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Fossil Plants from the Union Chapel Mine, Alabama

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ABSTRACT: The vertebrate tracks of the Union Chapel Mine are associated with a rich Early Pennsylvanian impression/compression and petrified flora. The flora appears to be dominated by arborescent lycopods (Lepidodendrales) including bark impressions of *Lepidophloios* and *Lepidodendron*. Lepidodendralean reproductive structures include intact cones (*Lepidostrobus*) and isolated cone scales (*Lepidostrobophyllum*). Several examples of lepidodendralean detached leaves (*Lepidophylloides*) have been recovered. Additional non-seed-bearing plants are represented by numerous arborescent horsetail (sphenophyte) remains including pith and stem casts of *Calamites*, a cone of *Calamostachys* and leafy stems (*Asterophyllites charaeformis*). Seed plants such as the pteridosperm foliage genera *Sphenopteris* and *Neuralethopteris* are common at the Union Chapel locality. Seed plant reproductive structures include excellently-preserved specimens of the pteridosperm seed *Trigonocarpus ampulliforme*, and the pollen organ *Whittleseya elegans*. The fine preservation and high degree of articulation of the Union Chapel plants indicates that they were not transported far before burial. This suggests that the trackmaking animals were living in, or at least visiting, tidal influenced environments. This paleoecological setting stands in sharp contrast to the extensive late Paleozoic (Early Permian) vertebrate track sites of the Hueco Formation in New Mexico, which are associated with a walchian conifer-dominated plant community. Numerous illustrations of the fossil plants are included in this chapter to document the nature of the flora associated with the tracks presented elsewhere in this volume.

INTRODUCTION

The fossil plants preserved with the trackways in the Union Chapel Mine of Walker County, Alabama present an opportunity to associate plants and animals in a unique taphonomic setting. The animals that wandered among the plants living on or near these Pennsylvanian age mud flats are of great interest. However, the plants also have an interesting and unique story to tell about the life in this place and time. It is with this need to present a record of the abundant plant material associated with the trackways that we document the floristic elements present in these Lower Pennsylvanian sediments.

The plants of the Union Chapel Mine occur in the Lower Pennsylvanian, Pottsville Formation. Joseph Wood (1963) described a Pottsville flora, the Stanley Cemetery Flora, from west central Indiana. These two floras contain similar elements indicating that floristic elements extended from one North American coal basin to another. During the Early Pennsylvanian a large Northern Hemisphere land mass, Laurasia, consisted of much of North America, Europe, and parts of Asia. Low and swampy areas extended from the American midwest into western Europe. Consequently, certain species of land plants that make up the famous Carboniferous coal swamp forests are found in Asia, Europe, and North America. Changes in species composition in these floras occurred throughout the Carboniferous (DiMichele and Phillips, 1995).

Carboniferous basins contained peat-accumulating swamps of coastal lowlands that accumulated fine-grained silts from floods (Gastaldo, 1990) forming mud flats. In these wet areas many species of land plants shed their various organs such as cones, seeds or large branches, and these were dispersed in a forest or swamp, much as plant organs are dispersed today. Major groups represented in the Early Pennsylvanian include the lycopods, sphenopsids, ferns, seed ferns and cordaites. Examples of these major groups are still living today except for the seed ferns and the cordaites (which may be considered only very distantly related to conifers today). Most of this flora consists of long extinct swamp inhabiting trees. As various organs were shed, they fell adjacent to the parent plants, onto the mud or into the shallow water of the swamp. As trees died their branches and stems dropped to the forest floor. Some have a natural hollow cavity (*Calamites*) while the stems of lycophytes and most seed plants lack a hollow cavity. With the subsequent decay of plant material and infilling of sediment, a cast is formed (Gastaldo et al., 1989). Some of the trees had special tissues and morphological features to facilitate their life in the swamp environment (Phillips et al., 1976).

Plant megafossils from the Alabama coal fields are noted in Bunbury (1846), Lyell (1846a, b), Lesquereux (1879, 1880, 1884, 1888), McCalley (1896, 1900), White (1900, 1943), Smith (1903), Rothrock (1949), Mamay (1955), Read and Mamay (1964), Metzger (1965), Gastaldo (1984, 1985, 1988, 1990), Gastaldo and Boersma (1983a, b), Gillespie and Rheams (1985), and Lacefield (2000). Similar Pennsylvanian plants from

TABLE 1. List of Fossil Plants in the Union Chapel Mine, Alabama

Name	Number of described specimens
Order LEPIDODENDRALES	
Family LEPIDODENDRACEAE	
Lepidodendron aculeatum Sternberg	1
Lepidodendron obovatum Sternberg	1
Lepidophloios laricinus (Sternberg) Goldenberg	1
Aspidiopsis sp.	1
Lepidophylloides intermedium Lindley & Hutton	2
Lepidostrobus sp. A	3
Lepidostrobus sp. B	3
Lepidostrobophyllum cf *majus* (Brongniart) Hirmer	3
Family SIGILLARIACEAE	
Syringodendron sp.	2
Order EQUISETALES	
Family CALAMITACEAE	
Asterophyllites charaeformis (Sternberg) Goeppert in Wimmer	3
Calamites suckowii Brongniart	2
Calamites undulatus Sternberg	2
Calamites goepperti Ettingshausen	2
Calamostachys sp.	1
Order MEDULLOSALES	
PTERIDOSPERMS	
ALETHOPTERIDS	
Alethopteris valida Boulay	1
SPHENOPTERIDS	
Sphenopteris elegans (Brongniart) Sternberg	1
Sphenopteris pottsvillea (D. White) Gastaldo and Boersma	1
Lyginopteris hoeninghausi (Brongniart) H. Potonié	2
NEUROPTERIDS	
Cyclopteris sp.	1
Neuralethopteris pocahontas (White) Goubet et al.	1
Neuralethopteris biformis (Lesquereux) Goubet et al.	4
MISC. PTERIDOSPERMS	
Myeloxylon sp.	1
Whittleseya elegans Newberry	1
Holcospermum sp.	1
Trigonocarpus ampulliforme Lesquereux	1
Trigonocarpus sp.	1
Carpolithes sp.	1
CORDAITALES	
Artisia sp.	1
Cordaicarpon sp.	1
Cordaites sp.	1

elsewhere in the United States were listed by Newberry (1853), Lesquereux (1866), Noe (1925), Janssen (1939), Langford (1958), Canright (1959), Wood (1963), Darrah (1969), Gillespie and Crawford (1985), Gillespie et al. (1978, 1989), and Goubet et al. (2000). Comparative studies with the European flora are found in Schlotheim (1820), Sternberg (1820-1838), Brongniart (1822, 1828, 1828-1834, 1849, 1881), Martius (1822), Lindley and Hutton (1831-1833), Goeppert (1844), Unger (1850), Ettingshausen (1854), Goldenberg (1857), Geinitz (1862), Boulay (1876), Stur (1877), Kidston (1889, 1894), Cremer (1893), Potonié (1897-1899), Nathorst (1914), Hirmer (1927), Crookall (1955, 1966), Laveine (1967), Remy and Remy (1977), Josten (1991), and Kvacek and Straková (1997). This is one of the few documented impression/compression megafloral assemblages from Alabama.

MATERIAL, SOURCE STRATA, AND METHODS

All of the fossil plants presented in this paper were collected and donated by amateur paleontologists who have an interest in fossil plants and trackways preserved in the Warrior Basin coal field, Pottsville Formation, Lower Pennsylvanian, Union Chapel Mine, Walker County, Alabama, sec. 21, T. 14. S, R. 6. W, Cordova 7.5-Minute Quadrangle. They were collected from the spoils of the coal mine and in some cases are closely associated with trackways preserved on the same surface. This study of floral diversity is based on over 125 fossil plant specimens. The relative abundance of individual taxa in the collection may reflect original composition of the flora. More likely, however, the attractiveness of particular plant species to collectors in the field, the dispersal and differential preservation of particular plant species, or a combination of these factors, bias the collection of some species over others. Regardless, because many different species are present, some represented by only one or two examples, it is likely that much of the total systematic diversity of species is represented in this small collection of plant fossils. The specimens are housed in the collections of the Paleobotanical/Palynological Section of the Florida Museum of Natural History, University of Florida, Gainesville, Florida. All specimens are labeled with a locality number of UF18902 followed by specific specimen numbers. Systematic organization and taxonomic terminology in this paper are based on Harrington and Durrell (1957), Andrews (1970), Radford et al. (1974), Remy and Remy (1977), and Taylor and Taylor (1993).

