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Cover Page Footnote
Many individuals have contributed to this research effort. We particularly wish to thank Jane Sundberg of Colonial National Historical Park, NPS Archaeologist David Orr, and Cary Carson and Wendy Sumerlin of the Colonial Williamsburg Foundation for providing organizational and funding supprt, and Gregory Brown of the Colonial Williamsburg Department of Archaeological Research for providing the Jamestown map. Myra Harrison, Manager of the NPS Northeast Cultural Resources Center, encouraged participation by CRC personnel in the collection stage of the project. Linda Scott Cummings and Patricia Hudson of Paleo Research Laboratories, Golden, Colorado, provided administrative support and pollen extraction during an exploratory phase of analysis, while Vera Markgraf of the Institute of Alpine and Arctic Research (INSTAAR), University of Colorado, Boulder, provided extraction facilities for the expanded research phase of this project.

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Exploratory Pollen Analysis of the Ditch of the 1665 Turf Fort, Jamestown, Virginia

Gerald K. Kelso, Audrey J. Horning, Andrew C. Edwards, Marley R. Brown III, and Martha W. McCartney

Pollen analysis of subsoil, slopewash, episodic fill, plowzone, and archaeological backdirt deposits in a core from a ditch associated with the 1665 Turf (earthwork) Fort at Jamestown, Virginia, record bare, slightly weedy local conditions around 17th-century artisan dwellings on the Jamestown waterfront and register the Virginia forest in the background before construction of the fort. Goosefoot dominated the earthwork slope; close relatives of the goldenrods were initially the most prominent plants in the ditch bottom after construction; and sedges indicating wetter conditions appeared later in the open-ditch period. Pollen percolation rates adjusted for plowing and applied to ragweed-type (Ambrosia-type) percentages suggest that cultivation over the ditch began ca. 1729. Cultural matrix deposition, slopewash, and pollen percolation were critical to the preservation of this record, and serve to emphasize the importance of evaluating pollen record formation processes in cultural landscape studies.

L'analyse du pollen présent dans le sous-sol, les alluvions provenant de l'érosion des pentes, les remblais épisodiques, la zone de labour et les dépôts de terre archéologique contenus dans une carotte provenant d'un fossé associé au Turf Fort, un ouvrage de terre de 1665, à Jamestown (Virginie), montrent que le sol était dénudé ou légèrement recouvert de mauvaises herbes autour des habitations d'artisans du XVIIe siècle situées sur le bord de l'eau de Jamestown et témoignent de la présence de la forêt virginienne à l'arrière-plan avant la construction du fort. Le pied-d'oie dominait le talus de l'ouvrages de terre; des plantes étroitement apparentées à la verge d'or étaient initialement les plus remarquables dans le fond du fossé après la construction; des joncs indiquant des conditions plus humides sont apparus plus tard au cours de la période du fossé à ciel ouvert. D'après les taux d'infiltration de pollen ajustés, en fonction du labourage et appliqués aux pourcentages de jacobées (Ambrosia), la culture de la zone au-dessus du fossé a débuté vers 1729. Le dépôt de la matrice culturelle, les sédiments de la pente et l'infiltration du pollen ont joué un rôle critique dans la conservation de ce témoignage et servent à faire valoir l'importance d'évaluer les processus de formation polliniques dans les études du paysage culturel.

Introduction

The Department of Archaeological Research at Colonial Williamsburg and the National Park Service has recently undertaken an archaeological assessment of Jamestown Island, Virginia (FIG. 1). A primary objective of this project was the recovery of data concerning the 17th-century historical environment and cultural landscape. The research design for the Jamestown assessment is based on interdisciplinary studies involving macrofossil analysis, soil microstratigraphy, palynology, archaeology, and documentary data. This approach has already provided valuable insights into local environments and landscapes (Mrozowski, Kelso, and Currie 1994; Kelso et al. 1995). The objectives of the pollen research reported here were to determine whether local environmental and land-use information was preserved in the matrix filling the ditch of an earthwork constructed to protect British shipping during the Second Dutch War (1665–1667) and to ascertain whether palynological site formation process indicators would contribute to our understanding of the history of the ditch.

Documentary History of The Turf Fort

Dutch warships and privateers periodically invaded the Chesapeake Bay during the Second Dutch War. On 3 June 1665 King Charles II ordered Governor William Berkeley of Virginia to construct defenses for British shipping. Ships were ordered to gather and ride anchor at four places, including Jamestown. The county militias were to be

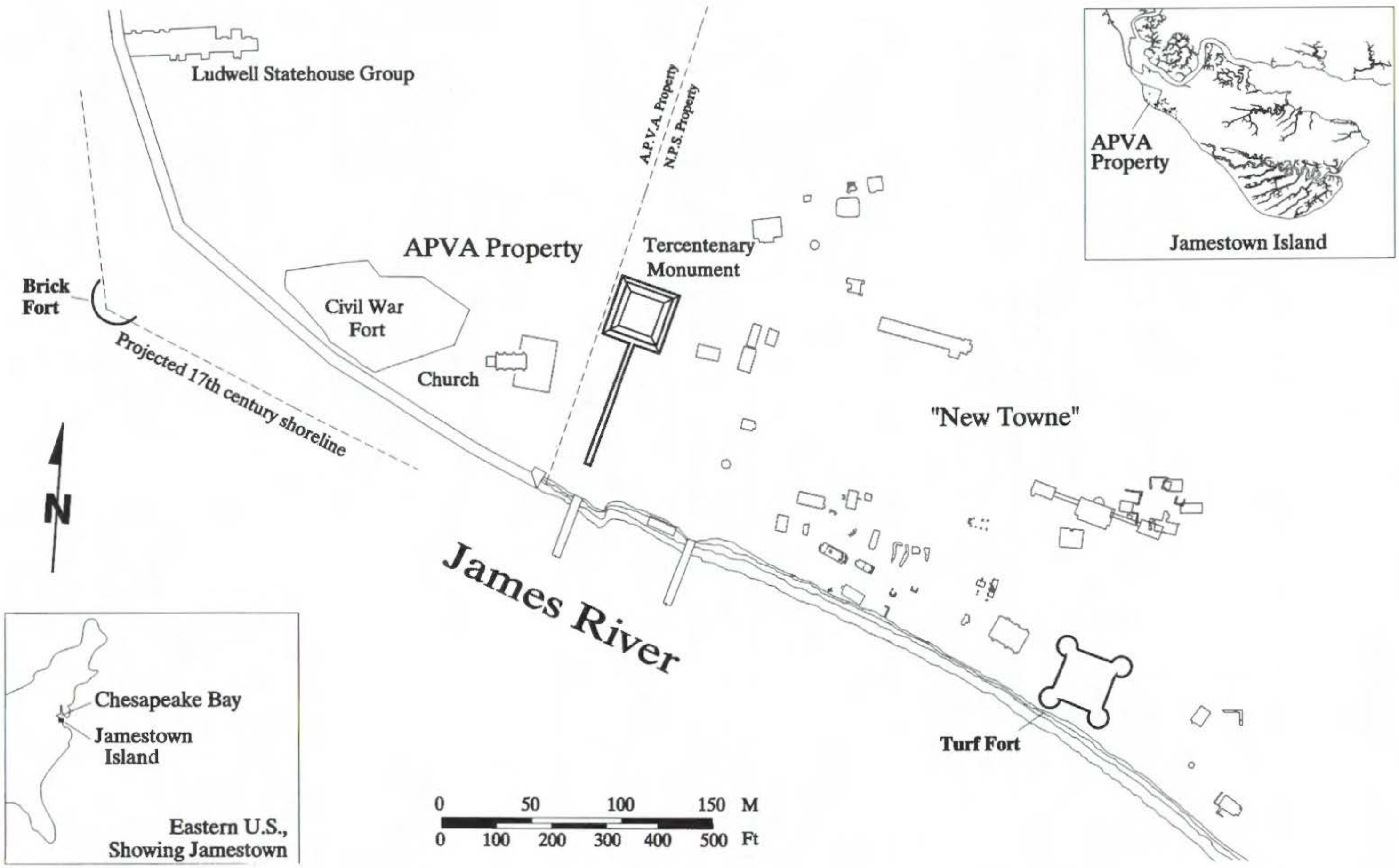

Figure 1. Map of Jamestown indicating location of the 1665 Turf Fort and the 1672–1674 Brick Fort.

