

## **Chesapeake Bay Pollen**

**By Debra A. Willard**

Pollen is part of the life cycle of seed plants, the haploid male gametophyte, and pollen grains commonly are preserved as fossils. They are useful for reconstruction of past plant communities and, by extension, climatic and environmental trends from lacustrine, estuarine, and marine sediments. Plants have evolved a number of mechanisms to ensure successful reproduction, including pollination by wind, insects, and birds, among others. The type of pollination strategy used by a plant is a major control on the abundance and distribution of its pollen in sediments, with wind-pollinated plants the best represented in most sediments. Because virtually all pollen is transported some distance from the source plant, it is critical to correlate pollen abundance in surface samples with that of the source vegetation before interpreting past vegetational composition from fossil pollen assemblages. Such studies have been undertaken in lacustrine and wetland sediments from eastern North America by Davis (1963), Davis and Webb (1975), Delcourt, Delcourt, and Davidson (1983), Overpeck, Webb, and Prentice (1985), Webb and McAndrews (1976), and Willard and Weimer (1997). In an ongoing study, we are augmenting existing data by sampling annual pollen accumulation in both pollen traps and clay pads in forested wetlands as well as examining pollen from the surface centimeter of Chesapeake Bay sediment. These data are helping to establish how much variability is introduced by analysis of time-averaged surface samples as compared to analysis of annual samples.

Databases with abundance and distribution of modern pollen in offshore sediments have been compiled for quantitative paleoecological analysis of pollen assemblages from estuarine and marine systems. These include research by Mudie (1982) on the coastal and continental shelf areas off eastern Canada; Heusser (1983/84) on slope and rise sediments between Florida and Greenland; and Groot (1966) on sediments in the Delaware River

estuary. In the Chesapeake Bay region, extensive work by Brush and others has provided the groundwork for interpretation of vegetational patterns from pollen assemblages preserved in the Chesapeake Bay and its tributaries (see Brush and DeFries (1981) and DeFries (1986)). Pollen from major plant taxa in eastern North America has been illustrated in several publications, including McAndrews *et al.* (1973), Bassett *et al.* (1978), and Jones *et al.* (1995).

In this report, we illustrate several of the most common pollen types found in the Chesapeake Bay (Table 6) and provide pollen census data from box, piston, and gravity cores collected in the bay (Appendix 5). Ongoing research on pollen assemblages from the Chesapeake Bay region is documenting the distribution of pollen in the modern estuary and surrounding watershed and establishing temporal patterns in plant distribution in response to changes in both climate and land use over the last millennium.

**Table 6. Pollen from the Chesapeake Bay**

<b>Scientific Name</b>	<b>Common Name</b>
<i>Acer</i>	Maple
<i>Alnus</i>	Alder
<i>Ambrosia</i>	Ragweed
<i>Artemisia</i>	White Sage
Asteraceae	Aster family
<i>Betula</i>	Birch
<i>Carya</i>	Hickory
<i>Castanea</i>	Chestnut
<i>Celtis</i>	Hackberry
<i>Cephalanthus</i>	Buttonbush
Chenopodiaceae	Pigweed family
<i>Cornus</i>	Dogwood
<i>Corylus</i>	Hazelnut
Cyperaceae	Sedge family
Ericaceae	Heath family
Euphorbiaceae	Spurge family
<i>Fabaceae</i>	Legume family
<i>Fagus</i>	Beech
<i>Fraxinus</i>	Ash
<i>Ilex</i>	Holly
<i>Juglans</i>	Walnut
<i>Liquidambar</i>	Sweet-gum
<i>Liriodendron</i>	Tulip Poplar
<i>Myrica</i>	Wax Myrtle
<i>Nyssa</i>	Black Gum
<i>Ostrya/Carpinus</i>	Ironwood/Hornbeam
<i>Picea</i>	Spruce
<i>Pinus</i>	Pine
<i>Plantago</i>	Plantain
Poaceae	Grass family
<i>Polygonum</i>	Knotweed
<i>Quercus</i>	Oak
<i>Salix</i>	Willow
Taxodiaceae/Taxaceae/Cupressaceae	Cypress/Yew/Cedar families
<i>Tilia</i>	Basswood
<i>Tsuga</i>	Hemlock
<i>Typha</i>	Cattail
<i>Ulmus</i>	Elm