SYSTEMATIC PALEOBOTANY

The Union Chapel flora contains many elements typical of the Early Pennsylvanian of the northern hemisphere (Table 1). The original forests probably consisted of a mixture of tall trees such as *Lepidodendron*, *Lepidophloios* and *Sigillaria*, some of which may have reached heights of over 100 feet (Phillips et al., 1976). These were mixed with shorter trees of *Calamites* (up to 50 feet tall) and *Psaronius* (about 30 to 40 feet tall). All of these plants reproduced by spores, some of which may have been dispersed in the shallow water of the swamp. *Medullosa*, a seed fern up to 30 feet tall, may have had *Neuralethopteris* foliage, bore *Trigonocarpus* seeds and *Whittleseya* pollen organs. Other seed ferns may have been shorter or even vine-like plants. An early conifer-like fossil plant is represented by *Cordaites*.

In this chapter we present as complete a description of the flora and illustrate each of these genera and/or species. It is important to remember that each individual plant usually falls into many pieces and each of the pieces is given a separate form generic name. Thus many different names go together to make up one individual plant.

Family LEPIDODENDRACEAE
Genus LEPIDODENDRON Sternberg, 1820

This genus accommodates stem impressions with leaf cushions of bark in spiral arrangement, rhomboidal to narrowly rhomboidal, acute at both ends. Central leaf scars are rhomboidal and perpendicular to the long axis of the leaf cushion. The leaf cushions bear a medial line separating two parichnos scars.

LEPIDODENDRON ACULEATUM Sternberg, 1820

Figures 1.1, 1.2

Lepidodendron aculeatum STERNBERG, 1820, p. 20, 23, pl. 6, fig. 2; pl. 8, figs. 1Ba,b.

Description: Leaf cushions in spiral arrangement, narrowly rhomboidal. Central leaf scars near middle, obtuse at apex, acute at sides and base. Medial line distinct, with depressions at both ends.

Discussion: The leaf cushions of this specimen are similar to those figured in Darrah (1969, pl. 30, fig. 1) and Gillespie et al. (1989, pl. 2, fig. 11) but lack the transverse wrinkles on the medial line as in Sternberg (1820), Lesquereux (1879, 1880), Langford (1958), Gillespie et al. (1978), and Kvacek and Straková (1997). This species was listed from Alabama by Lesquereux (1888) and Gillespie and Rheams (1985).

Material examined: UF 18902-34014.

LEPIDODENDRON OBOVATUM Sternberg, 1820

Figures 1.3, 1.4

Lepidodendron obovatum STERNBERG, 1820, p. 20, 23, pl. 6, fig. 1, pl. 8, figs. 1Aa,b; tent. 10.

Description: Leaf cushions in spiral arrangement, rhomboidal (obovate). Central leaf scars at top, obtuse at apex and base, acute at sides. Medial line distinct from scar to base, with depression at base.

Discussion: The leaf cushions of this specimen are similar to those figured in Gillespie et al. (1978, pl. 11, fig. 5) but lack the quadratic rhombic shape as in Gillespie and Rheams (1985) and Gillespie et al. (1989).

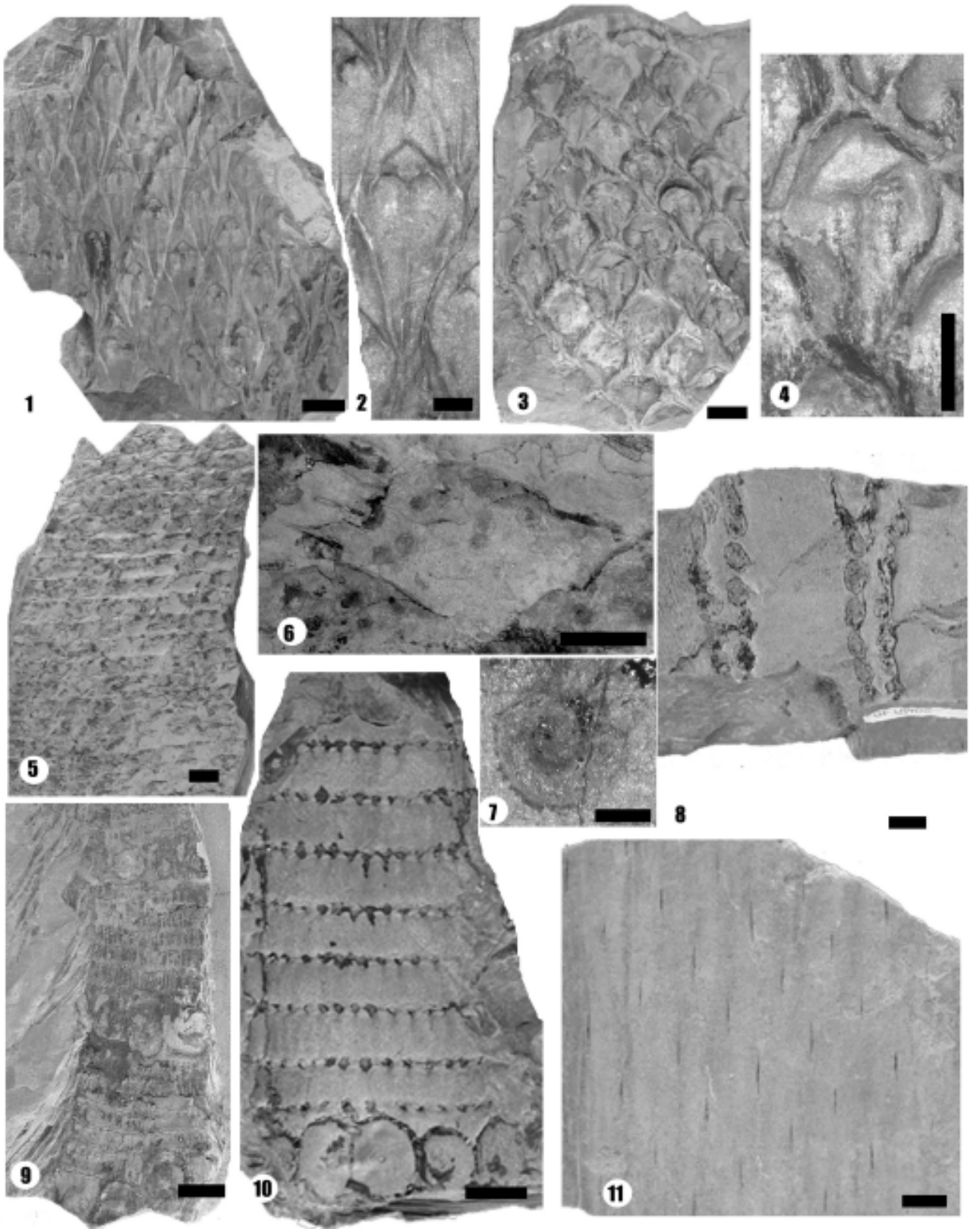

FIGURE 1.1, 2, UF 34014, *Lepidodendron aculeatum*; 1, Bark; 2, Leaf scar; 3, 4, UF 34008, *Lepidodendron obovatum*; 3, Bark; 4, Leaf scar; 5-7, UF 34371, *Lepidophloios laricinus*; 5, Bark; 6, Leaf scar, 7, Snail on leaf scars; 8, UF 34016, *Syringodendron* sp.; 9, 10, *Calamites goepperti*; 9, UF 33994; 10, UF 33992; 11, UF 34013, *Aspidiopsis* sp. UF loc. 18902. Bar-1 mm (7), 5 mm (2, 4, 6, 10), 10 mm (1, 3, 5, 8, 9, 11).