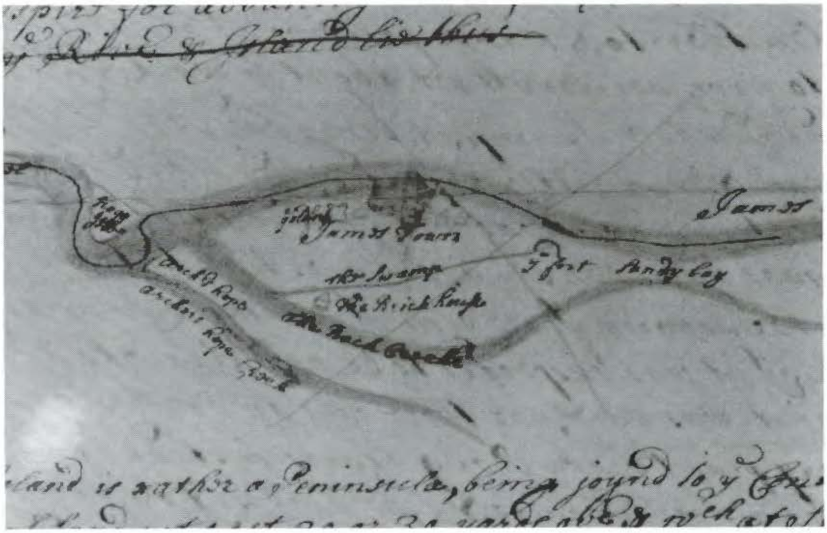

Figure 2. Reverend John Clayton's 1688 sketch of Jamestown indicating location of the 1665 Turf Fort and the 1672–1674 Brick Fort. Note that on this map north is down.

mustered, and men were required to construct "a platform for battery and lines for small shot to defend the ships" at each site. Governor Berkeley directed that the work commence by September 1665. By October the governor and council had decided on an actual fort for Jamestown. Instructions for the completion of the fort included the stipulation that the inhabitants of James City and Surry Counties were "to give so much work as might fill up the works with earth," indicating the planned earthen nature of the fort. Additionally, pine trees, to be obtained from any convenient locale, were to be incorporated in the fort, presumably to construct platforms or to serve as revetments for the earthen bastions (McCartney 1993).

Work may have been stopped on the Jamestown fort after the king, at the urging of Bristol merchants, ordered the construction of a fort at Point Comfort, now Fort Monroe, at Hampton, Virginia. Work at Jamestown, however, appears to have been re-started after two ships were taken near Point Comfort in June of 1666. In July 1666 Governor Berkeley reported to the Crown that his forces "had designed a fort at James Town in the center of the county" and that 14 great guns had been brought to the site." The destruction of the Point Comfort fort by a storm in February 1667 and a Dutch foray into the Chesapeake in June of the same year caused renewed concern for the safety of the colony. By September 1667 a decision had been made to build five forts, one at Jamestown and one each on the York, Rappahannock, Potomac, and Nansemond rivers. Each was to mount 8 great guns behind walls 10 ft (3.33 m) high and 10 ft (3.33 m) thick. In November 1667 Berkeley reported that the Jamestown fort was almost complete, and the others appear to have been completed by July 1668. Early completion of the Jamestown fort suggests that the fort of 1668 was the same structure commenced in 1665 (McCartney 1993; Horning and Edwards 1996).

The Jamestown fort appears to have been abandoned shortly after it was completed, and a brick fort was constructed in response to alarms during the Third Dutch War (1672–1674). This brick fort was located on the western end of the island at the confluence of Pitch and Tar Swamp and the James River (FIG. 1). Both it and the Jamestown fort were still in existence, albeit unused, when they were described and roughly located on a sketch map (FIG. 2) by the Reverend John Clayton in

1688 (Boyle Papers No. 39). In describing the 1660s turf fort, Clayton noted that

> there was indeed an old Fort of Earth in the Town, being a sort of Tetragone with something like four Bastions at the four corners, as I remmember, but the channel luying further off to the middle of the River there, they let it be demolished and built that new one. (Force 1947:III:XII:24)

The turf fort, indicated as "ye old fort" on Clayton's sketch map (FIG. 2) appears to be aligned with its shortest side parallel to the river bank and has a rough bastion at each corner. The fort was referenced again in 1689, when Henry Hartwell patented a lot of approximately two acres that was bounded on the west by "ye Eastern Bastions of an old Ruin'd Turf fort" (McCartney 1993; Virginia Land Office 1679–1789). The last documentary reference known to the authors is a land patent recorded in 1721 for a piece of property bounded on the east by "the old Fort" (McCartney 1993; Ambler Manuscripts No. 101). This final record suggests that the fort was still visible during the first quarter of the 18th century and implies that it had not been deliberately dismantled.

Archaeology of the Turf Fort

The pollen data reported here were collected during 1993 excavations by an advanced field school jointly sponsored by the Department of Archaeological Research at Colonial Williamsburg and the National Park Service. These were not the first excavations in the area of the fort. During the fall of 1934, at the onset of the first government-sponsored archaeological explorations at Jamestown, the area was extensively test pitted. Unfortunately, no record was made of these tests or of their findings (Horning and Edwards 1996). In a 1936 memo, however, archaeologist H. Summerfield Day noted the existence of "deep fills" in the area, and surmised that the features represented borrow excavations for the construction of the historically documented fort (Day 1936). In 1955 the area was subjected to systematic cross trenching under the direction of archaeologist John Cotter. Cotter (1958) noted four broad "trough areas" and, like Day, surmised that they might represent borrow excavations for the Turf Fort earthworks. No further testing was undertaken during the 1950s initiative to determine possible relationships among the trough features.

Cotter's 1955 test trenches were the focus of the 1993 CW/NPS excavations in the area. The objectives of the excavations were to determine the relationship of the previously noted troughs and to ascertain whether portions of an earthwork protecting a pollen record of micro- and macroenvironmental conditions might have survived. A unit measuring 5 m north/south by 12 m east/west was gridded over Cotter's trenches. Cotter's trenches were reopened, and a 25 percent sample was taken while removing the plowzone from one 6 m^2 unit around and over a large ditch feature evident in the southern portion of his north-south oriented trench (Cotter 1958). An additional 3 × 6 meter unit was subsequently opened to further explore the ditch feature (FIG. 3). The ditch feature was 230 cm wide and 60 cm deep (FIG. 4). It had fairly steep sides, a generally flat bottom, and ran parallel to the riverbank. This trench appeared to intersect a smaller ditch, 120 cm wide and 33 cm deep, at a 90° angle, but the probable juncture of the two ditches had been destroyed by previous excavations. Both ditches contained a dark yellowish brown (10YR3/4) sandy clay loam that did not contain any artifacts, and multiple deposits of slopewash were evident in the bottoms of both ditches. The deepest slopewash in the large ditch is darker than either the subsoil or the ditch fill and appears to have been formed by a single, fairly massive slump (FIG. 4). It is thickest at the bottom angle of the inland side of the ditch and thins toward the river side, suggesting that it came off of the earthwork. A number of thin, sandy lenses that appear to reflect multiple sheetwash episodes overlie the darker slump (FIG. 5). Nine circular soil stains surround the probable intersection of the ditches (FIG. 3). These were originally thought to be postmolds, but are now considered to be undocumented circular test pits from the 1930s excavations (Horning 1996). All features were capped by 20 cm of plow soil and 10 cm of overburden containing a mixture of 17th

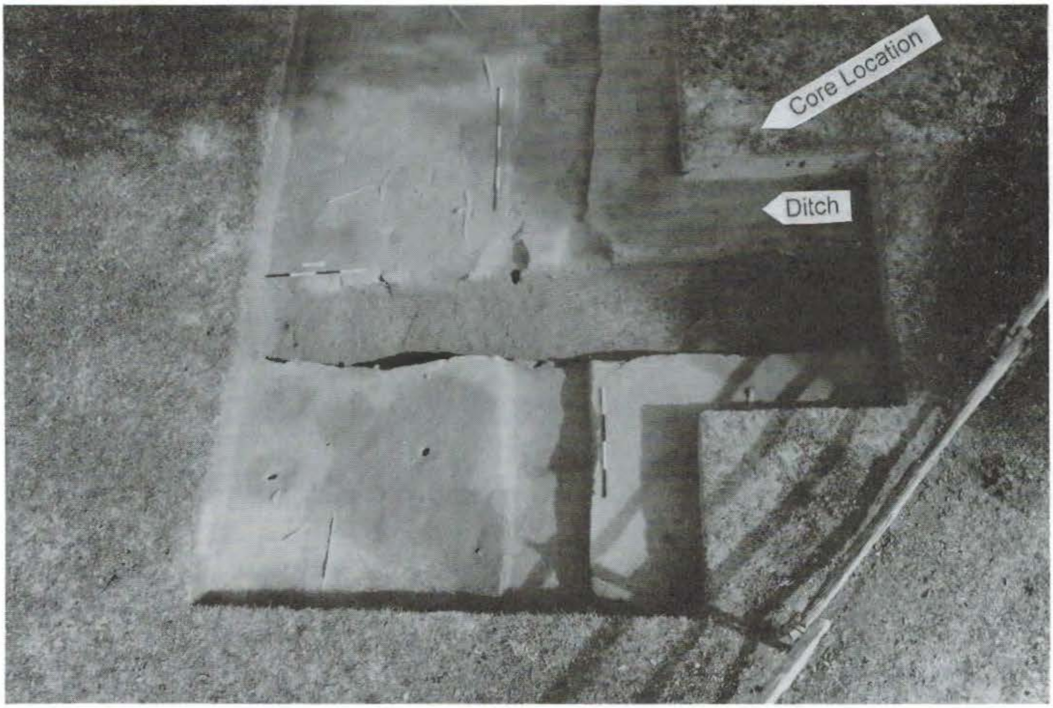

Figure 3. Overview of 1993 Turf Fort excavations.

through 20th-century artifacts. This deposit, termed "parkzone," appears to be unscreened backdirt from Cotter's 1955 excavations.