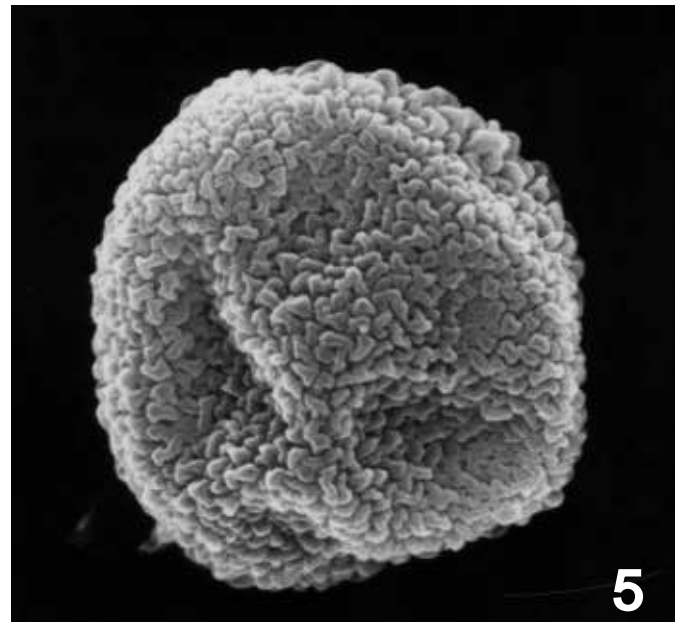
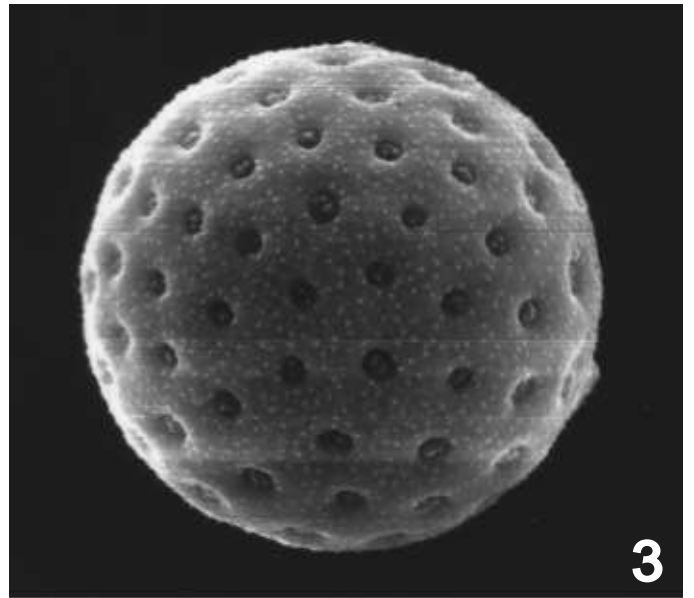
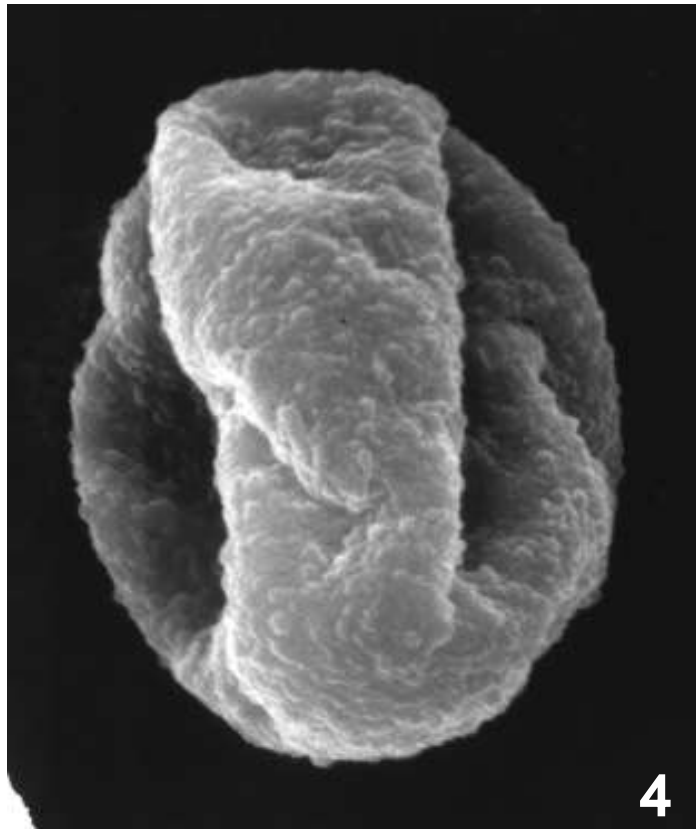
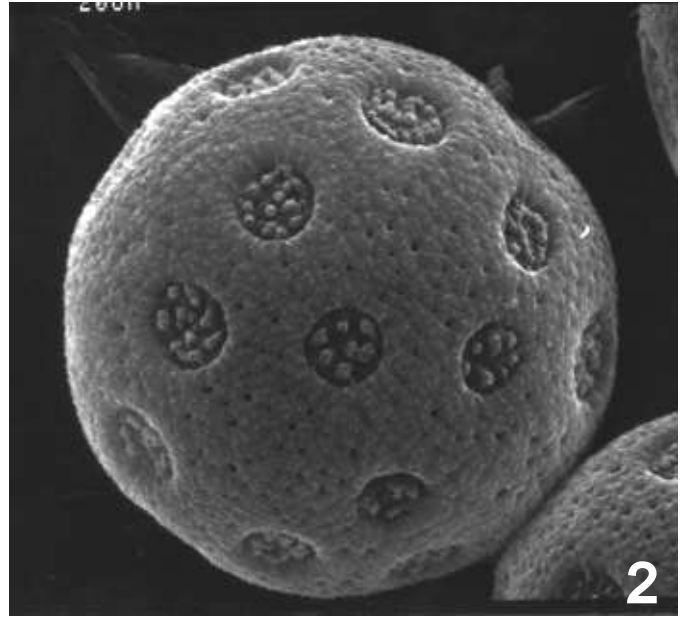
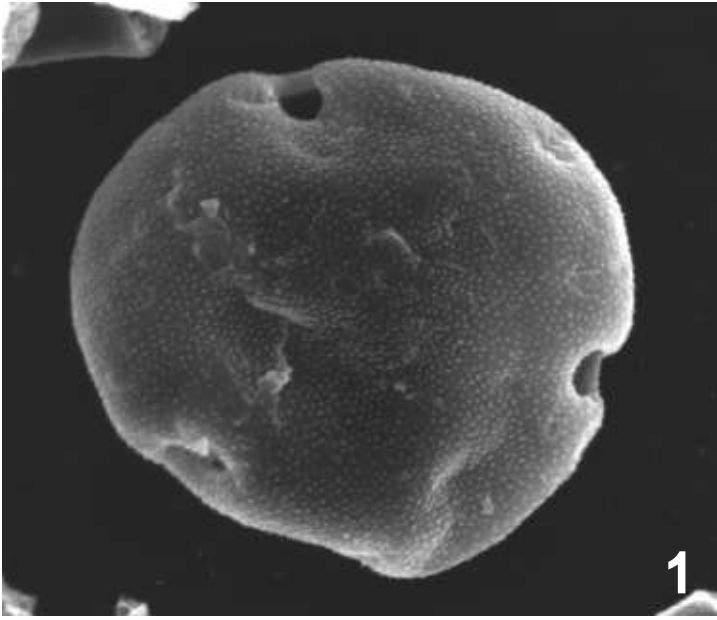
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## Plate 1

