bundle.

The pinnules are of a simple Sphenopteridium type, reminding one of, but simpler than, the Sphenopteridium keilhaui described by Nathorst[20] from the Upper Devonian of Bear Island. A stronger resemblance is shown to certain sterile leaf segments from the same locality, correlated by Nathorst with Cephalopteris (Cephalotheca) mirabilis[21] which will be treated more fully under the discussion of the seeds and microsporangia. The character of the pinnules is shown in

Fig. 4 Part of the frond of Eospermatopteris showing the ultimate pinnae with the pinnules. (Reduced slightly more than one-third)

figures 1-4 on plate 10. They are twice bilobed with the divisions of the first bifurcation more or less recurved; and they do not narrow down proximad but join the stem by a broad base. The first bifurcation occurs at about half the length of the pinnule; the second bifurcations are near the tips which appear to be blunt and rounded.

[20] Nathorst, A. G., Handl. k. Svenska Vetenskaps-Akad. 1902, 36, no. 3, 13, 14, pl. 2, figs. 3–13. *See* Arber, E. A. Newell, Devonian Floras, 1921, p. 62, 63.

[21] Ref. cited, p. 15, pl. 1, fig. 20.

The fragmentary preservation of the pinnules would seem to indicate that they were of a rather delicate nature. There is no evidence of a midrib. The pinnules are set comparatively far apart so that the general effect of the foliage in the case of Eospermatopteris is much less dense (figure 4) than is the case with Lyginopteris, Heterangium and others of the seed ferns.

Seeds. The seeds of Eospermatopteris bear a strong external resemblance to those of Lyginopteris oldhamia, called Lagenostoma lomaxi[22] before the relation between the two was known, and to other Lyginopterid seeds. The character of the seeds is well shown on plate 10, figures 5-12, plate 11, figures 1-5, and in text figure 6. On some of the slabs the seeds are very abundant but on none of the specimens are any sterile laminae found in conection with the seeds, though branches bearing pinnules occur frequently in the same layers. The seeds were probably borne near the tip of the frond or the tips of some of the pinnae, with complete abortion of the sterile laminae; or perhaps there was modification of the bilobed pinnules. At any rate, the seeds are borne in pairs at the ends of forked branchlets. The ultimate division bearing the pair of seeds may be as short as a quarter of an inch, or less, or may be almost an inch long. In a number of cases when the seeds are borne close to the dichotomy, the arrangement of the fruits is rather crowded, and there is an appearance given of more than one seed being borne on a stalk. Sometimes the dichotomies are such a short distance apart as to bring, frequently two, sometimes three, pairs of seeds close together, giving a clustered effect to the seeds. The seeds, as in the case of Lagenostoma, are inclosed in an outer husk or cupule which completely envelops the seed. In some cases the cupule appears to come to a point at the top (plate 10, figures 9, 10); in a few cases, some of which are figured here on plate 10, figures 7, 8, the cupules appear to be lobed as in Lagenostoma lomaxi and L. sinclairi (figure 5). This may, since it is infrequent, be only an accident of preservation; or it may be that the majority of these fruiting bodies are in an immature condition. Some specimens in a very immature condition have been found. A few specimens show the impression of what appears to be a vascular bundle running up through the main branchlet, forking at the dichotomy and continuing up each arm of the dichotomy

[22] Oliver, F. W. and Scott, D. H., Proc. Roy. Soc., 1903, 71:477–81; Phil. Trans. Roy. Soc. (B), 1905, 197:193–247, pls. 4–10; Scott, D. H., Studies in Fossil Botany, pt II, 1909, p. 386–96; Seward, A. C., Fossil Plants, 1917, 3:55–64.

almost to the seed. Some specimens show fine lines on the cupule which may mark the position of fibro-vascular bundles. The seed (plate 10, figures 6, 9, 11, 12; plate 11, figures 1, 2) is broadly oval to round; the impression of it is very distinctly shown in the larger and older fructifications, and can be distinguished even in the immature ones (plate 10, figure 5). The measurements of some of the larger seeds are as follows: 5.3mm x 2.5mm; 5.6mm x 3.1mm; 6.4mm x 3.4mm; 6.3mm x 3.4mm. On several slabs were found groups of small rounded thick bodies, some of them free, others attached to pedicels, plate 11, figures 3-5, which have every appearance of being seeds. The largest of these bodies vary from a length and width of 3mm to a length of 3.2mm and a width of 2.7mm.

Fig. 5 *Lagenostoma sinclairi.* Two seeds of Lyginopteris enclosed in lobed cupules, and borne terminally on branches of the rachis, x3⅓. (From Scott, 1909, after Arber)

Some specimens are slightly wider than long, but this, I think, is due to distortion in preservation. These bodies are, I believe, the seeds without the integument, the nutlets; their general character and thickness carry out this idea, and in addition portions of what appears to be the integument are sometimes seen along the margins of some of the nutlets.