The locations of the two ditches generally correspond to the site of the Turf Fort on Reverend Clayton's sketch map of 1688 (FIG. 2) and their orientation, one parallel to the river, the other perpendicular to the bank, is consistent with his drawing of the fort. It is probable that the ditches were part of the defensive works. The slopewash deposits in both ditches suggest that they remained open for a time.

Pollen Analysis Methods

Pollen sampling at the turf fort was by coring. Cores were collected from the large ditch, the small ditch, and the circular holes (FIG. 3) by driving a sharpened piece of 2 in (5.2 cm) (inside diameter) PVC pipe into the matrix. The depth of the drive was marked on the exterior of each core tube, so that soil compression could be calculated from the difference between the length of the drive and the length of the recovered core. The core tubes were extracted with a large mechanical jack attached by a chain to a bolt through a hole in the top of the tube. Second drives were taken from the same holes with a second, longer piece of PVC to insure that a complete record had been recovered. A 1993 penny was dropped into each hole to prevent future investigators from mistaking the core holes for 17th-century postholes.

Analysis to date has concentrated on the core from the larger ditch. The core tube was split on a table saw set to cut only the PVC, and the upper half of the split pipe was removed, leaving the core lying in the bottom half for a sampling tray. The core was cut into 2-cm contiguous samples. The majority of the analyzed samples (No. 57–12) were spaced at 2-cm intervals (FIG. 6). The placement of 12

Figure 4. Excavation face of large ditch, showing bottom, river side (right), and slopewash deposits. Core location is 30 cm behind this face.

Figure 5. Detail of excavation face of large ditch, showing the multiple sheetwash deposits over the massive (darker) slump deposit.

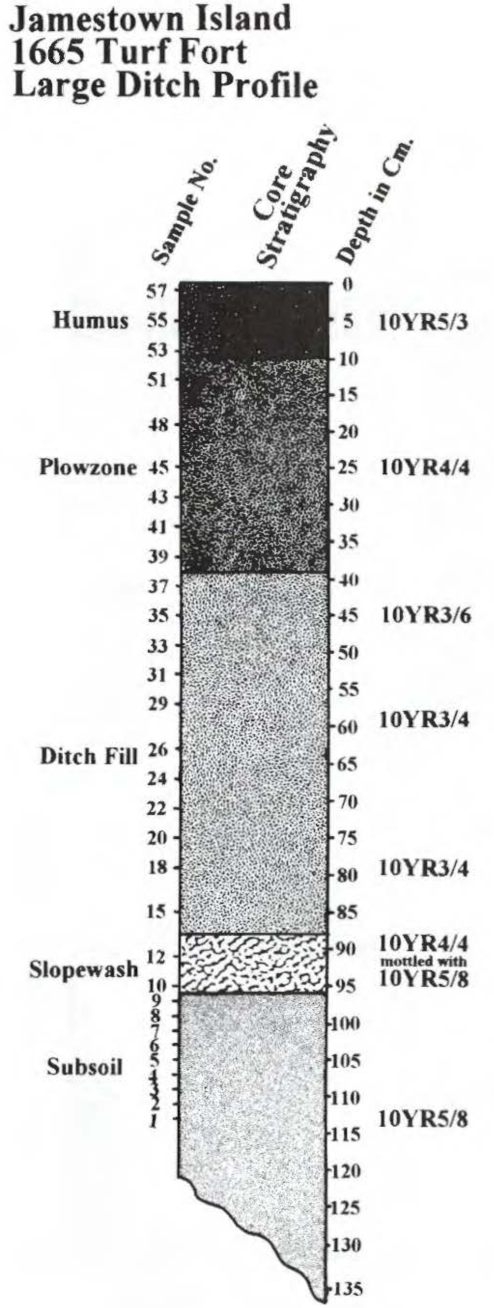

Figure 6. Turf Fort large ditch core stratigraphy.

exploratory samples resulted in 4-cm intervals between 5 samples. None of these broader intervals occurred at places critical to the interpretation of vegetation patterns or pollen record formation processes. The deepest 20 cm of polliniferous matrix appeared to contain critical, undisturbed 17th-century vegetation data. It was analyzed in 10 contiguous 2-cm samples.

Pollen extraction followed Mehringer 1967 The HNO^3 portion of Mehringer's process was not employed and the strength of NaOH in his final step was reduced to .05 percent. The pollen was identified at 430× with problematical grains examined under oil immersion at 970×. Total pollen concentrations per gram of matrix were computed by Benninghoff's exotic pollen addition method (1962) to permit examination of pollen record formation processes and site formation processes. Accurate sedimentation rate data were not available for the Turf Fort ditch, and pollen concentrations were not calculated for individual types to preclude such figures being mistaken for pollen influx rates. Pollen grains that were too corroded to identify and the quantities of deteriorated oak (*Quercus*) pollen grains, a type present in all but the deepest sample, were also tabulated to provide the degradation element of the site formation process record. In this study the terms "deteriorated," "corroded," and "degraded" are used interchangeably, in the generic sense, to refer to cumulative post-depositional damage other than tearing. These terms do not refer to specific kinds of damage in the manner employed by Cushing (1964) and Havinga (1967, 1974, 1984). The pollen grains that were too corroded to identify were included in the total pollen concentration figures, but were excluded from the sum from which the pollen type percentages were calculated.

Two kinds of pollen diagrams (FIGS. 7, 8) are presented in this study. Figure 7 is a summary of all pollen spectra calculated from the total pollen sum—all tree pollen, all herb pollen, and all pollen that was well preserved, but not recognized—for all samples. Such pollen diagrams are preferred when presenting relatively unambiguous changes in vegetation and site formation processes. Figure 8 contains two pollen sums. One of these (solid bars) is based on the total pollen sum. The other sum (hollow bars) is calcu-

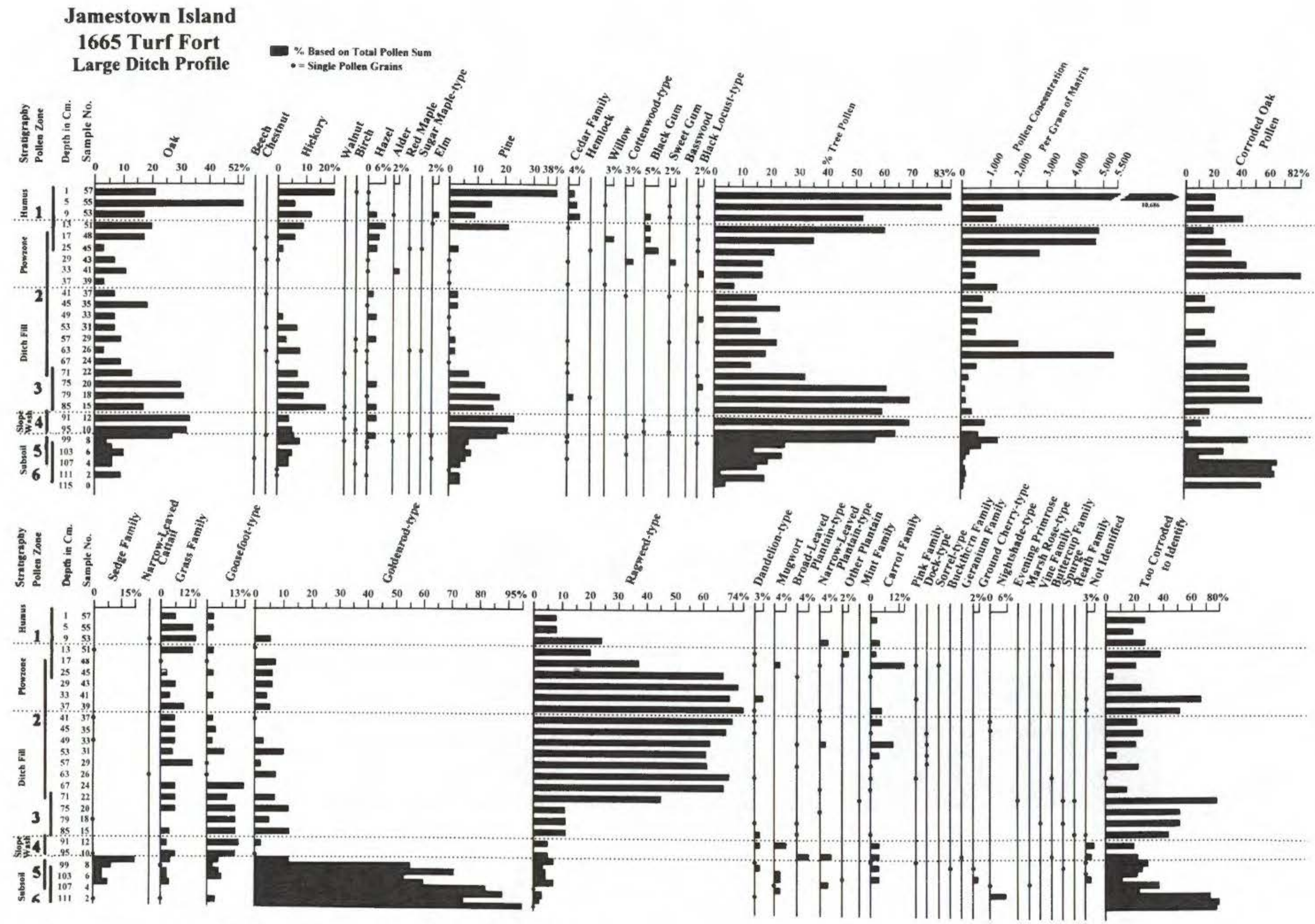

Figure 7. Turf Fort large ditch pollen percentages based on total pollen sum.

lated from herb (nonarboreal) pollen only. This kind of presentation serves to separate the background (largely tree) pollen contribution from the herb pollen that usually originated closer to the sampling site and clarifies the local vegetation sequence. The statistical influence of the background pollen contribution was a problem only in the interpretation of the subsoil and slopewash pollen spectra, and the double sums are presented in Figure 8 for only the deepest 16 samples (No. 24–1).