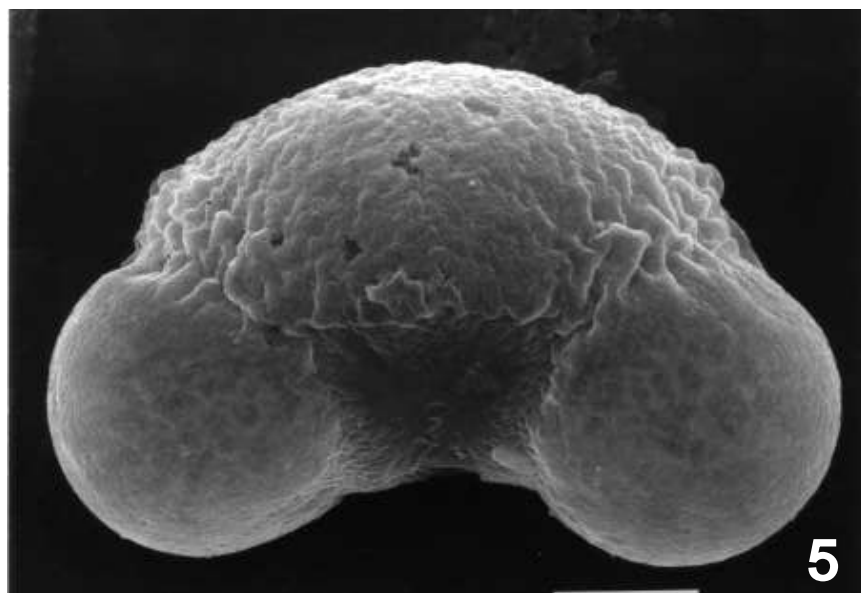
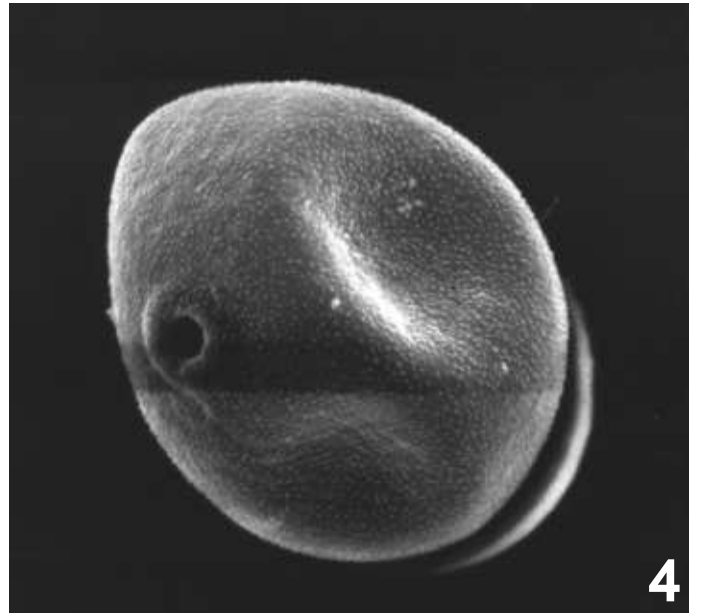
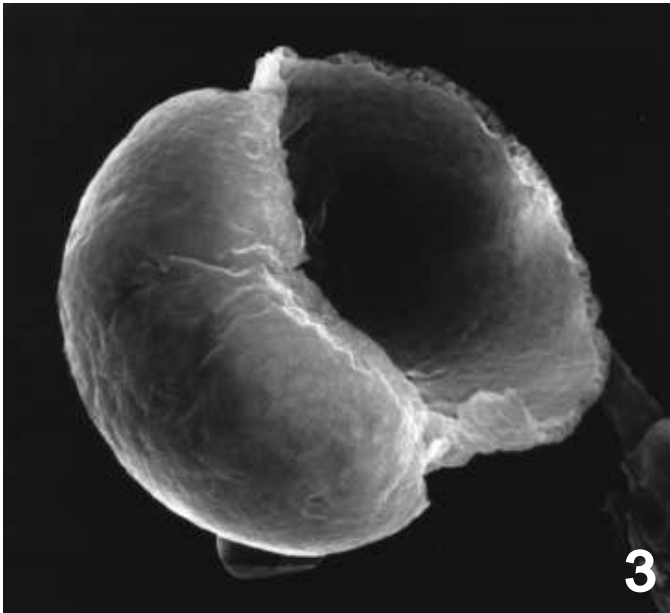
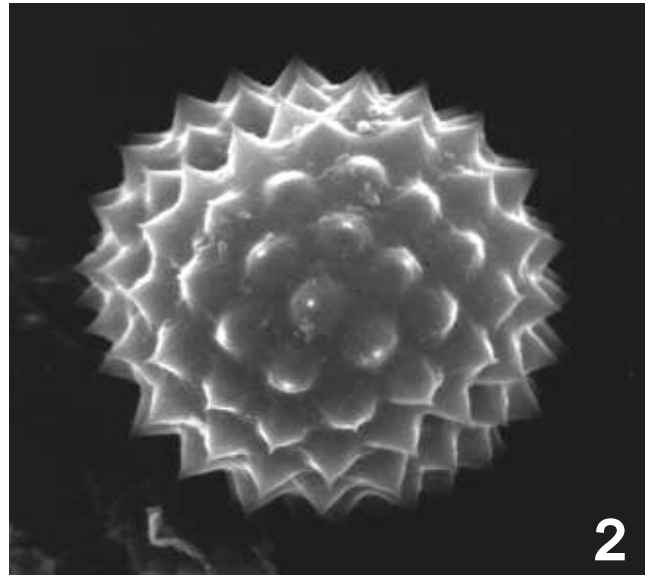
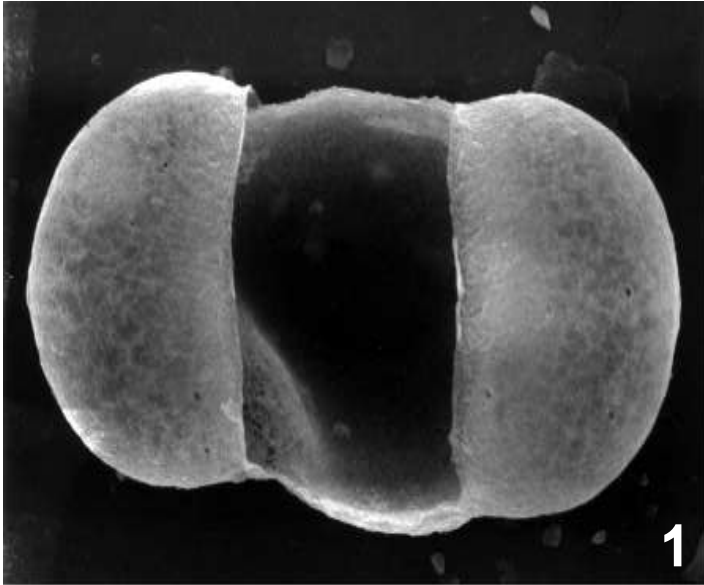
- 1) *Juglans* Linnaeus (Walnut), PRCK 100-102 cm., x 2600.
- 2) *Liquidambar* Linnaeus (Sweet Gum), PTMC 3-2 106-108 cm., x 2800.
- 3) Chenopodiaceae Ventenat (Pigweed Family)/Amaranthaceae Jussieu (Goosefoot Family), PTXT 50-52 cm., x 2600.
- 4) *Quercus* Linnaeus (Oak), PRCK 100-102 cm., x 4800.
- 5) *Tsuga* Carrière (Hemlock), PRCK 100-102 cm., x 1300.