This species was listed from Alabama by Gillespie and Rheams (1985).

Material examined: UF 18902-34008.

Genus LEPIDOPHLOIOS Sternberg, 1825
LEPIDOPHLOIOS LARICINUS (Sternberg) Goldenberg, 1857
Figures 1.5-1.7

Lepidodendron laricinum STERNBERG, 1820, p. 22, tent. 23, pl. 11, figs. 2-4.
Lychnophorites laricinum (STERNBERG) MARTIUS, 1822, p. 144.
Lepidofloyos laricinum (STERNBERG) STERNBERG, 1825, p. 4, tent. 13.
Lepidophloios laricinus (STERNBERG) GOLDENBERG, 1857, p. 30, pl. 3, fig. 14, pl. 15, figs. 11-13, pl. 16, figs. 1-8.

Description: Leaf cushions overlapping in spiral arrangement, rhomboidal, acute at both ends. Central leaf scars horizontal to long axis of leaf cushion, and in lower portion of leaf cushion. Central leaf scars bilobed at apex, acute at the sides, and rounded at the base.

Discussion: The leaf cushions of this specimen are similar to those figured in Gillespie and Crawford (1985, pl. 1, fig. 5), and Gillespie and Rheams (1985, pl. 3, fig. 7), but lack the clearly visible central leaf scars as in Sternberg (1820), Gillespie et al. (1978, 1989), and Kvacek and Straková (1997). This species was listed from Alabama in Lesquereux (1880, 1884) and Gillespie and Rheams (1985). Numerous worm tubes on the leaf cushions (Fig. 1.7) are similar to those identified by Lesquereux (1866, pl. 38, fig. 6) as shells of a spirorbid polychaete, *Spirorbis carbonarius*.

Material examined: UF 18902-34371.

Genus ASPIDIOPSIS H. Potonié, 1893
ASPIDIOPSIS sp.
Figure 1.11

Description: Sub-surface bark. Short, narrow longitudinal scars in spiral arrangement.

Discussion: This sub-surface portion of a *Lepidodendron* is very similar to the specimen figured by Janssen (1939, fig. 29).

Material examined: UF 18902-34013.

Genus LEPIDOPHYLLOIDES Snigirevskaya, 1958
LEPIDOPHYLLOIDES INTERMEDIUM Lindley & Hutton, 1831
Figure 2.7

Lepidophyllum intermedium LINDLEY AND HUTTON, 1831, p. 125, pl. 43, fig. 3.
Cyperites bicarinata LINDLEY AND HUTTON, 1831, p. 123-124, pl. 43, fig. 1.2.

Description: Fragments of linear leaves with midvein and two thinner longitudinal veins on each side of midvein, interspersed among numerous minute striations. Leaf width tapers apically.

Discussion: These leaves are similar to those figured by Lindley & Hutton (1831, pl. 43, figs. 1, 2), Janssen (1939, fig. 47), and Gillespie et al. (1978, pl. 13, fig. 2). This type of leaf was listed from Alabama by Lacefield (2000). Snigirevskaya (1958) proposed the new genus *Lepidophylloides* for detached leaves due to previous use of *Lepidophyllum* (Taylor & Taylor, 1993).

Material examined: UF 18902-34378, 18902-34373b.

Genus LEPIDOSTROBUS Brongniart, 1828

This genus accommodates elliptic to linear lycopod cones. Sporangia and cone scales are in spiral arrangement. We recognize two types in the Union Chapel flora.

LEPIDOSTROBUS sp. A
Figures 2.3, 2.4, 2.6

Lepidostrobus BRONGNIART, 1828, p. 87.

Description: Strobili linear, length 3-6x width. Sporangia and cone scales in spiral arrangement. Sporangia transversely rhombic, a few scales near apex lanceolate with medial longitudinal ridge.

Discussion: These narrow cones are similar to those figured by Gillespie et al. (1978, pl. 15, fig. 6) and Lacefield (2000) and were listed from Alabama by Lesquereux (1880) and Lacefield (2000).

Material examined: UF 18902-33993, 18902-34007, 18902-34372.

LEPIDOSTROBUS sp. B
Figures 2.1, 2.2

Description: Strobili elliptic, length 2x width, with pedicel. Scales spiral, with distinct bulges, lanceolate with attachment of entire base.

Material examined: UF 18902-34042, 18902-34365, 18902-34375.

Genus LEPIDOSTROBOPHYLLUM Hirmer, 1927
LEPIDOSTROBOPHYLLUM cf. MAJUS (Brongniart) Hirmer, 1927
Figures 3.3, 3.12.1

Lepidophyllum majus BRONGNIART, 1828, p. 87.
Lepidostrobophyllum majus (BRONGNIART) HIRMER, 1927, p. 193, 231, fig. 213.

Description: Cone scales lanceolate, widest near middle, sloping slightly towards base, sloping sharply towards apex. Scales with numerous longitudinal striations. Midvein wide, lateral striations narrow.

Discussion: These scales are similar to those figured by Lesquereux (1879, pl. 69, fig. 37, 1880), Langford (1958, fig. 183), and Darrah (1969, pl. 29, figs. 6, 7) but lack an obvious triple-nerved aspect.