Historical archaeologists most often encounter plants under their common English names in documents. These English terms are employed in the text and pollen diagrams. The Latin name for each taxon is given in parentheses after the first mention of the plant in the text, and Table 1 provides equivalent Latin and vernacular names.

Pollen Record Formation Processes

Pollen preservation is a problem for those attempting to research 17th-century landscapes and cultural ecology. The pollen deposited on natural ground surfaces is moved down through the deposit by percolating groundwater (Dimbleby 1985: 5, fig. 3), disassociating it from the matrix and material culture with which it was deposited. The moving pollen is attacked and progressively destroyed by aerobic fungi (Goldstein 1960) and oxygen in the groundwater (Tschudy 1969). In the Chesapeake area this means that the oldest pollen at the bottom of a normal sequence is no more than 100 to 117 years in age (Kelso and Miller 1993; Kelso et al. 1995: 47). Under normal circumstances percolation and degradation produce a pollen profile in which the largest quantities of pollen are located at the top of the sequence and quantities of identifiable pollen decline with depth until a point is reached at which no pollen remains. Quantities of degraded pollen constitute a mirror image of the pollen concentrations. They increase with depth until all microfossils recognizable as pollen are too corroded to identify (Kelso 1993: fig. 7). Particular matrix environments such as soil compression, rapid sedimentation, the presence of metal corrosion products, the deposition of flat objects, and quick, deep burial will protect at least some pollen from percolation and complete degradation (Schoenwetter 1962; Van Zeist 1967; King, Klipple and Duffield 1975; Dimbleby 1985; Kelso 1993; Kelso et al. 1995). Rapid, deep burial by cultural and natural agents was most important in protecting the Turf Fort pollen spectra, but the normally destructive percolation process was instrumental in preserving many critical data.

Results

Core Stratigraphy

Pollen analysis at the Turf Fort has been focused on the large ditch, because the depth of matrix indicated that the potential for pollen preservation by slopewash and backfilling was highest at that locus. The larger ditch was cored at the spot indicated in Figure 3, 30 cm behind the face depicted in Figure 4. One hundred and fourteen centimeters of core were recovered from a 127 cm first drive, indicating 10.24 percent matrix compression. Fifty-three cm of core were recovered from the 53 cm second drive, indicating that there had been no core compression in the deeper matrix.

Five stratigraphic layers were evident in the large ditch core (FIG. 6). The most shallow layer consists of 9.5 cm of relatively light colored humus (10YR5/3). It coincides with the root depth of the present grass cover. No artifacts were recovered in the core, but the humus was about the same thickness as the Cotter excavation backdirt ("parkzone") noted in the test squares. A relatively uniform dark yellowish brown (10YR4/4), 29.5 cm deposit underlay the grass roots in the core (FIG. 4). This is the plow soil previously observed at the excavation face. The stratum below the plowzone consisted of 57 cm of ditch fill. The upper 10 cm of this ditch fill were dark yellowish brown (10YR3/6) and the subsequent 18.5 cm were dark brown (10YR3/3). The deepest 8 cm of ditch fill consisted of dark yellowish brown (10YR4/4) matrix mottled with yellowish brown sediment (10YR5/8). It

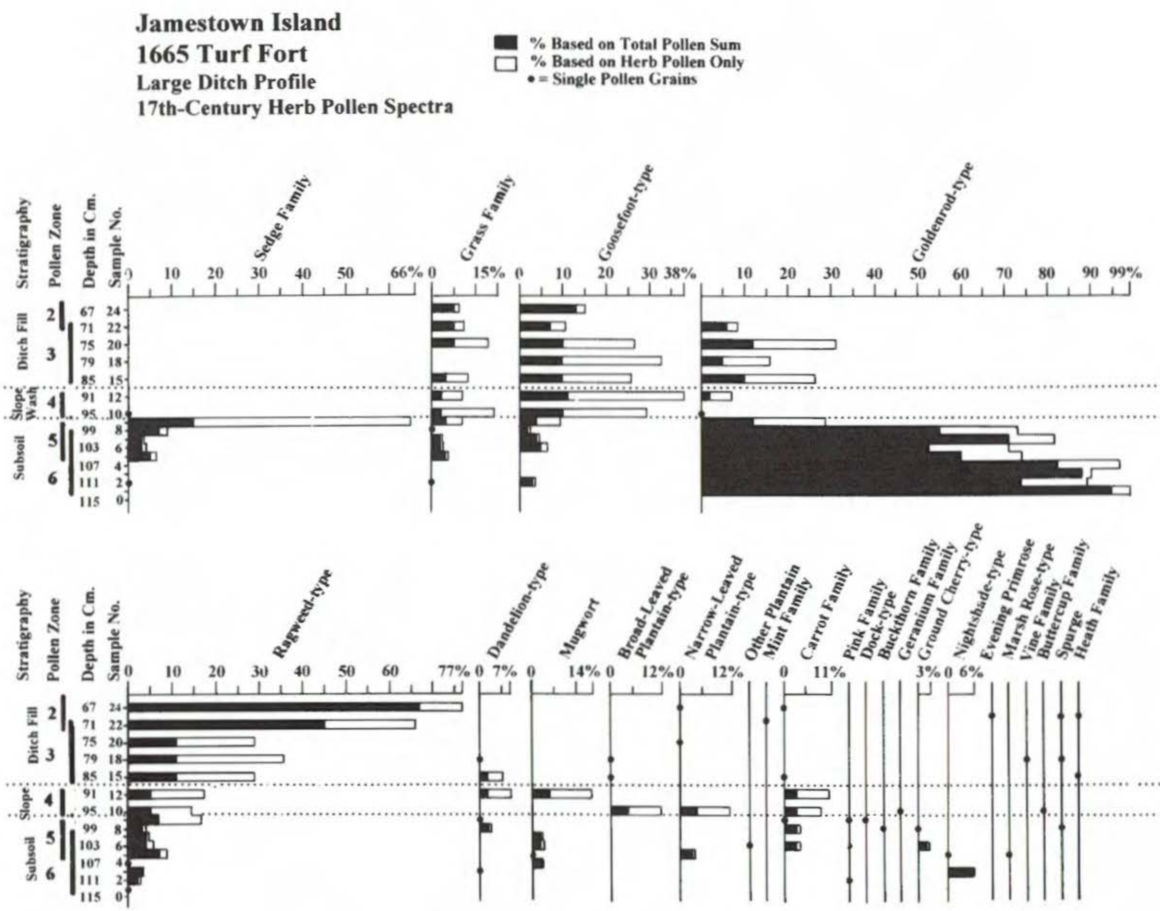

Figure 8. Turf Fort large ditch herb pollen percentages of samples 24–1. Solid bars indicate percentages based on total pollen sum. Hollow bars indicate percentages based on herb pollen sums only.

Table 1. Latin and vernacular names of arboreal and non-arboreal plants discussed in the text.