## Plate 2

- 1) *Pinus* Linnaeus (Pine), PTMC 3-2 422-424 cm., x 1800.
- 2) *Ambrosia* Linnaeus (Ragweed), PTXT 50-52 cm., x 2600.
- 3) *Pinus* Linnaeus (pine grain with air bladder broken off), PRCK 100-102 cm., x 1800.
- 4) Poaceae Barnhart (Grass Family), PTXT 50-52 cm., x 1600.
- 5) *Pinus* Linnaeus (Pine), PTMC 3-2 422-424 cm., x 2000.





Depth (cm)	<i>Pinus</i>	<i>Carya</i>	<i>Quercus</i>	<i>Liquidambar</i>	<i>Tsuga</i>	<i>Picea</i>	<i>Betula</i>	<i>Corylus</i>	<i>Salix</i>	<i>Nyssa</i>	<i>Ulmus</i>	<i>Juglans</i>	<i>Ostrya/Carpinus</i>	<i>Fagus</i>	<i>Myrica</i>	<i>Alnus</i>	<i>Acer</i>	<i>Liriodendron</i>	<i>Celtis</i>	<i>Fraxinus</i>	<i>Castanea</i>	Taxodiaceae/Taxaceae/Cupressaceae	<i>Ilex</i>	<i>Tilia</i>	Poaceae	Chenopodiaceae	Ambrosia
4	155	11	110	30	1	1	15			9	2	2	4	8	7	2	3	1					1		6	4	20
7	166	14	89	16	3	4	7			1	3	2		7			1						1		2	5	20
11	150	12	104	11	2	6	3				3	1	1	6										4	5	15	
15	150	9	104	12	2	7	4	1			3			2	2	2	2							4	2	19	
19	146	5	105	10	1	5	5				3			1	3	3						1		3	4	20	
21	161	21	96	13	6	5	5			4	1	2	3	8	3		1							17	4	20	
23	200	13	65	5	4	7	1				1	2		1										3		4	
27	213	15	55	5		7	1					1		3										5		3	
31	202	19	66	11	2	4	1			4	1	1	1	7								1		6	3	2	
35	217	18	71	11		6	1				1			5			1					1		4	1	6	
39	201	25	79	7	1	7	2			4	2	2		8			1							3	2	5	
43	116	10	46	9	3	7	3		1	6			3	6	8			1			1	1		3		20	
77	175	22	73	8		4	6		1	7	3		2	4	13	3								6	2	61	
107	186	10	44	8	4	5	5			7	1	1		4	4									2	2	13	
129	194	17	40	5	7	4	7			3	2	1	2	3	1	1	1							7	2	10	
151	230	11	90	6	2	6	1			1	5	1	1	2										1		12	
157	143	9	99	7	6	4	8	2		2			1	10	5	4	1		1			1		7		40	
161	192	16	108	2	3	2					1		1	1							1				3		
165	170	20	174	7	2	2	3				2	1	1											1	1	3	
167	148	17	142	5	2	2	1						1									1		1	4	2	
171	201	17	105		4	7	1					1		4											1		
175	150	18	141	3	1	3	1			1	1		3			2					1			1	1	1	
181	170	23	119		3	3						2												2			
185	149	21	128	3	2	5	3				1	1		12		3	2				4			5	1	9	
191	199	19	146	4	2	5	2				1	1		1			3					1			1	1	
195	175	25	102	3	1	6	1			1		1		3			1								3	3	
201	144	15	124	2	2	3	4			1		2		3	1		1					2	1	1	9	1	
205	172	25	113	5	2	4	1					1		7								1			2		
211	161	24	116	2	1	5	3			3				4			1							2		2	
215	151	28	141	3	4	5	2				1			2			1							3	1	2	
237	141	15	120	6	5	2	4	2				1		3	1									3	2		
261	142	18	118	5	4	8	1			2				8	1					2				2	2		
307	133	17	147	2	5	3	6		2	2	1	1		4			1					7		4	4	1	
335	148	19	121	5	5	2	6			1		2		15								3	1	5	3	1	
357	189	31	136	7	6	3	8			6	2				1							1		4	2		
395	159	13	124	1	8	2	1						1									1		5	3		
419	194	23	126	2	3	3	4		1			1		2								2		2	3		
447	181	23	95	4	4	3	4			1	1				1	1						1		2	2		