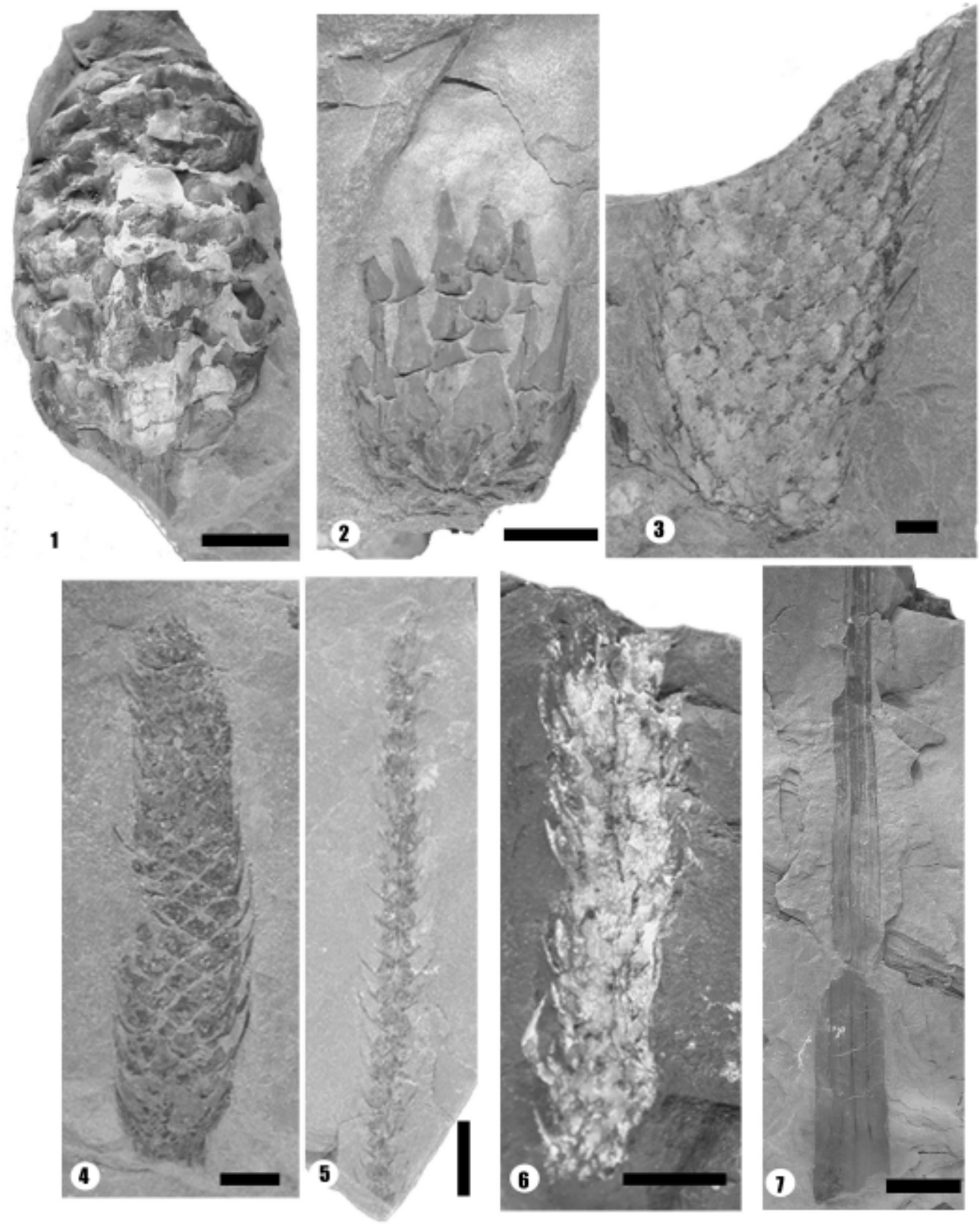

FIGURE 2.1, 2, *Lepidostrobus* sp. B.; 1, UF 34042; 2, UF 34365; 3, 4, *Lepidostrobus* sp. A.; 3, UF 33993; 4, UF 34007; 5, UF 34011, *Calamostachys* sp.; 6, UF 34372, *Lepidostrobus* sp. A.; 7, UF 34378, *Lepidophylloides intermedium*. UF loc. 18902. Bar-5 mm (2-6), 10 mm (1, 7).

Hirmer (1927) proposed the new genus *Lepidostrobophyllum* for detached cone scales (sporophylls).

Material examined: UF 18902-34369a, 18902-34374, 18902-34377.

Family SIGILLARIACEAE
Genus SYRINGODENDRON Sternberg, 1820
SYRINGODENDRON sp.
Figures 1.8, 3.9, 3.11

Syringodendron STERNBERG, 1820, p. 22, 24.

Description: Lower decorticated stem. Ribs lacking. Subcortical surface striate. Subcortical scars double, elliptic, and in vertical rows. Scars with rough, broken cross striations. Upper decorticated stem large (Figs. 3.9, 3.11), 19 cm in diameter. Surface with straight to wavy longitudinal parallel striations formed into bands of ridges and furrows. Predominantly oval scars in spiral arrangement, elevated above the surface. Long axis of scars parallel to striations.

Discussion: The few morphological characters available for decorticated stem impressions make it difficult to place this in any particular species.

Material examined: UF 18902-34016, 18902-34379.

Family CALAMITACEAE
Genus ASTEROPHYLLITES Brongniart, 1822
ASTEROPHYLLITES CHARAEFORMIS (Sternberg) Goeppert in Wimmer, 1844
Figures 3.8, 3.10

Bechera charaeformis STERNBERG, 1825, p. 45, tent. 30, pl. 55, figs. 3, 5.
Asterophyllites charaeformis (STERNBERG) GOEPPERT in WIMMER, 1844, p. 198.

Description: Branching opposite. Stems with thin longitudinal striations. Leaves narrow and whorled, 4 or more per whorl. Leaves arch upward or basal portion horizontal to stem axis and distal portion arching upwards. Tip of leaves overlapping base of superadjacent whorl.

Discussion: These specimens are similar to those figured by Gillespie and Rheams (1985, pl. 2, fig. 5), Gillespie et al. (1978, pl. 25, figs. 1, 4, 1989, pl. 1, fig. 8), and Kvacek and Straková (1997, pl. 13, fig.1). This species was reported from Alabama by Gillespie and Rheams (1985).

Material examined: UF 18902-33986, 18902-34373a, 18902-33990.

Genus CALAMITES Brongniart, 1828

This genus accommodates pith cast with internodes of longitudinal ribs and furrows. The internodes are wider than long and the longitudinal ribs are straight to undulate. The nodal areas possess or lack leaf/branch scars.

CALAMITES SUCKOWII Brongniart, 1828
Figures 3.4, 3.5

Calamites suckowii BRONGNIART, 1828, p. 124, pl. 14, fig. 6; pl. 15, figs. 1-6; pl. 16.

Description: Pith cast with internodes of longitudinal ribs and furrows. Internodes wider than long. Longitudinal ribs with straight sides and rounded to acute apices.

Discussion: The pith cast is similar to those figured by Lesquereux (1879, pl. 1, fig. 3, 1880) and Gillespie et al. (1989, pl. 2, fig. 1), but lack the basal constriction described by Langford (1958) and Darrah (1969). This species was reported from Alabama by Lesquereux (1884).

Material examined: UF 18902-34043, 18902-34366.

CALAMITES UNDULATUS Sternberg, 1825
Figures 3.1, 3.2

Calamites undulatus STERNBERG, 1825, tent. 26.
Stylocalamites undulatus (STERNBERG) KIDSTON, 1889, p. 401.
Calamitina undulata (STERNBERG) KIDSTON, 1894, p. 580.
Calamites undulatus STERNBERG; CROOKALL, 1966, p. 555, pl. 121, figs. 2, 3, pl. 122, figs. 1-3, pl. 124, figs. 1, 2, pl. 125, fig. 1, pl. 126, figs. 2, 3, pl. 127, figs. 1-4, pl. 128, fig. 1.

Description: Pith cast with internodes of longitudinal ribs and furrows. Internodes wider than long. Longitudinal ribs with undulate sides and squared apices.

Discussion: The pith cast is similar to those figured by Langford (1958, fig. 28), Gillespie et al. (1978, pl. 23, fig. 3), and Kvacek and Straková (1997, pl. 58, fig. 5) but the undulations are smoother.

Material examined: UF 18902-34047, 18902-34018.

CALAMITES GOEPPERTI Ettingshausen, 1854
Figures 1.9, 1.10

Calamites goepperti ETTINGSHAUSEN, 1854.

Description: Stem pattern with internodes filled with longitudinal ribs and furrows. Internodes wider than long. The longitudinal ribs are straight and end in small leaf scars. Nodal areas consist of small leaf scars and occasional larger branch scars. The branch scars are packed close together with flattened sides and a square-like outline. Linear leaf-like structures extend from stems. These appear to be leaves.

Discussion: These specimens are similar to those figured by Janssen (1939, fig. 65), Langford (1958, fig. 25), and Gillespie et al. (1978, pl. 24 fig. 4).

Material examined: UF 18902-33992, 18902-33994.