ARBOREAL	
Pinus	pine
Tsuga	hemlock
Cupressaaceae	cedar/juniper
Quercus	oak
Fagus	beech
Castanea	chestnut
Betula	birch
Alnus	alder
Corylus	hazel
Acer saccharum	sugar maple
Acer rubrum	red maple
Juglans	walnut
Caraya	hickory
Salix	willow
Populus	cottonwood/poplar
Ulmus	elm
Robinia-type	black locust
Liquidambar	sweet gum
Nyssa	black gum
NON-ARBOREAL	
Poaceae	grass
Chenopodiaceae/cheno-ams	goosefootfamily/amaranth type
Asteraceae	ragweed family
Artemisia	mugwort
Ambrosia-type	ragweed-type
Solidago-type	goldenrod-type
Ligulflorae	dandelion-type
Apiaceae	carrot family
Labiatae	mint family
Solanaceae	nightshade family
Physalis-type	ground cherry-type
Solanum-type	nightshade-type
Caryophyllaceae	pink family
Rhamnaceae	buckthorn family
Plantago lanceolata-type	lanceolate-lance-leaved plantain
Plantago-major-type	road-leaved plantain
Onagraceae	evening primrose
Vitaceae	vine (grape) family
Ericaceae	heath family
Cyperaceae	sedge family
Typha	cattail
Rosa palustrus-type	marsh rose-type
Rumex acetosa-type	sorrel-type
Euphorbia	spurge
Geraniaceae	geranium family
Not Identified	well preserved but not recognized
Too Corroded to Identify	recognized as pollen but unidentifiable to taxon

appeared to be slopewash, but was lighter in color relative to the ditch-fill overburden than was the massive-appearing slump deposit seen at the excavation face 30 cm to the west (FIG. 4). The thin slopewash lenses overlying the slump at the excavation face were not evident in the core. The remainder of the core appeared to be undisturbed yellowish brown

(10YR5/8) subsoil with scattered tree root stains.

Large Ditch Pollen Spectra

Pollen was recovered from the upper 114 cm (unadjusted for compression) of the Turf Fort ditch core. Quantities were adequate to economically permit 400-grain pollen counts in the humus and plowzone and 100-grain counts in the ditch fill and subsoil. Six pollen zones are evident in the large ditch pollen sequence (FIGS. 7, 8). These are: (1) the high tree (arboreal) pollen frequencies in the humus layer and upper plowzone (samples 57–45); (2) the concentration of large ragweed-type (Ambrosia-type) percentages in the center of the profile (samples 48–22); (3) the resurgence of tree pollen at the bottom of the ditch fill (samples 22–15); (4) the depressed sedge family (Cyperaceae) and goldenrod-type (Solidago-type) percentages associated with high tree pollen percentages in the slopewash deposit (samples 12–10); (5) the block of sedge family (Cyperaceae) counts at the top of the stratigraphic subsoil (samples 9–5); and (6) the domination of most of the subsoil (samples 8–1) by goldenrod-type pollen.

These pollen zones are the products of the human activities responsible for the 5 stratigraphic layers (subsoil, slopewash, ditch fill, plowsoil, and humus) noted in the matrix, but some of the pollen has been moved by post-depositional soil processes. The pollen zones overlap in some portions of the profile and do not entirely conform to the visible matrix stratigraphy. To further complicate the situation, the oldest pollen in this profile does not appear to be located at the bottom of the sequence.

Pollen Zone 1

The youngest pollen zone (No. 1) occupies samples 57–45 in the humus layer at the top of the soil profile (FIG. 6). Oak, hickory (*Carya*), and pine (*Pinus*) are the most prominent taxa in this pollen zone. Cedar family (Cupressaceae) counts are larger in the upper three samples of the zone than elsewhere in the profile, while the hazel (*Corylus*) and black gum (*Nyssa*) pollen types are more important in the lower half of the zone. Grass (Poaceae) pollen frequencies were relatively high in three samples, and only minor quantities of pollen from herbs normally classified as weeds were noted in the humus portion of the pollen zone. The irregular pollen concentrations and quantities of degraded pollen suggest a mixture of pollen percolated into the soil before and after the Cotter excavations and older pollen deposited with his backdirt, but the data generally record the stable, well-maintained landscape of the park period.

Pollen Zone 2

The massive domination of the lower half of the stratigraphic plow soil and the upper half of the ditch fill (samples 45–22) by ragweed-type pollen marks Pollen Zone 2. Ragweeds are better adapted to withstand the water and temperature stress of bare, disturbed ground than most other weeds, and they are, consequently, the premier agricultural weed of eastern North America (Bazzaz 1974). Large increases in the percentages of this type in bog and lake deposits are the accepted horizon marker for the advent of Euroamerican-style agriculture in paleoenvironmental pollen sequences (Davis 1965: 395). These plants produce large quantities of pollen, and some of it is rather widely dispersed (Wodehouse 1971; Raynor, Ogden, and Hayes 1974). Experimental data, however, indicate that the majority of ragweed pollen grains come to earth within 3 m downwind of their source, over 90 percent are no longer airborne at 9 m, and the pollen contributions from ragweed-dominated plots fall to normal background concentrations within 110 m (Raynor, Ogden, and Hayes 1968: 224; 1973: fig. 7). The 37 percent to 72 percent ragweed-type pollen in samples 45–22 unquestionably reflects agriculture, probably on or very near the core locus. This is consistent with local tradition indicating that the area of the Turf Fort was plowland during the early 20th century and, probably, throughout a large portion of the 19th century.

The ragweed-type pollen marking the agricultural period at the core site has percolated down into the ditch fill layer. The maximum depth of penetration is clearly marked by the abrupt decline in the type and uniform percentages below sample 22. Pollen percolation rates can be used to establish approximate dates for events registered in soil profiles (Kelso 1994a). A local rate of 1 cm in 5.85 years is available from Jamestown Refuse Pit No. 1, 500 yards northwest of the Turf Fort (Kelso et al. 1995: 47). The top of the plowzone appears to have been the ground surface before deposition of Cotter's 1955 back dirt (Cotter 1958). This would be the obvious point from which to calculate percolation. A pollen sequence recovered in and under a still-broken plowsoil preserved below the raised floor of a 1785 barn at St. Mary's City, Maryland, suggests, however, that pollen percolation under an actively cultivated plot starts at the bottom of the plowsoil, rather than at the ground surface (Kelso and Miller 1993). Calculating percolation from the bottom of Turf Fort (FIG. 6) stratigraphic plowsoil, with allowance for soil compression, yields a 226-year percolation sequence. This would place the inception of agriculture at ca. 1729, not long after the final documentary notation of the Turf Fort in 1721 (Horning 1996).

Pollen Zone 3

The tree pollen percentages are high in samples 24–22 through sample 9 from the deeper ditch fill, the slopewash, and the upper subsoil. Goosefoot-type Chenopodiaceae/*Amaranthus*) is more prominent in the deeper ditch fill and slopewash (samples 24–10) than elsewhere in the profile, but goldenrod-type percentages are depressed in the slopewash. The quantities of dandelion-type (Liguliflorae), mugwort (*Artemisia*), broad-leaved-plantain-type (*Plantago major-type*), narrow-leaved plantain (*Plantago lanceolata-type*), and carrot family (Apiaceae) pollen are higher in the slopewash and upper subsoil (samples 5–12) than they are in the ditch fill. Pollen concentrations are also slightly higher in the slopewash and upper subsoil, while the quantities of degraded oak pollen and pollen too degraded to identify are larger in the deeper portion of the deeper ditch fill. These data can be divided into Pollen Zones 3, 4, and 5, each recording a separate pollen source and a separate pollen record formation process.

The oldest pollen in the Turf Fort profile appears to be registered in Pollen Zone 3, composed of samples 22 through 15 at the bottom of the ditch fill. The matrix containing this pollen was intentionally placed in the ditch when the fort was dismantled, and the pollen in these samples is a remnant of the original ditch fill spectrum that has not been obliterated by agricultural-period pollen percolated down into the ditch fill. The most probable source of ditch fill was the earthwork of the fort. Pollen does not percolate down into mounds of earth (Kelso 1995; Kelso and Hsu 1995), and little of the pollen in the earthwork matrix was deposited on the earthwork when it was standing. Most of the spectrum in the earthwork matrix was already in the soil when it was mined to create the earthwork. This soil was probably taken from the nearby broad troughs that Cotter found during his 1955 excavations (Cotter 1958; Horning 1996). The pollen in the earthwork had percolated down into the soil profile at the borrow pit location and the remnant ditch fill pollen spectrum (Pollen Zone 3) is a mixture of the pollen rain on that area over the 100 years preceding the construction of the fort (Kelso and Miller 1993; Kelso et al. 1995: 47). The pollen from the deeper part of the borrow pit should have been significantly degraded before it was preserved by incorporation in the earthwork. This accounts for the low pollen concentrations in samples 22–15 and for the relatively poor pollen preservation indicated by the quantities of pollen too corroded to identify and deteriorated oak pollen.

The tree pollen that is so prominent in Pollen Zone 3 does not necessarily reflect the vegetation directly over the borrow pit. Tree pollen starts out at higher altitude than herb pollen and has a better chance of being lofted into the upper atmosphere by convection currents. It dominates the regional pollen rain, and the tree pollen in Zone 3 registers the documented forest covering the 17th-century landscape on and around Jamestown Island. Tree pollen from the regional pollen rain will also be prominent in the spectra of areas where thin local vegetation sheds relatively few pollen grains (Martin 1963: fig. 2; Tauber 1965: 33), and tree pollen counts in Pollen Zone 3 may be high relative to those of the agricultural period and the open-ditch spectra of the subsoil because there was little herbaceous vegetation at the borrow pit location.