Depth (cm)	<i>Asteraceae indet.</i>	<i>Fabaceae</i>	<i>Cornus</i>	<i>Cyperaceae</i>	<i>Euphorbiaceae</i>	<i>Ericaceae</i>	<i>Typha</i>	<i>Plantago</i>	<i>Polygonum</i>
4	3		1					1	
7	1			1			1		
11	2			2			1		
15	5			3			1		
19							1		
21	1			2					
23									
27				2			1		
31	1						1		
35	1								
39	1						1		
43	1						1	1	
77	1	1					1	6	
107	1						1		
129	1					1	2	1	
151	1								
157	3	2				1	3	2	
161	3								
165	4			2					
167	1								
171									
175	1			2					
181									
185	1			1			1		
191				2					
195				1					
201	1			4	1	1			
205	1			2					
211	1								
215									
237	3								
261	2	4		1			1		
307				4					
335		1		2				1	
357	4	2		1	1	1			
395	1	2							
419	2			3					
447	1	1					1		

Depth (cm)	<i>Pinus</i>	<i>Carya</i>	<i>Quercus</i>	<i>Liquidambar</i>	<i>Tsuga</i>	<i>Picea</i>	<i>Betula</i>	<i>Corylus</i>	<i>Salix</i>	<i>Nyssa</i>	<i>Ulmus</i>	<i>Juglans</i>	<i>Ostrya/Carpinus</i>	<i>Fagus</i>	<i>Myrica</i>	<i>Alnus</i>	<i>Acer</i>	<i>Celtis</i>	<i>Fraxinus</i>	<i>Castanea</i>	Taxodiaceae/Cupressaceae/Taxaceae	
1	287	14	81	23	1	3	8	2			6	2	4	59	1	3	3				2	
6	218	14	59	21		1	4			1	6	1		30	4	1	2		2	1		
11	149	12	69	21		1	4				2	2	4	35	4	2	2		1	1	1	
16	145	15	68	25	1		5			1	3	1	2	35	4		1		3	1		
21	181	15	56	26		2	4			1	1	3	3	22	3	1			2			
26	169	16	52	10		1	1	1	1		9	1	3	24	3	1	6		1			
31	160	26	76	17		8	7		1		12		1	29	5	1	1		2	1		
36	160	23	64	17	1	7	6		1		8	1	2	22	7	1	1		2		1	
41	161	24	64	12	1	2	6				3		3	30	2	2	1					
46	172	4	75	8		10	1	1	1		1	1	2	14	1	1	1			1	1	
51	150	15	90	12	1	3	10				4	1	2	10	4	2	1				1	
56	185	12	58	14	2	5	7				1		1	22	4	2	2		2			
51	189	11	45	9	6	4	3			1	5			14	4	3			1		1	
66	152	19	92	9		7	6			2		1	1	12	3	1	4		5			
71	148	22	65	8	1	5	7			3		1	3	20	3	3	1					
76	160	17	62	4	1	5	5	1		3	3	1	3	13	1	2	1			1	1	
81	165	17	47	6	2	9	5	1	1	2	2		4	12	2	4			1	3		
86	168	18	39	8	2	7	3		1	3	3		2	19	5	7	4			1		
91	174	26	48	11	4	7	5			2	3	1	3	23	4	2	3				3	
96	125	16	42	8		6	11		1	2	2		3	34		9	3			2	2	
101	97	4	48	4	2	3	2	1		1	2			3	1	2	2			1	1	
106	140	11	41	5	5	3	9	1		1	2			58	2	3	1	1	5		1	
111	237	19	41	9	5	5	5	1	2	3	1	5		58	2	3	2			3	1	2
116	153	5	46	7	5	4	3	2	3		2	6	1	50	2	7	1	1	1	2	1	