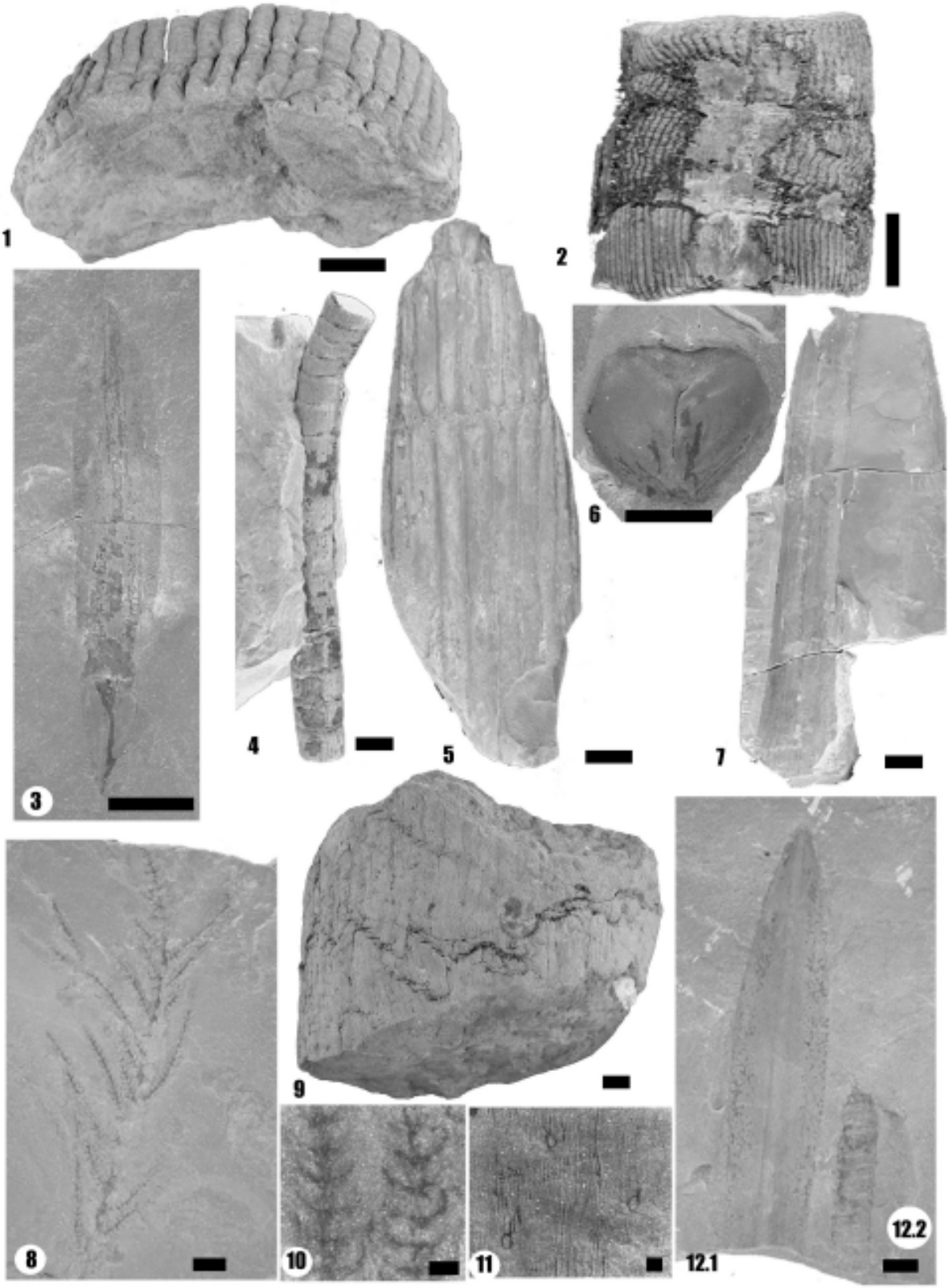

FIGURE 3.1, 2, *Calamites undulatus*; 1, UF 34047; 2, UF 34018; 3, UF 34374, *Lepidostrobophyllum* cf *majus*; 4, 5, *C. suckowii*; 4, UF 34043; 5, UF 34366; 6, UF 34368, *Cordaicarpon* sp.; 7, UF 33989, *Cordaites* sp.; 8, 10, UF 34373a, *Asterophyllites charaeformis*; 9, 11, UF 34379, *Syringodendron* sp.; 10, Enlargement of 8 showing whorled leaves; 11, Enlargement of 9; 12.1, UF 34369a, *Lepidostrobophyllum* cf. *majus*; 12.2, UF 34369b, *Artisia* sp. UF loc. 18902. Bar: 1 mm (10, 11), 5 mm (6, 8, 12.1, 12.2), 10 mm (1, 3, 4, 5, 9), 20 mm (2), 3 cm (7).

Genus CALAMOSTACHYS Schimper, 1869
CALAMOSTACHYS sp.
Figure 2.5

Description: Stroboli linear, length 50 mm, width 5-7 mm. Sporangia midway between whorls of sterile bracts. Internode length 2 mm, bract length 2-4 mm. Basal portion of bracts perpendicular to main axis, then arch apically.

Material examined: UF 18902-34011.

MEDULLOSALES
PTERIDOSPERMS
ALETHOPTERIDS
Genus ALETHOPTERIS Sternberg, 1825
ALETHOPTERIS VALIDA Boulay, 1876
Figure 4.3

Description: Frond fragment. Pinnae opposite, lanceolate, pinnatifid. Pinnules alternate, broadly attached to rachis, connate, oblong, obtuse apex. Pinnules of lower to midsection of pinnae 2-3 mm wide, 5-7 mm long. Pinnules reducing upward to elongate apical pinnule with crenate margin. Midvein of pinnules fork near apex. Lateral veinlets in pairs of 5-7, divide 1-2 times ending at margins at acute to right angles. Basal pinnules with some veinlets arising from rachis.

Discussion: The frond is similar to specimens with more obtuse apex of pinnules figured by Crookall (1955, Pl. 1, fig. 3) and Josten (1991, Pl. 167, figs. 2, 3).

Material examined: UF 18902-34036.

SPHENOPTERIDS
Genus SPHENOPTERIS (Brongniart) Sternberg, 1825

This genus accommodates pinna which are alternate and narrowly attached to the rachis. The pinna are lobed to pinnatifid, and the pinnules are broad to narrowly attached to the rachis.

SPHENOPTERIS ELEGANS (Brongniart) Sternberg, 1825
Figure 4.8

Filicites elegans BRONGNIART, 1822, p. 33, pl. 2, fig. 2.
Sphenopteris elegans (BRONGNIART) STERNBERG, 1825, tent. 15.

Description: Pinna fragment. Pinnules alternate, tri-pinnate, and ovate in outline. Pinnules with narrow attachment. Primary lobes alternate, secondary and tertiary lobes with rounded apex. Single veins entering terminal lobes.

Discussion: The pinna is similar to those figured by Lesquereux (1879, pl. 55, fig. 6, 1880), Gillespie et al. (1978, pl. 8, fig. 1), and Gillespie and Rheams (1985, pl. 3, fig. 3). This species was reported from Alabama by Gillespie and Rheams (1985). Our specimen is different from the Alabama species of *Eremopteris* (Lesquereux, 1879, 1880; White, 1900, 1943) due to narrow secondary and tertiary lobes, and single veins entering the terminal lobes.

Material examined: UF 18902-34030.

SPHENOPTERIS POTTSVILLEA (D. White) Gastaldo and Boersma, 1983
Figure 4.2

Mariopteris pottsvillea D. WHITE, 1900, p. 874, pl. 190, figs. 6 (non pl. 190, figs. 3-5).
Sphenopteris pottsvillea (D. WHITE) GASTALDO AND BOERSMA, 1983, p. 223, pl. 8, pl. 9, pl. 10, figs. 6, 7.

Description: Pinna alternate, narrowly attached and somewhat decurrent to axis. Pinna lobed to pinnatifid. Pinnatifid state with basal lobe separate. Pinna apex obtuse to acute. Pinnules alternate, ovate and obtuse, broad attachment to rachis. Pinnules confluent towards top of pinna. Parallel veins originating low at an acute angle continuing straight or arching out to apex. Veins forking 1-3 times.

Discussion: The pinna is similar to those figured by White (1900, pl. 190, figs. 3-6, 1943, pls. 8-10), Read and Mamay (1964, pl. 5, fig. 1), Gastaldo and Boersma (1983a, pls. 8-10), Gillespie and Rheams (1985, pl. 1, fig. 5), Gillespie and Crawford (1985, pl. 1, fig. 7), Gastaldo (1988, fig. 2), and Gillespie et al. (1989, pl. 1, fig. 7). This species was reported from Alabama by White (1900, 1943), Gastaldo and Boersma (1983a), Gillespie and Rheams (1985), and Gastaldo (1988).

Material examined: UF 18902-34033.