Herb pollen does not travel as far as tree pollen and tells us more about local vegetation. The proportions of grass, goosefoot-type, goldenrod-type, and ragweed-type pollen in the deeper ditch fill reflect land use at, or relatively close to, the sampling locus. The ragweed type counts, for instance, are higher than those of the subsoil but much lower than the counts from the agricultural period. This suggests somewhat disturbed soils but indicates that the borrow pit locus had not been under cultivation prior to construction of the fort. Soil disturbance destroys the perenniating organs of grasses (Behre 1983: 226), and there is not as much grass pollen here as in the park period pollen spectra at the top of the profile, but somewhat more than in the subsoil. Goldenrod and goosefoot are plants of ruderal spaces and agricultural fields, but they are more likely to be found in the formerly disturbed waste ground around the fence line than among the crops and ragweed on the tilled ground. Goldenrod-type and goosefoot-type are more important in this part of the ditch fill than in the current pollen rain recorded in the humus (Zone 1).

The herb pollen counts and the high tree pollen percentages of Pollen Zone 3 suggest relatively bare, somewhat disturbed, but uncultivated ground with a little grass here and there and a fair number of weeds in sheltered spaces. Archaeological and documentary evidence indicates that the area where the Turf Fort was constructed was the location of at least one domestic complex, that of a gunsmith, during the 1620s and 1630s (McCartney 1996a; Horning 1996), and the pollen data are consistent with those of actively used, but not formally landscaped, houselots from later sites (Kelso 1993, 1994b, 1994c). It would appear that the artisan(s) who lived in the area purchased or traded for their staples, or perhaps cultivated some of the land on the eastern end of Jamestown Island, which recent research suggests was used as an agricultural area by town dwellers (McCartney 1996b).

Pollen Zone 4

Pollen samples 12–10 constitute Pollen Zone 4. This pollen zone lies within the slopewash deposit, and the spectrum should consist of pollen that was originally in the soil mined to build the earthwork and pollen deposited on the earthwork while the ditch was open. Tree pollen dominates Pollen Zone 4. Some of this tree pollen was probably washed out of the earthwork above, but a significant portion of it appears to have been relatively fresh pollen from the earthwork surface and preserved in the slopewash. This is suggested by pollen concentrations that are comparable to those of the upper portion of the subsoil, but slightly higher than those of the ditch fill (backfilled earthwork deposit), and by quantities of pollen too degraded to identify and corroded oak pollen that are noticeably lower than those of the ditch fill above.

The tree pollen percentages, hickory excepted, in the slopewash and in the upper subsoil sample (No. 9) are significantly higher than those of the majority of the subsoil samples (to be discussed). This suggests reforestation late in the period when the ditch was open. This was probably not a regional event. Settlers were moving out from the population centers to clear farms and plantations during the late 17th century (McCartney 1994: 15), and deforestation was the normal process. A decline in the local herb pollen contribution would also be required to permit the regional pollen rain to be more visible. This would be expressed in a decrease in pollen concentrations, but the opposite occurs here: pollen concentrations increase. The relatively well-preserved tree pollen in the slopewash (Pollen Zone 4) and upper subsoil more likely record trees returning to the area around the fort that had been cleared for palisade materials and fields of fire.

The herb pollen spectra in Pollen Zone 4 suggest that the ground cover in and around the ditch shortly before it was filled differed somewhat from that of the pre-Turf Fort era recorded in the earthwork matrix used to fill the ditch. The most obvious differences are the contrasts between the goldenrod-type, goosefoot-type, and ragweed-type frequencies of the ditch fill, slopewash, and subsoil samples. Goldenrod-type percentages are lower in the slopewash than in the ditch fill and much lower than in the subsoil below the ditch bottom. This suggests that there were goldenrods or close relatives growing in the ditch bottom before the slopewash occurred but that there were fewer of these plants at the source of the slopewash on the earthwork above.

Goosefoot-type percentages in the slopewash were comparable to those of the pre-fort spectra in ditch fill above the slopewash, but the presence of goosefoot-type pollen in the subsoil spectra indicates that these plants were also growing in the area while the ditch was open. Goosefoot-type percentages are larger in the slopewash spectra than in the subsoil spectra, and too-corroded-to-identify percentages are similar to those of the upper portion of the subsoil, but significantly lower than those of the ditch fill spectra. These counts suggest that the many of the goosefoot-type pollen grains in the slopewash are relatively new compared to those in the ditch fill from the interior of the earthwork and implies that most of them came from plants growing on the surface of the earthwork.

The ragweed-type pollen contribution is lower in both the slopewash and subsoil spectra than in the ditch fill, suggesting that the soil in the ditch and on the earthwork was relatively stable compared to that of the pre-Turf Fort landscape recorded in the ditch fill samples. These counts are actually smaller than those of the park period samples at the top of the profile, and it is possible that most of the ragweed-type pollen grains were wind-transported from populations growing at some distance from the fort. There was, on the other hand, more mugwort, narrow-leaved plantain, carrot family, and dandelion-type pollen in the slopewash and subsoil and more broad-leaved plantain in the slopewash than was present in the portion of the ditch fill (samples 22–15) that had not been altered by percolated pollen from the agricultural period. The plant taxa shedding these pollen types prefer ruderal spaces and are not normally pioneers on actively disturbed soils. Two of the types—carrot family and dandelion-type—are also insect dispersed. Such pollen is produced in small quantities relative to that of wind-pollinated species like ragweed and goosefoot (Erdtman 1969: 117). The pollen is securely held in the flower by the sticky oils and resins through which it is transferred to the insect vector (Faegri and van der Pijl 1971: 63), and most of the pollen not carried away falls to the ground with the flower, very close to the point of origin. The presence of these types in the slopewash and subsoil suggests that the parent plants of most of the pollen were growing both on the earthwork and in the ditch, the broad-leaved plantain was restricted to the earthwork, and that both the ditch and surmounting earthwork were waste ground subject to much less human activity than was normal in the area before construction of the fort. This is consistent with the low ragweed-type counts and with the abandoned status of the fort and the decline of Jamestown in the late 17th and early 18th centuries (McCartney 1993: 14).

Pollen Zones 5 and 6

The two deepest, if not oldest, pollen zones in the Turf Fort ditch profile overlap within the stratigraphic subsoil. The isolated block of sedge pollen frequencies in samples 9–5 comprises the younger (Zone 5) of the two pollen zones. The series of high goldenrod-type pollen percentages dominating samples 8–1 constitute Pollen Zone 6. The subsoil appeared undisturbed, and should have contained no pollen when the ditch was constructed. Most of the pollen in natural, percolated soil pollen profiles is concentrated in the upper 4 cm, and the largest quantities of pollen too corroded to identify are found at the bottom (Dimbleby 1985: 5, fig. 3; Kelso 1993: fig. 7). The largest quantities and the highest pollen concentrations in the Turf Fort large ditch subsoil are evident in samples 8 and 9, and the largest quantities of pollen too corroded to identify were recovered from samples 1 and 2. The corroded oak percentages are irregular and may indicate some redeposition of pollen from the earthwork matrix, but the Pollen Zones 5 and 6 spectra are quite different from both those of the slopewash and of the ditch fill. The bottom of the ditch was exposed to the local pollen rain for some period of time, and the subsoil spectra were percolated down into the matrix from the contemporaneous pollen rain deposited on the ditch bottom during the period when the ditch was open.

Chronology is important in interpreting the vegetation data of the subsoil pollen spectrum. Pollen Zone 6 at the bottom of the sequence must be discussed first. Pollen Zone 6 is dominated by goldenrod-type pollen. Some pine and ragweed-type pollen was noted in the deepest sample (No. 1), and a number of other kinds of pollen—goosefoot-type, nightshade-type (Solanaceae, cf. *Solanum*), sedge family, grass family, oak, hickory (*Carya*), and hazel (*Corylus*)—appear shortly thereafter in samples 2 and 3. Ragweed-type frequencies and tree pollen, pine in particular, increase subsequently, while dandelion-type, mugwort, narrow-leaved plantain, broad-leaved plantain, carrot family, ground cherry-type (Solanaceae, cf. *Physalis*), and marsh rose-type (Rosaceae, cf. *Rosa palustrus*) appear in more shallow Pollen Zone 6 samples. This reflects a developing vegetation in the ditch, on the earthwork, and, possibly, in a cleared area around the fort.

Goldenrod, or a close relative, appears to have been the pioneer in the ditch. The later appearance of the other types could be partially a function of soil processes. Goosefoot, for instance, prefers a relatively rich soil (Behre 1983: 223). Increases in this type coincided with documented application of large quantities of organic fertilizer at Shattuck Farm Marsh, Andover, Massachusetts (Kelso 1985: 387), and the type correlates with a distinct organic layer in a profile from the Kirk Street Agents' House, Lowell, Massachusetts (Kelso 1993: 83). Goosefoot may have had to wait for at least some humus development in the ditch or on the earthwork. The pollen from members of the insect-pollinated nightshade family (Solanaceae)—ground cherry-type and nightshade-type—was found in the subsoil but not in the slopewash. This suggests that the parent plants were probably growing only in the bottom of the ditch and not on the slope of the earthwork.