Depth (cm)	<i>Ilex</i>	<i>Tilia</i>	Poaceae	Chenopodiaceae	<i>Ambrosia</i>	Asteraceae indet.	Fabaceae	Cyperaceae	Euphorbiaceae	<i>Sagittaria</i>	<i>Typha</i>	<i>Polygonum</i>
1	1		7	2	9	6		2			1	
6			4	2	18	4						1
11			5	3	22	4					2	
16			8	2	25	2		1				
21				2	16							
26			10	1	34	3		1			1	
31			4	4	42			2				2
36		1	8	2	33	2		2			1	
41			7	4	28	1		3				
46			1	4	25			1				
51			3	7	31	1						
56			8	2	33	3		3				1
51			5	4	49	3						1
66			6	3	66	2		1		3		
71			9		52	3		5				
76			6	1	32	1		2				1
81	1		13	5	41	5		2		7	2	
86			8	11	47	2		3			1	
91			9	4	51	1				1	1	
96			10	4	42	3		1		6		
101	1		1	2	22		2					
106	1	1	7	1	43	2		1			1	
111		1	14	2	25	3	5	2	1		3	
116			12	2	37			3				

Depth (cm)	<i>Pinus</i>	<i>Carya</i>	<i>Quercus</i>	<i>Liquidambar</i>	<i>Tsuga</i>	<i>Picea</i>	<i>Betula</i>	<i>Corylus</i>	<i>Salix</i>	<i>Nyssa</i>	<i>Ulmus</i>	<i>Juglans</i>	<i>Ostrya/Carpinus</i>	<i>Fagus</i>	<i>Myrica</i>	<i>Alnus</i>	<i>Acer</i>	<i>Liriodendron</i>	<i>Celtis</i>	<i>Fraxinus</i>
1	199	17	84	14	4		2			5	2	3		3	2	1		1		
11	202	18	57	12	5	2	2			3		1		3			1		1	
21	220	20	85	9	4	3	2			1		2		3			1			
31	207	15	78	4	5	2	3				1	2		2						1
41	245	19	59	1	9	4								2	1					
51	168	15	83	4	2	3	1	1		2	2	3		4	2					1
56	210	28	52	4	10	4	1			2	1	2		1						1
61	159	11	161	5	3	2	7	1	1					1	1	1	1			1
71	208	14	53	2	7	7			1		1	1		1	1	3				
76	149	7	93		3		2	1		2				3	1					
81	198	11	76	1	10		1					3								
91	142	10	149	8	4	3	1	1			1			2	2					2
101	242	10	59	2	9	3								1						
106	287	18	92	3	7	1	1	1			1		1				3			
111	162	12	109	1	7	2	1		2		2		1	1	4					

Depth (cm)	<i>Castanea</i>	<i>Taxodiaceae/Taxaceae</i> <i>/Cupressaceae</i>	<i>Ilex</i>	<i>Tilia</i>	<i>Cephalanthus</i>	<i>Poaceae</i>	<i>Chenopodiaceae</i>	<i>Ambrosia</i>	<i>Asteraceae</i> indet.	<i>Artemisia</i>	<i>Fabaceae</i>	<i>Cornus</i>	<i>Cyperaceae</i>	<i>Euphorbiaceae</i>	<i>Ericaceae</i>	<i>Typha</i>	<i>Plantago</i>	<i>Polygonum</i>
1			2		1	4		4		1	1		2			3	1	
11			1			4	4	6					2					
21		1	2			1	3	3					1					1
31							2	2			1					1	1	
41			2			3		2	1				1					
51						1	3	12	1		1		1	1		1		
56				1		1		7	1		1	1	1		1	1		
61	4		3	1			2	42					1					
71						2		4	1									1
76	3					2	2	21	1						1			
81			1			3	1	1										
91	3		2			3		6					1					
101			1			1	1											
106		2	1			1		1					2					
111		4	1					9					1	1				

Depth (cm)	<i>Pinus</i>	<i>Carya</i>	<i>Quercus</i>	<i>Liquidambar</i>	<i>Tsuga</i>	<i>Picea</i>	<i>Betula</i>	<i>Nyssa</i>	<i>Ulmus</i>	<i>Juglans</i>	<i>Ostrya/Carpinus</i>	<i>Fagus</i>	<i>Alnus</i>	<i>Acer</i>	<i>Fraxinus</i>	TCT	<i>Tilia</i>	<i>Poaceae</i>	<i>Chenopods</i>	<i>Ambrosia</i>	<i>Asteraceae indet.</i>	<i>Cyperaceae</i>	<i>Typha</i>	<i>Polygonum</i>
101	197	16	61	8	5	3	6			4	1	14	1		1			5	1	24	7		3	
111	200	23	72	4	2	3	6		1	4		7	1					3	1	37	13	3	1	
121	261	18	36	3	9	4	2		1	2		3						5		7	1	1	1	
131	247	18	50	5	12	3	2				1					1					2	2	1	
141	224	14	68	4	6	3	4		1			3		1					1	10	4	1		
151	203	6	75	4	3	2	4			1		2						1		15	1	2	1	
161	225	22	36	7	6	7				3		5						1		1				
171	206	19	92	4	6	4	3			1	2	8	1	1				2		8	4	2		1
181	211	15	91	2	7	4	4		1	1	2	7		3						9	6	1	2	
191	206	21	75	1	5	6	1		2			4						2		2	1	3		
201	203	20	100	5	4		1	1	1	1	1	3	1				1	1		10	2	2		