Genus LYGINOPTERIS H. Potonié, 1897
LYGINOPTERIS HOENINGHAUSI (Brongniart) H. Potonié, 1897
Figures 4.4, 4.7

Sphenopteris hoeninghausi BRONGNIART, 1830, p. 199, pl. 52.
Dadoxylon oldhamium Binney, 1866, p. 115.
Lyginopteris oldhamia (Binney) H. Potonié, 1897, p. 170.
Lyginopteris hoeninghausi Gothan, 1931, p. 71-79, pl. 21, figs. 1, 2, pl. 22, figs. 1, 2, pl. 23, figs. 4, 5.

Description: Fragment of frond. Secondary pinna alternate. Tertiary pinna alternate with narrow attachment. Pinna lobed to pinnatifid with obtuse apex. Pinnules alternate, ovate to shallow lobed, broadly attached and decurrent to rachis. Pinnules confluent towards top of pinna. Veins parallel, emerging from rachis, forking 1-2 times.

Discussion: The frond is similar to those figured by Gillespie and Rheams (1985, pl. 2, fig. 6), Gillespie and Crawford (1985, pl. 3, fig. 1) and Gillespie et al. (1989, pl. 1, fig. 14) but the pinnules are broadly attached to rachis and slightly lobed. This species was reported from Alabama by Gillespie and Rheams (1985).

Material examined: UF 18902-34038, 34039.

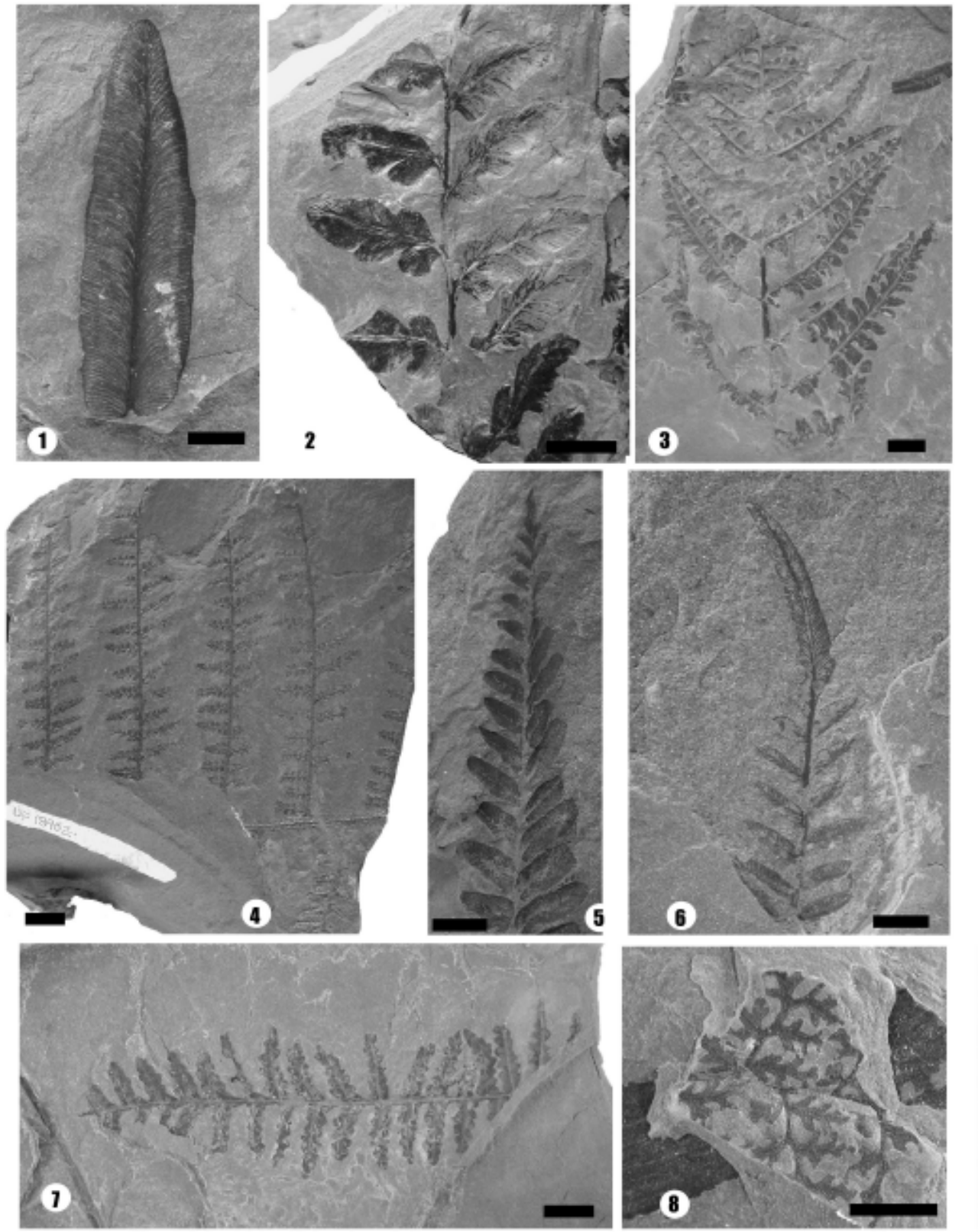

FIGURE 4.1, UF 34029, *Neuralethopteris biformis*; 2, UF 34033, *Sphenopteris pottsvillea*; 3, UF 34036, *Alethopteris valida*; 4, UF 34039, *Lyginopteris hoeninghausi*; 5, UF 34025, *Neuralethopteris pocahontas*; 6, UF 34023, *Neuralethopteris biformis*; 7, UF 34038, *Lyginopteris hoeninghausi*; 8, UF 34030, *Sphenopteris elegans*. UF loc. 18902. Bar: 5 mm (1, 6, 8), 10 mm (2-5, 7).

NEUROPTERIDS
Genus CYCLOPTERIS Brongniart, 1831
CYCLOPTERIS sp.
Figure 5.3

Cyclopteris BRONGNIART, 1831, p. 215

Description: Leaf oval, broad base 5 cm wide, upper portion 11 cm wide. Convex on upper surface. Veins flabellate, parallel, arched, thin and all the same size.

Discussion: Could not verify if the veins forked or dichotomize, but the leaf is similar to *Neuropteris inflata* Lx. illustrated by Lesquereux (1866, pl. 37, fig. 2).

Material examined: UF 18902-34046, 18902-34046´.

Genus NEURALETHOPTERIS Cremer ex Laveine 1967

This genus accommodates pinnae that are lanceolate with a single terminal pinnule. Pinnules are alternate and lanceolate to ovate. Pinnules are narrowly attached at the middle with a short pedicel and are rounded to cordate. Pinnules have a prominent midvein. The lateral veins divide once near the midvein, then a second time half way to margin and then meet at the margin at a 45-90° angle.

NEURALETHOPTERIS POCAHONTAS (White) Goubet et al., 2000
Figure 4.5

Neuropteris pocahontas D. WHITE, 1900, p. 888-890, pl. 189, figs. 4, 4a, pl. 191, figs. 5, 5a.

Description: Pinna fragment, lanceolate. Pinnules alternate and ovate, with narrow attachment. Base round to slightly cordate, obtuse to rounded apex. Prominent midrib to near apex then divides. Lateral veins prominent, arise from midrib at acute angle then arch out to margin dividing 2-3 times. First division near midrib, veins meet margin at or near 90° angle. Terminal pinnule narrow and oblong, with basal lobes.

Discussion: The pinna is similar to those figured by Lesquereux (1879, 1880), White (1900, pl. 190, figs. 7, 8), Gillespie et al. (1978, pl. 44, fig. 1), and Gillespie and Rheams (1985, pl. 2, fig. 7). This species was reported from Alabama by White (1900), and Gillespie and Rheams (1985).

Material examined: UF 18902-34025.