The decline of goldenrod-type percentages in the upper part of Pollen Zone 6 (FIG. 7) indicates a decrease in the population of the parent plants during the later portion of the open-ditch interval. This is not a statistical response to the increase in tree pollen in these samples, because goldenrod-type still declines when tree pollen is removed from the sum (FIG. 8, hollow bars). The further decrease in goldenrod percentages in the slopewash deposits, where the percentages of the other herbs do expand statistically (FIG. 8, hollow bars), suggests that the plants shedding goldenrod-type were largely located in the bottom of the ditch, rather than on the earthwork slope above.

The role of goldenrod as a pioneer tells us something about maintenance of the ditch. At the Kirk Street Agents' House, Lowell, Massachusetts, the 1845–1847 construction period was marked by a proliferation of ragweed-type pollen in the backlot profiles, while plants shedding goldenrod-type pollen took over waste ground at the rear of the lot during a brief fallow period between the end of construction and the beginning of intensive domestic activity behind the house (Kelso 1993: 83, figs. 16, 17). The absence of a ragweed-period at the bottom of the Turf Fort ditch profile suggests that the period of intense human activity around the ditch was relatively brief, and the immediate proliferation of goldenrod-type suggests that there was little, if any, subsequent soil disturbance. This is consistent with the documentary evidence that the fort was constructed and immediately abandoned.

The block of sedge family pollen in samples 5–9 is the horizon marker for Pollen Zone 5. Sedge pollen, other than the single grain in sample 2, appeared relatively abruptly in sample 5 and peaks in sample 9 at the surface of the ditch bottom, just below the slopewash. Sedges imply moist conditions in the ditch, and the appearance of the type suggests a change in the drainage of the ditch. Goldenrod and its close relatives tend to prefer relatively well-drained soils, and the declines in the percentages of goldenrod-type and the two members of the nightshade family were probably a function of this change in moisture conditions.

The peak of sedge-family percentages and the decline of goldenrod-type in sample 9 are very abrupt. This suggests that something other than a further increase in soil moisture may have been responsible for the high sedge count at the ditch surface. Sedges flower in the summer and fall—July through October—while the majority of plants shedding goldenrod-type pollen flower from August through November (Britton and Brown 1913:II, 352–441; III, 380–441). These seasons overlap and the sudden increase in the sedge family pollen count and precipitous decline in the goldenrod-type frequency suggests that the slopewash was a relatively sudden event that occurred in the late summer or early fall, while the sedges were in flower but before most plants shedding goldenrod-type pollen had achieved antithesis. The disappearance of sedge family above sample 9 also indicates that the 8 cm of slopewash deposit accumulated with sufficient rapidity to smother most of the plants in the bottom of the ditch. Slump rather than slopewash may have occurred at the point where the core was taken. Sedges did not return to the ditch bottom, and the goldenrod-type pollen contribution was reduced to 2 percent in only one of the two slopewash samples. This suggests that the ditch was filled shortly after the slopewash interval.

Summary and Discussion

Three previous pollen studies have been conducted under the Jamestown Archaeological Assessment Project. In each of these the pollen record was created by a single post-depositional process and preserved by a single natural or cultural event. In Jamestown Refuse Pit Number 1 the microenvironmental pollen record deposited with trash dumped in a borrow pit was preserved from percolation and the agents of degradation by flat artifacts (Kelso et al. 1995). At the Kingsmill section of Jamestown Island the local pollen sequence that had percolated down into the soil from a 17th-century ground surface was preserved by burial under a low berm marking the boundary of an agricultural field (Kelso 1995). In core JI–65 from Pitch and Tar Swamp an apparent local agricultural record percolated down into the soil and was preserved by marsh transgression caused by sea level rise (Kelso 1994d).

At the Turf Fort, in contrast, a relatively complex succession of natural and cultural pollen record formation and preservation processes were involved in creating and protecting the vegetation history. The first process was rapid, deep burial by human agents. The Turf Fort was constructed by throwing up earthworks, probably with matrix from the ditch and from the broad trough areas that Cotter (1958) noted during his excavations. A pollen spectrum recording the vegetation of approximately 100 years prior to 1665 was already in this matrix. This pollen spectrum was initially preserved from attack by fungi and free oxygen by the mounding of the earthwork, and its survival was prolonged when the earthwork was thrown down to fill the ditch. The pre-1665 spectrum preserved in the deeper ditch fill matrix records the extensive regional forest of the time, and what appears to be a relatively bare, somewhat disturbed local landscape supporting some grass and ragweed, with weeds like goldenrod and goosefoot in sheltered spaces. This tells us something about the domestic landscape that the artisans who occupied this area created for themselves, and it suggests that any cultivation undertaken by these craftsmen was done elsewhere.

The vegetation in the ditch and on the earthwork of the Turf Fort during the period when the ditch was open differed from that of the pre-1665 era, and this vegetation changed significantly before the ditch was filled. Pollen records deposited on the surfaces of soils are subject to homogenization by bioturbation, and percolation, the second pollen record formation process, assists landscape history by separating the pollen records of successive groundcovers as it moves the pollen down into the profile. Pollen percolation, augmented by slump burial, preserved a vegetation record in the Turf Fort ditch subsoil indicating that goldenrods, or close relatives, and a few ragweeds were the initial pioneers in the ditch. These were joined during deposition of the first half of the spectrum by at least one variety of nightshade; plants closely related to narrow-leaved plantain; and, possibly, some goosefoot. A change to more mesic conditions within the ditch is heralded by the appearance of sedges in the upper half of the subsoil pollen sequence. The goldenrod population declined during this interval of wet ground, as grass, ragweed, and goosefoot populations expanded, and mugwort, members of the carrot family, and a variety of nightshade closely related to ground cherry colonized the ditch bottom. Eventually, just before the burial of the ditch bottom by slopewash, soil conditions may have become too wet for many of the minor herbs. At the same time these changes were occurring in the ditch, the tree pollen spectra suggest the development of a secondary tree population in the area around the fort.

Slopewash, or possibly soil slumping, is the third pollen record formation process active in the ditch, and data from the slopewash or slump deposit that sealed the ditch bottom suggest that the goldenrod relatives were largely situated in the bottom of the ditch, while the majority of the plants shedding goosefoot-type pollen were growing on the slope of the ditch or earthwork above. Dandelions, or close relatives such as chicory, plants shedding both broad-leaved and narrow-leaved plantain-type pollen, and members of the carrot family were growing both in the ditch and on the slope above it. The deposition of the slopewash seems to have been rapid enough to catch the flora between the pollination periods of sedges and the goldenrod relatives, suggesting a late summer or early fall timing for the event. Neither sedges nor goldenrod re-colonized the slopewash, implying that the ditch was filled shortly thereafter. It is possible that the slopewash or slump was precipitated by disturbance of the ditch side or earthwork related to the dismantling of the fort.

The downward movement of ragweed pollen, calibrated with the Jamestown Refuse Pit 1 pollen percolation rate and adjusted to the bottom of the visible plowzone, suggests that agriculture began over the ditch ca. 1729, within a few years after the last known reference (1721) to the Turf Fort in the documentary record. This implies that the fort was dismantled to permit cultivation in the depopulated Jamestown of the 18th century, and agriculture appears to have been the function of the plot right up the establishment of the park vegetation. This park period is recorded in the tree and grass pollen in the upper plowzone and in the humus that developed on the thin layer of archaeological backdirt deposited in the mid-1950s.

The results of the study are significant for a variety of reasons. From a technical point of view, they serve to emphasize the importance of considering pollen record formation processes when interpreting historical soil pollen sequences. The Turf Fort ditch record could not be read from the bottom or the top like a normal pollen profile, because, in addition to natural pollen percolation, it had been formed by plowing, soil mining, soil redeposition, and slopewash, the latter possibly caused by human activity related to dismantling of the fort. These processes resulted in the oldest pollen being located some distance above the bottom of the sequence and in the placement of largely contemporaneous pollen contributions from the distinct plant populations occupying the ditch bottom and the earthwork slope in the successive subsoil and slopewash strata. Discovering what has happened to the pollen record after it was deposited was as important to this study of vegetation and human land-use history as the plants themselves.

History also profited from the study. Surprisingly little is known about the appearance of the first capital of Virginia, and the Turf Fort large ditch pollen profile has provided what appears to be a relatively complete vegetation history of the area from construction of the Turf Fort to the present day and a snapshot of the 17th-century landscape prior to construction of the fort. The data corroborate and expand the scant documentary history of the 1665 Turf Fort, and have been invaluable in understanding the appearance of an important segment of the 17th-century townsite. They also demonstrate the utility of the relatively low impact and cost effectiveness of palynology in evaluation studies. The pollen core provided greater assurance that the features uncovered during the 1993 field season actually relate to the documented Turf Fort and yielded critical information regarding the use and abandonment of the fort. To obtain the same site-specific history of use and abandonment at the fort by employing standard archaeological techniques could have required the excavation of a considerably larger area, covering the majority of the fort, and would have required a substantial outlay of funds. In the context of the Jamestown assessment project, which concentrated upon inventorying and evaluating resources through out the approximately 1500 acres on Jamestown Island administered by the National Park Service, a major excavation at the Turf Fort would not have been appropriate or even feasible. In situations in which sites are not under threat, palynology has the capacity to inform overall site interpretations and to shed considerable light on the local environment of the past without destroying the resource or draining the budget.