Depth (cm)	<i>Pinus</i>	<i>Carya</i>	<i>Quercus</i>	<i>Liquidambar</i>	<i>Tsuga</i>	<i>Picea</i>	<i>Betula</i>	<i>Nyssa</i>	<i>Ulmus</i>	<i>Juglans</i>	<i>Ostrya/Carpinus</i>	<i>Fagus</i>	<i>Myrica</i>	<i>Alnus</i>	<i>Acer</i>	Taxodiaceae/Taxaceae/ Cupressaceae	<i>Ilex</i>	<i>Tilia</i>	Poaceae	Chenopodiaceae	<i>Ambrosia</i>	Asteraceae indet.	Cyperaceae	<i>Typha</i>	<i>Polygonum</i>
11	210	21	81	6	5	8	4		1	2	1	8	3		1			3	1	21	1	3			
33	225	24	87	4	10	5	3			1		2			1			1	4		3	1	2	1	
77	205	25	114	8		10	2	1	2	1	3	1		1	1			1	1						
125	200	21	146	7	5	5	4					2		1	1	2		1	1			2	1		
171	200	18	120	9	4	7			2			1	2			1		4	1		1	1	1		
209	160	21	154	4	3	6	4		1			6	1		1			1	4						
249	159	29	154	9	6	5	1			1	2	2		1		1		1	2		2		2		
273	170	36	145	5	6	4	1		1	3	3	4				1		1	1	1	1			1	
323	150	29	191	6	8	4	2			1	1	1			1			3	1	1	1		1		
337	133	31	246	7	8	5	1				2	5	1		4	1		3	4	2	1	2			
357	113	38	188	17	7	5	2	1			1	8					1	4	2	1					

Depth (cm)	<i>Pinus</i>	<i>Carya</i>	<i>Quercus</i>	<i>Liquidambar</i>	<i>Tsuga</i>	<i>Picea</i>	<i>Betula</i>	<i>Ulmus</i>	<i>Juglans</i>	<i>Ostrya/Carpinus</i>	<i>Fagus</i>	<i>Myrica</i>	<i>Alnus</i>	<i>Acer</i>	<i>Fraxinus</i>	Taxodiaceae/Taxaceae/Cupressaceae	<i>Ilex</i>	<i>Tilia</i>	Poaceae	Chenopodiaceae	<i>Ambrosia</i>	Asteraceae indet.
1	138	9	138	10			5	1	3	1									2	3	20	6
11	122	7	136	6		4	2	3	1	1	1				1					5	36	3
21	153	11	121	7		5	3	1	1	1					1	1			3	4	38	9
31	210	18	98	3	2	8	1	1	1			1			1				1	1	8	2
41	175	18	132		2	3	1		1						1	1			1		45	7
51	170	13	130	3	4	1			2	1	2		2	1					1		21	3
61	236	19	90	2	14	3		1	3											1		
71	245	21	43		6	9			1													
81	144	23	171		4	5	3		1	2	2					1	1			1	1	2
91	143	20	150	4	9	5	1		1		2										2	2
101	128	26	164	4	2		2	1		1			1								1	1
111	201	35	62	1	10	6	1	1			1			1								
121	178	35	86	4	7	2				1	1									2		1
131	144	29	167	2	4	4				1	3		3						1	3		2
141	216	32	88	2	11	4					1			1								
151	200	42	74	3	6	5		1			2											1
161	151	22	131	1	1	6				3				1						1	1	1
171	110	12	194	3	5	4	3	2		5	2		4			1			1	1	5	3
181	149	40	125	4	8	4			2	1										1	1	1
201	173	38	92	3	8	4			2		1						2			1		2

Depth (cm)	<i>Pinus</i>	<i>Carya</i>	<i>Quercus</i>	<i>Liquidambar</i>	<i>Tsuga</i>	<i>Picea</i>	<i>Betula</i>	<i>Corylus</i>	<i>Salix</i>	<i>Nyssa</i>	<i>Ulmus</i>	<i>Juglans</i>	<i>Ostrya/Carpinus</i>	<i>Fagus</i>	<i>Myrica</i>	<i>Alnus</i>	<i>Acer</i>	<i>Fraxinus</i>	<i>Castanea</i>	Taxodiaceae/Cupressaceae/Taxaceae	<i>Ilex</i>
11	177	15	82	18		5	6			2	1	2		4			2			1	
16	200	17	86	15	4	8	2	1		2	2	2	1	3	1	1	2			1	
21	210	21	51	13	1	5	2				1		2	5			1				
26	199	22	96	11	4	5	10		1	1	6	1	6	6		2	2				
41	198	15	104	15	1	5	2			1	3	3		5			3				
51	164	16	99	10	3	6	2				4	2	2	3	2						1
61	185	13	66	5	4	4	3	1			2	1	1	4	1	1			1		1
71	211	27	31	8	4	12	3			2	1	1	1	4	1						
81	201	13	53	10	5	9	4		1			2		2	1			1			
91	150	18	77	2	4	10	3	1		1		2		1	1	5	2				
101	156	14	68	3	3	10	3		1	1	1		1	6	1						
111	208	17	83	4	5	15	2				2	1		2	1						
121	150	17	88	3	1	11	4				1	1	3	7	1	1			1	1	
131	175	10	84	2	3	3	5				1	1	2	1		2	1				
141	200	13	71	6	12	7	2				2	1		3			1				
151	244	10	38	3	6	12	3					1		3		1					1
161	180	16	69		10	2	1					2									
171	163	26	96	1	6	6	5				1	2		4		1	1			1	
181	200	14	57	4	11	14				1		1		4		1					
191	151	10	123	2	7	6	3				2			6			2	1			
201	216	11	59	3	9	11	1			1		1		2			1				
211	153	22	126	3	6	7	6				3	1		2	1	1				1	
221	152	23	134		5	7	2					1		2		3					
232	212	23	61	3	3	11	2							1		1	1				
242	200	23	73	2	3	14	2							2							1
251	189	40	67	1	4	13	2					2		4							