NEURALETHOPTERIS BIFORMIS (Lesquereux) Goubet et al., 2000
Figures 4.1, 4.6

Neuropteris biformis Lesquereux, Atlas 1879, pl. 13, fig. 7; 1880, p. 121.

Description: Pinna fragment lanceolate with single terminal pinnule. Pinnules alternate, lanceolate, and not overlapping. Pinnule base rounded to slightly cordate, narrow attachment at middle with short pedicel. Prominent midvein to near acute apex. Lateral veins divide 2 times meeting margin at 45-90° angle. Terminal pinnule elongate, acute apex and slightly bulging base. Isolated pinnule lanceolate, 3.2 cm long by 0.8 cm wide. Apex acute, base cordate. Strong midvein reaches nearly to apex. Secondary veins angle upward from midvein then running straight out to margin, divide 2-3 times. Average count is 42-45 per centimeter of margin.

Discussion: The pinnules are similar to specimens figured by Goubet et al. (2000, figs. 12.7, 13) and Gillespie and Rheams (1985, pl. 2, figs. 9, 10).

Material examined: UF 18902-34023, 18902-34350, 18902-34351, 18902-34029.

MISCELLANEOUS PTERIDOSPERMS
Genus MYELOXYLON Brongniart, 1849
MYELOXYLON sp.
Figure 5.7

Myeloxylon BRONGNIART, 1849.

Description: Fragment of branched stem, with presence of vascular strands.

Dicussion*:* The stem is similar to a specimen figured by Darrah (1969, pl. 80, fig. 2).

Material examined: UF 18902-33988.

Genus WHITTLESEYA Newberry, 1853
WHITTLESEYA ELEGANS Newberry, 1853
Figure 5.6

Whittleseya elegans NEWBERRY, 1853, p. 106, figs. 1-2b.

Description: Campanulate structure with parallel longitudinal striations, radiating out from base and ending in dentate apex. Base rounded with peduncle, apex truncate with dentate teeth.

Discussion: The structure is similar to those figured by Lesquereux (1879, pl. 4, fig. 1, 1880) and Darrah (1969, pl. 71, fig. 2).

Material examined: UF 18902-34364, 18902-34364´.

Genus HOLCOSPERMUM Nathorst, 1914
HOLCOSPERMUM sp.
Figure 5.5

Holcospermum NATHORST, 1914, p. 28.

Description: Seed ovate, rounded at base and narrowed upward. Longitudinal striations radiating from base and converging near apex.

Discussion: The seed is similar to *Holcospermum multistriatus* figured by Lesquereux (1879, pl. 85, figs. 22, 23, 1880) and Darrah (1969, pl. 68, figs. 2, 3), *H. mammillatus* by Lesquereux (1884, pl. 110, figs. 39-42), plus *H. maizeretense* Stockmans & Williere in Gillespie and Rheams (1985, pl. 1, fig. 4) and Gillespie et al. (1989, pl. 1, fig. 4). This species is reported from Alabama by Gillespie and Rheams (1985).

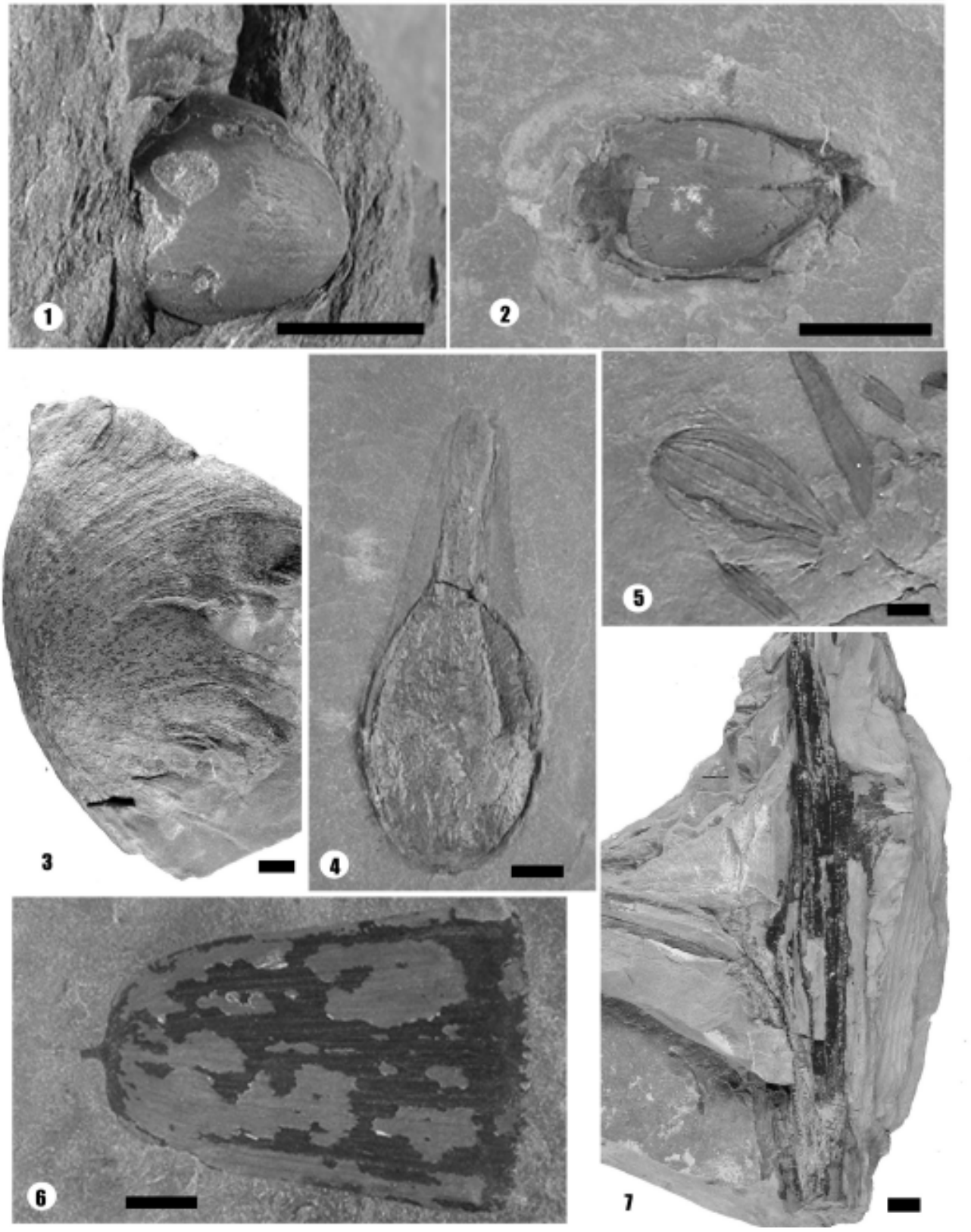

FIGURE 5.1, UF 34041, *Carpolithes* sp.; 2, UF 34040, *Trigonocarpus* sp.; 3, UF 34046, *Cyclopteris* sp.; 4, UF 34362, *T. ampulliforme*; 5, UF 34370, *Holcospermum* sp.; 6, UF 34364´, *Whittleseya elegans*. 7, UF 33988, *Myeloxylon* sp. UF loc. 18902. Bar: 5 mm (4-6), 10 mm (1, 2, 3, 7).

Material examined: UF 18902-34370.

Genus TRIGONOCARPUS Brongniart, 1828
TRIGONOCARPUS AMPULLIFORME Lesquereux, 1884
Figure 5.4

Trigonocarpus ampulliforme LESQUEREUX, 1884, p. 823, pl. 109, figs. 18-20.

Description: Seeds ovate, narrowed upward to a tubular neck. Base rounded with small circular depression. Sclerotesta surrounding nucellus and microplye extension. Faint ribs on sclerotesta.

Discussion: The seeds are similar to those figured by Lesquereux (1884, pl. 109, figs. 18-20), White (1900, pl. 191, fig. 8), Gillespie and Crawford (1985, pl. 3, fig. 6), and Gillespie and Rheams (1985, pl. 2, fig. 1). This species is reported from Alabama by Gillespie and Rheams (1985).