Microsporangia. The sporangia-bearing organs of Eospermatopteris, as in the case of the seeds, are borne at the tips of forking branchlets. There is one specimen in which these organs are borne close to the dichotomy; and another specimen, plate 11, figure 6, in which these organs are borne some distance from the dichotomies, and yet close enough together to give a clustered effect. In both cases, the sporangia-bearing organs are in a young condition. The older specimens in our hands, in all but one case, have become separated from the pedicels.

Fig. 6 Slab showing groups of seeds of Eospermatopteris. The seeds are borne in pairs at the ends of forked branchlets. (x1)

Up until 1905, nothing was known of the male fructifications of the Pteridospermophytes; but during that year Doctor Kidston[23] discovered a species of Crossotheca (C. höninghausi, Kidston) in connection with the foliage of Lyginopteris (Sphenopteris höninghausi). The fertile pinnules are oval in form, measure about 2-2.5mm in length and bear six, rarely seven, bilocular sporangia.[24] The sporangia which are convergent when young, spread out at maturity assuming a fringelike arrangement, which gives to the sorus the form of an epaulet (figure 7).

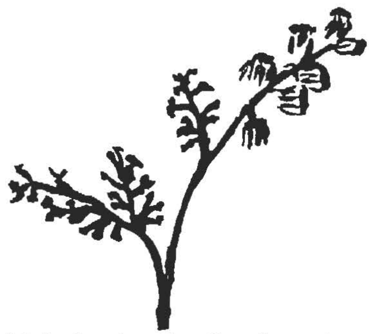

Fig. 7 *Crossotheca höninghausi.* Fertile pinnae in connection with sterile pinnae of *Sphenopteris höninghausi*, the leaf of Lyginopteris. (x2)

In our specimens no separate sporangia or microspores have been found. The sporangia-bearing organs or modified pinnules are of similar character to that of Crossotheca, but they are considerably larger, broadly funnel-shaped or cup-shaped, with the pedicel attached at the center. In general appearance there is a resemblance, in the younger specimens, to the moplike clusters of sporangia found on fertile fronds of Cephalopteris mirabilis described by Nathorst[25] from the Upper Devonian rocks of Bear Island. Only in the mature specimens is it clearly seen that the sporangia of Eospermatopteris must have been borne directly on the under side of the modified pinnule, while in Cephalopteris the clusters of sporangia are borne on a separate stalk on the lower surface and at the base of the fertile pinnae. In the matter of the sporangia-bearing organ, there is more resemblance between the male fructifications of Eospermatopteris and Lyginop-

[23] Kidston, R., Proc. Roy. Soc. (B), 1905, 76:358-60, pl. 6; Phil. Trans. Roy. Soc. (B), 1906, 198:413-45, pls. 25-28.
[24] *See* Seward, A. C., Fossil Plants, 1917, 3:52-55; Scott, D. H., Studies in Fossil Botany, Pt. II, 1909, p. 396-401.
[25] Nathorst, A. G., Handl. k. Svenska Vetenskaps-Akad., 1902, 36, no. 3, 15-17, pls. 1, 2. *See* Seward, A. C., Fossil Plants, 1910, 2:537, fig. 355.

teris; but the sporangia apparently were clustered more as is the case with Cephalopteris. An interesting fact here is that there is a great similarity between the sterile foliage referred by Nathorst to C. mirabilis and the sterile foliage of Eospermatopteris. Nathorst[26] compares Cephalopteris with a Belgian species of Upper Devonian age described by Crépin[27] as Rhacophyton condrusorum and by Gilkinet[28] as Sphenopteris condrusorum; and this, too, shows striking similarity to our Eospermatopteris as to foliage. It is also worthy of note that, while the exact position of Cephalopteris can not be definitely determined from lack of available data, it is thought probable that it was a seed-bearing Pteridospermophyte and not a true fern.[29]

There are only about a dozen small slabs containing specimens of the sporangia-bearing organs of Eospermatopteris; but we are exceedingly fortunate in having that many, and in having in this collection both young and mature specimens.

From the way in which the sporangia-bearing organs are preserved, it would seem that in the younger specimens, plate 11, figure 6, this structure is more funnel-shaped, and that it broadens out and becomes more saucer-shaped at maturity, plate 11, figures 7, 8. It may be that sporangia are present in the immature specimens, but their preservation as impressions makes any detection of this condition impossible. The older specimens are preserved also as impressions, but flattened out, so that the absence of the sporangia is apparent. On the underside, closely clustered around the place of attachment of the pedicel and extending out toward the margin, are numerous rounded depressions, some of which appear to show a small scar at the bottom. These have been interpreted to mark the place of attachment of the sporangia; and they cease some distance from the margin showing that the clustered sporangia were confined toward the center. In most of the specimens the marginal area is marked with numerous concentric lines or wrinkles; but they would seem to be due to shrinkage or in part to the flattening down of a saucer-shaped structure. When the specimens are so preserved that the impression of the upper surface is shown, lines or wrinkles are seen

[26] Nathorst, A. G., Handl. k. Svenska Vetenskaps-Akad., 1902, 36, no. 3, p. 16.