Depth (cm)	<i>Tilia</i>	Poaceae	Chenopodiaceae	<i>Ambrosia</i>	Asteraceae indet.	Cyperaceae	<i>Typha</i>	<i>Polygonum</i>
11	1	4	4	9			1	
16		2	3	9	1	1	1	
21		2		10		1		
26		2	1	19	1		2	
41		3		10		2	2	1
51		4	5	11			1	
61		6	1	31		1	1	
71		1		10		1		
81		2	3	22	1	1		
91	1	6	3	59	5	2	1	
101		5	2	40	2	2		
111	2	5	1	24	3	3		
121		3	2	33	2			
131	1	4	2	38	3	1		
141		1	2	23				
151		2	2	6				
161			3	4			1	
171		2	1	6	1	1	3	
181		1		1				
191		4	2	2	3	2	2	
201			1	1	2			
211		3		3	1	1		
221			3	2		1		
232				1				
242		1	1	1	1		1	
251		1		1	1			

Depth (cm)	<i>Pinus</i>	<i>Carya</i>	<i>Quercus</i>	<i>Liquidambar</i>	<i>Tsuga</i>	<i>Picea</i>	<i>Betula</i>	<i>Corylus</i>	<i>Salix</i>	<i>Nyssa</i>	<i>Ulmus</i>	<i>Juglans</i>	<i>Alnus</i>	<i>Acer</i>	<i>Liriodendron</i>	<i>Celtis</i>	<i>Fraxinus</i>	Poaceae	Chenopodiaceae	<i>Ambrosia</i>	Asteraceae indet.	Fabaceae	<i>Cornus</i>	<i>Nuphar</i>
1.5	246	24	39	27	6	2	1	3	2	1	2	1						2	2	2		1		
5.5	347	29	30	31	6	4	1			5	1	1	1	2	3			5	2	2		1		
8.5	226	22	36	20	4	1		1		3	3	3				1	1	3	2	1	1	1	1	1
11.5	97	20	61	21	2	4	6	1	1	3	4	8	3	1		4		10	2	2	1	2	2	
15.5	226	24	29	17	6	4	1	2			2	1		1				1	3	2		2	1	

## Core: Ragged Point

## Appendix 5: Pollen

Depth (cm)	<i>Pinus</i>	<i>Carya</i>	<i>Quercus</i>	<i>Liquidambar</i>	<i>Tsuga</i>	<i>Picea</i>	<i>Betula</i>	<i>Corylus</i>	<i>Nyssa</i>	<i>Ulmus</i>	<i>Juglans</i>	<i>Ostrya/Carpinus</i>	<i>Fagus</i>	<i>Myrica</i>	<i>Alnus</i>	
0.5	216	9	35	18	3	1		1								
4.5	349	29	75	21	3	1				3	10	1	1			
8.5	200	23	56	10	7	2							4			
11.5	206	20	76	9	2	2				1	3		2			1
15.5	183	18	84	10	1	1	1			2	6		4	1		2
19.5	206	15	79	7		1			2	3	1		1			
23.5	212	12	90	7	6	2		3		1	3		12			

Depth (cm)	<i>Acer</i>	<i>Liriodendron</i>	<i>Fraxinus</i>	<i>Castanea</i>	Poaceae	Chenopodiaceae	<i>Ambrosia</i>	Asteraceae indet.	<i>Fabaceae</i>	<i>Cornus</i>	Cyperaceae	Euphorbiaceae	<i>Utricularia</i>	<i>Typha</i>	<i>Liguliflorae</i>
0.5	1				4	1		1							
4.5			1		1	2	4					1	1		
8.5			1		1	8	4	1	1		2				
11.5	2	1			4	1	11	2		1				1	1
15.5		1	3	1	3	2	15							2	
19.5	1		1		3	3	6		1	2	1	1			
23.5	1		1	1	8	5	13	1	1		3				

Depth (cm)	<i>Pinus</i>	<i>Carya</i>	<i>Quercus</i>	<i>Liquidambar</i>	<i>Tsuga</i>	<i>Picea</i>	<i>Betula</i>	<i>Corylus</i>	<i>Salix</i>	<i>Nyssa</i>	<i>Ulmus</i>	<i>Juglans</i>	<i>Ostrya/Carpinus</i>	<i>Fagus</i>	<i>Myrica</i>	<i>Alnus</i>	<i>Acer</i>	<i>Liriodendron</i>	<i>Celtis</i>
0.5	254	14	73	32	3	11	2	2		2	3	3	2		1				
4.5	212	19	110	42	1	11	1	1		7	5	6	1	5	1				
9.5	184	21	78	23	3	12	6	2		4	2	3	1	3	3				
14.5	184	16	55	8	6	11	5		1	3		4						1	
20.5	262	25	40	9	2	24				1				5	1	1	1		



Depth (cm)	<i>Fraxinus</i>	<i>Castanea</i>	<i>Poaceae</i>	<i>Chenopods</i>	<i>Ambrosia</i>	<i>Asteraceae indet.</i>	<i>Fabaceae</i>	<i>Cornus</i>	<i>Cyperaceae</i>	<i>Nuphar</i>	<i>Eupphorbs</i>	<i>Utricularia</i>	<i>Typha</i>	<i>Myriophyllum</i>	<i>Ilex</i>	Taxodiaceae/Cupressaceae/Taxaceae	<i>Plantago</i>	<i>Liguliflorae</i>
0.5			3	1	11	2							1	1				
4.5			12		12		1		1				3	1	1			
9.5	1	1	5		24								2	1	1	2		
14.5	1		6	1	16								2	2				
20.5			1		12	1											2	