Material examined: UF 18902-34362, 18902-34362´.

TRIGONOCARPUS sp.
Figure 5.2

Trigonocarpum BRONGNIART, 1828, p. 137. *Trigonocarpus* BRONGNIART, 1881, p. 39.

Description: Seed that is three valved, ovate, and sclerotesta with faint ribs. Short, acute apex and rounded base.

Material examined*:* UF 18902-34040, 34040´.

Genus CARPOLITHES Schlotheim, 1820
CARPOLITHES sp.
Figure 5.1

Carpolithes SCHLOTHEIM, 1820.

Description: Seed ovate, surface smooth, with obtuse apex and rounded base. Possible ribs present.

Material examined: UF 18902-34041.

CORDAITALES
Family CORDAITACEAE
Genus ARTISIA Sternberg, 1838
ARTISIA sp.
Figure 3.12.2

Artisia STERNBERG, 1838, p. 192.

Description: Central pith cast with transverse, irregular spaced septations.

Discussion: This pith cast is similar to ones figured by Janssen (1939, fig. 56), Langford (1958, fig. 224), Canright (1959, pl. 5, fig. 10), Wood (1963, pl. 11, fig. 8), and Gillespie et al. (1978, pl. 53, figs. 1, 2).

Material examined: UF 18902-34369b.

Genus CORDAICARPON H. B. Geinitz, 1862
CORDAICARPON sp.
Figure 3.6

Cordaicarpon GEINITZ, 1862, p. 150.

Description: Seed obovate with an apical protruding flange overriding an obtuse notch, base truncate. Medial longitudinal ridge flanked by broadly undulating smooth surface.

Discussion: This seed is similar to those of Langford (1958, fig. 625) but our specimen has a medial longitudinal line. It is also similar to those of Wood (1963, pl. 12, fig. 7), but our specimen has a depression flanking the obtuse apical notch.

Material examined: UF 18902-34368.

Genus CORDAITES Unger, 1850
CORDAITES sp.
Figure 3.7

Cordaites UNGER, 1850, p. 277.

Description: Linear fragment of leaf, entire margin. Length 50 cm, basal width 4 cm, apical width 6 cm. Numerous closely packed parallel longitudinal veins (30-40 per cm).

Discussion: This leaf is similar to *C. mansfieldi* figured by Lesquereux (1879, pl. 76, fig. 4, 1880), and *C. grandifolius* figured by Noe (1925, pl. 45, fig. 2) and Darrah (1969, pl. 48, fig. 3).

Material examined: UF 18902-33989.

DISCUSSION

The Union Chapel flora is characterized as a coastal lowland swamp forest dominated by large arborescent lycopods of the Lepidondendrales. Different organs of essentially the same type of lycopod trees are well preserved. This includes bark impressions of *Lepidodendron* and *Lepidophloios*, subsurface bark *Aspidiopsis*, detached leaves *Lepidophylloides*, intact cones *Lepidostrobus*, and isolated cone scales *Lepidostrobophyllum*. Of particular interest are the association of annelids and the bark of *Lepidopholoios* recorded from leaves and stems of various coal plants (Lesquereux, 1866). A minor constituent of large trees is *Sigillaria*, represented by highly eroded stem cast and impressions of *Syringodendron*. Smaller trees are represented by a cone of *Calamostachys*, stem and pith casts of *Calamites* and associated foliage of *Asterophyllites*. Understory plants are made up mainly of seed ferns, or pteridosperms, which includes foliage of *Neuralethopteris*, *Sphenopteris*, and *Cyclopteris*, stems of *Myeloxylon*, seeds of *Trigonocarpus*, and prepollen organs of *Whittleseya*. A minor group of understory plants includes *Alethopteris*, isolated seeds of *Holcospermum*, and of *Carpolithes*. A possibly riparian, tree-sized plant (Lacefield, 2000) includes isolated leaves of *Cordaites*, pith casts of *Artisia*, and seeds of *Cordaicarpon*. Figure 6 illustrates what a view of the

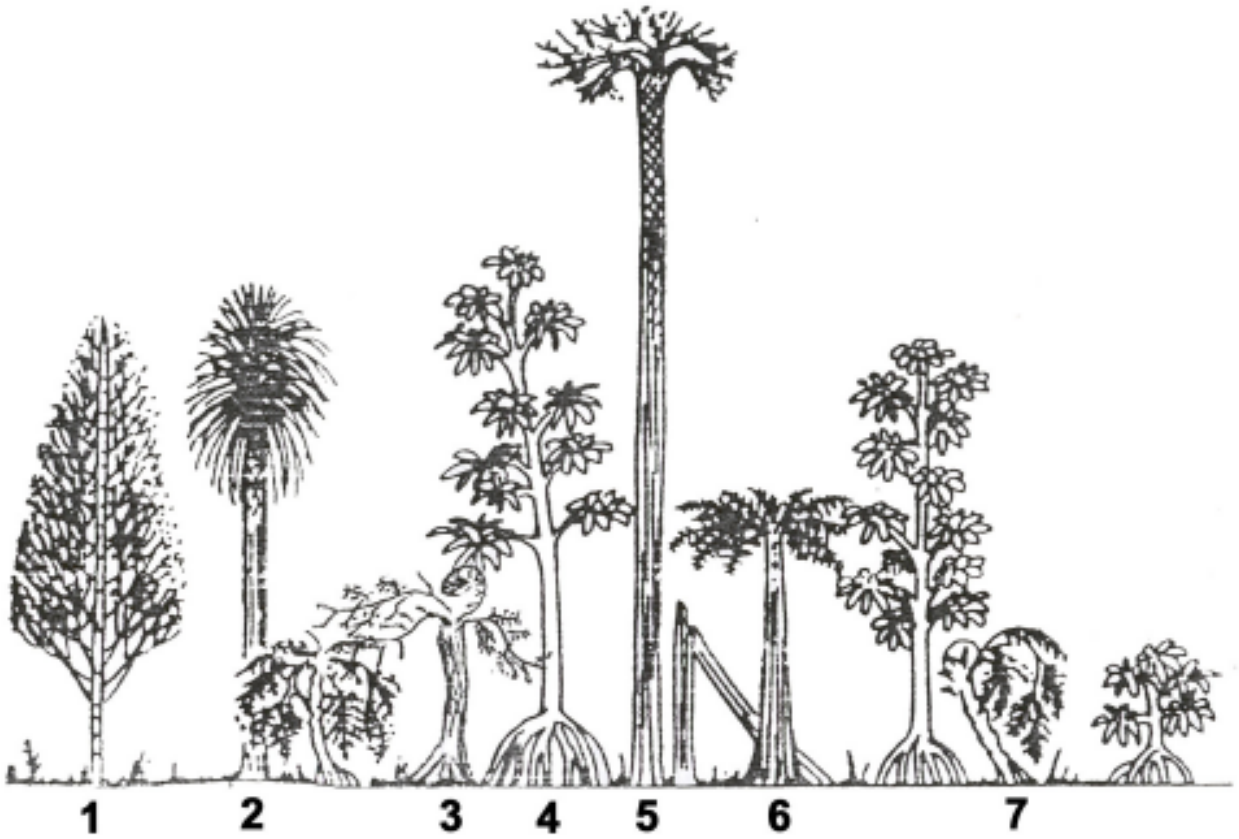

FIGURE 6. Reconstruction of coal swamp trees. 1, *Calamites*; 2, *Sigillaria*; 3, *Medullosa* (seed fern); 4, *Cordaites*; 5, *Lepidodendron/ Lepidophloios*; 6, *Psaronius*; 7, seed fern. Modified from Phillips et al. (1976).

swamp forest might have looked like.

For additional photographs of fossil plants from the Union Chapel Mine, see Dilcher and Lott (2005).

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