[27] Crepin, F., Bul. Acad. Roy. Belg., 2d ser., 1874, 38:356; Bul. Soc. Roy. Bot. Belg., 1875, 14:214.

[28] Gilkinet, A., Bul. Acad. Roy. Belg., 2d ser., 1875, 40, no. 8, 139; Mem. Soc. Geol. Belg., 1922, p. 5–10, pls. 1–4.

[29] Seward, A. C., Ref. cited, p. 537; Zeiller, R., Rev. Gén. Bot., 1908, 20:59;

radiating irregularly from the place of attachment of the pedicel. Very fine, closely-placed radiating lines are visible along the margin itself in some of the specimens, and these do not appear to be due to shrinkage in preservation.

The specimens vary in size and, as preserved, are rounded-oval to round in form. The round forms show the following diameters: 8.7mm, 9mm, 9.7mm, 17.4mm, 19mm, 19.5mm; the rounded-oval specimens have the following measurements: 11mm x 9.7mm; 11.3mm x 9mm; 11.8mm x 9.7mm. The oval specimens owe their shape to the fact that in preservation they have been squeezed out along one diameter; but taking this into consideration, they run about the same size as the smaller round forms which represent the average and most frequently represented sizes. As noted in the measurements above, three specimens show measurements about twice the average size, only two of which are completely preserved (plate 11, figures 9, 10). One of them shows a wavy margin and the other an almost fluted margin. Whether these three forms represent simply larger specimens or more maturely developed forms can not be decided, though the latter seems more probable.

Eospermatopteris erianus (Dawson)
Eospermatopteris textilis (Dawson)

Dawson[30] distinguished two species of trees in the Gilboa collections submitted to him. E. erianus was also noted as coming from Madison county, though there is now in the State Museum no specimen of this species from that section. Dawson's descriptions are as follows:

P. erianus. Trunk completely invested with cordlike aerial roots parallel to each other, and either closely appressed or arranged at regular intervals. Each root consisting of an outer, probably cellular, coat, with an axis of fibers and scalariform or reticulated vessels. (*See* plate 7).
P. textilis. Trunk with the outer surface marked with irregular ridges and furrows, produced by tortuous aerial roots, which in the center of the stem are seen to be interlaced with each other. They are less tortuous in what seems to be the upper part of the fragment. (*See* plates 2-6).

Dawson's species, then, were based upon the arrangement of the sclerenchyma strands of the outer cortex, which he interpreted as aerial roots; and today the species can stand only on those char-

[30] Dawson, J. W., Canadian Fossil Plants, Canadian Geol. Surv., 1871, p. 58, 59; Hall, J., 24th Rep't N. Y. State Cab. Nat. Hist., 1871, p. 15.

acters upon which they were originally separated, since we have discovered nothing further to add. Only the one kind of foliage has been found; also only the one type of seed and male fructification. It would appear then that only in the internal structure of the trunks could these two species of trees be distinguished while living; for surely if the two species differed in foliage and fructifications, with all the collections we have made, some evidence of this would have come to light. Stumps belonging to the type of E. textilis have been so far found in numbers greatly in excess of those of the E. erianus type; this might, also, account for the collection of only one kind of foliage and fructification, especially since the localities from which the collection of this material was made were few and of limited extent.

Summary

In 1869 was made a remarkable discovery of fossil tree stumps in the Upper Devonian (Ithaca) beds of Schoharie county, in the vicinity of the village of Gilboa. In 1897, a few loose trees were reported from a higher horizon at the Manorkill falls a mile above the old locality. Special efforts in 1920 led to the discovery of these stumps in place at the Manorkill locality at the 1120-foot level, 100 feet above the old locality. Since 1920 the city of New York has been doing construction work at Gilboa preparatory to impounding the waters of the Schoharie creek to meet with future demands. In the course of operations, the old locality, at the spot where the dam is being built, was uncovered and several specimens obtained; a new quarry at the 960-foot level was opened up 2300 feet north (downstream) of the old location and has yielded the greatest number and the largest stumps hitherto found, one of the largest of this group having a circumference at the base of 11 feet. With the recent additions to our collections the Museum now has a total of forty stumps, partial or complete. At all three horizons the stumps were found with their bases resting in and upon black shale representing the original mud in which the trees stood, in an upright position with the trunk extending into the coarser sandstone above. At least, then, three successive forests of these trees reared themselves to great heights along the marshy borders of the unstable coast line of the shallow Devonian sea, were submerged, destroyed and buried.

At the same time that the new tree horizons were discovered, a shale bed, in the vicinity of the Manorkill at the 1020-foot level, yielded specimens of roots, foliage, and, most important of all, seeds