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References

Ambler Manuscripts
1636– Library of Congress, Washington, D.C.
1809 Transcripts on Microfilm, Colonial Williamsburg Foundation Research Archives, Williamsburg, VA.

Bazzaz, F. A.
1974 Ecophysiology of Ambrosia Artemisiifolia: A Successional Dominant. *Ecology* 55: 112–119.

Behre, Karl-Ernst
1983 The Interpretation of Anthropogenic Indicators in Pollen Diagrams. *Pollen et Spores* 23(2): 225–245.

Benninghoff, W. S.
1962 Calculation of Pollen and Spores Density in Sediments by Addition of Exotic Pollen in Known Amounts. *Pollen et Spores* 6(2): 332–333.

Boyle Papers
1688 Sketch Map of Jamestown Island by Reverend John Clayton. In Boyle Papers No. 39, housed at the Archives of the Royal Society of London. Facsimile on file at Colonial Williamsburg Foundation Research Archives, Williamsburg, VA.

Britton, Nathaniel Lord, and Hon. Addison Brown
1913 *An Illustrated Flora of the Northern United States and Canada.* 1970 reprint in three volumes of the 1913 edition. Dover Publications Inc., New York.

Cotter, John
1958 Archaeological Excavations at Jamestown, Virginia. *Archaeological Research Series IV.* US Department of the Interior, National Park Service, Washington, DC.

Cushing, E. J.
1964 Redeposited Pollen in Late Wisconsin Pollen Spectra from East-Central Minnesota. *American Journal of Science* 262: 1075–1088.

Davis, M. B.
1965 Phytogeography and Palynology of the Northeastern United States. In *The Quaternary of the United States*, ed. by H. E.

Wright, Jr. and D. G. Frey, 377–401. Princeton University Press, Princeton, NJ.

Day, H. Summerfield
1936 Memorandum from Assistant Archaeologist H. Summerfield Day to Associate Archaeologist J. C. Harrington, September 1936, on file at Jamestown Archives, Colonial National Historical Park, Yorktown, VA.

Dimbleby, G. W.
1985 *The Palynology of Archaeological Sites*. Academic Press, New York.

Erdtman, Gunnar
1969 *Handbook of Palynology*. Hafner Publishing Co., New York.

Faegri, K., and L. Van der Pijl
1971 *Principles of Pollination Ecology*. Pergamon Press, New York

Force, Peter, comp.
1947 *Tracts and Other Papers Relating Principally to the Origin, Settlement, and Progress of the Colonies in North America, from Discovery of the Country to the Year 1776*. Reprint. 4 vols. Peter Smith, New York.

Goldstein, Solomon
1960 Degradation of Pollen by Phycomycetes. *Ecology* 41: 543–545.

Havinga, A. J.
1967 Palynology and Pollen Preservation. *Review of Palaeobotany and Palynology* 2: 81–98.
1974 Problems in the Interpretation of Pollen Diagrams of Mineral Soils. *Geologie en Mijnbouw* 53: 449–453.
1984 A 20 Year Investigation into Differential Corrosion Susceptibility of Pollen and Spores in Various Soil Types. *Pollen et Spores* 26(3–4): 541–558.

Horning, Audrey J.
1996 Early Waterfront Settlement in Jamestown's New Towne: The Structure 24 Domestic Complex. Manuscript on file at the Department of Archaeological Research, Colonial Willaimsburg Foundation Williamsburg, VA.

Horning, Audrey J., and Andrew C. Edwards
1996 Report on the 1993 Archaeological Investigations in the Jamestown Townsite. Report on file at the Department of Archaeological Research, Colonial Williamsburg Foundation, Williamsburg, VA.

Kelso, Gerald K.
1985 Palynology and Historic Land-Use in Central New England: The Record from Shattuck Farm. In The Camp at the Bend of the River, ed. by Barbara E. Leudtke, 360–399. *Occasional Publications in Archaeology and History* 4. Massachusetts Historical Commission, Boston.
1993 Pollen-Record Formation Processes, Interdisciplinary Archaeology, and Land Use by Mill Workers and Managers. The Boott Mills Corporation, Lowell, Massachusetts: 1836–1942. *Historical Archaeology* 27(1): 71–93.
1994a Pollen Percolation Rates in Euroamerican-Era Cultural Deposits in the Northeastern United States. *Journal of Archaeological Science* 21: 481–488.
1994b Pollen Analysis at the Paddy's Alley & Cross Street Sites Central Artery Project, Boston, Massachusetts. Report on file at John Milner Associates, Alexandria, VA.
1994c Pollen Analysis of the Domestic Backlots of Two Nineteenth Century Households in Washington, D.C. Prepared for John Milner Associates, Alexandria, VA.
1994d Exploratory Pollen Analysis of Core JR–65 from Pitch and Tar Swamp, Jamestown, Virginia. Report on file at the Department of Archaeology, Colonial Williamsburg, Foundation, Williamsburg, VA.
1995 Exploratory Pollen Analysis of the West Berm of a Probable 17th-Century Field in the Kingsmill Area. *Jamestown Archaeological Assessment Newsletter* 2(1): 8–16. Colonial Williamsburg Foundation, Williamsburg, VA.

Kelso, Gerald K., and Henry M. Miller
1993 Exploratory Pollen Analysis in the Back Lot of the Brome-Howard Slave Cabin, St. Mary's City, Maryland. Ms on file, Cultural Ecology Laboratories, Gloster, MS.

Kelso, Gerald K., and Dick Ping Hsu
1995 Battlefield Palynology: Reinterpretation of British Earthworks, Saratoga National His torical Park, Stillwater, New York. *Northeast Historical Archaeology* 24: 87–96.

Kelso, Gerald K., Stephen A. Mrozowski, Douglas Currie, Andrew C. Edwards, Marley R. Brown III, Audrey J. Horning, Gregory J. Brown, and Jeremiah R. Dandoy
1995 Differential Pollen Preservation in a 17th-Century Refuse Pit, Jamestown Island, Virginia. *Historical Archaeology* 29(2): 43–54

King, J. E., W. E. Klipple, and R. Duffield
1975 Pollen Preservation and Archaeology in Eastern North America. *American Antiquity* 40(2): 180–190.

McCartney, Martha W.
1993 Summary History of Turf Fort. Memorandum dated 28 July 1993, on file at the Colonial Williamsburg Department of Archaeological Research, Colonial Williamsburg Foundation, Willamsburg, VA.
1994 Jamestown: From Metropolis to Ghost Town in Less than a Century. *Jamestown Archaeological Assessment Newsletter* 1 (2/3): 12–15.
1996a Preliminary Analysis: Structure 24. Ms. on file, Department of Archaeological Research, Colonial Williamsburg Foundation, Williamsburg, VA.
1996b Preliminary Analysis of Land Ownership on Jamestown Island. Ms. on file, Department of Archaeological Research, Colonial Williamsburg Foundation, Williamsburg, VA.

Martin, Paul S.
1963 Geochronology of Pluvial Lake Cochise, Southern Arizona II, Pollen Analysis of a 42 Meter Core. *Ecology* 44: 436–444.

Mehringer, Peter J., Jr.
1967 Pollen Analysis of the Tule Springs Area, Nevada. In Pleistocene Studies in Southern Nevada, ed. by H. M. Wormington and D. Ellis, 120–200. *Anthropological Papers* 13. Nevada State Museum, Carson City.

Mrozowski, Stephen A., Gerald K. Kelso, and Douglas Currie
1994 The Use of Contextual Archaeology at Jamestown, Virginia. Paper presented at the 24th Annual Meetings of the Council for Northeast Historical Archaeology, Williamsburg, VA.

Raynor, Gilbert S., Eugene C. Ogden, and Janet V. Hayes
1968 Effects of a Local Pollen Source on Ragweed Pollen Concentrations from Background Sources. *Journal of Allergy* 41: 217–225.
1973 Dispersal of Pollens from Low-Level, Crosswind Line Sources. *Agricultural Meteorology* 11: 177–195.
1974 Mesoscale Transport and Dispersions of Airborne Pollens. *Journal of Applied Meteorology* 13(1): 87–95.

Schoenwetter, J.
1962 A Late Post-Glacial Pollen Chronology from the Central Mississippi Valley. *Pollen et Spores* 4: 376.

Tauber, Henrik
1965 Differential Pollen Dispersion and the Interpretation of Pollen Diagrams. *Geological Survey of Denmark Series* II, No. 89. Copenhagen.

Tschudy, R. H.
1969 Relationship of Palynomorphs to Sedimentation. In *Aspects of Palynology*, ed. by R. H. Tschudy and R. S. Scott, 79–96. John Wiley and Sons, New York.

Van Zeist, W.
1967 Archaeology and Palynology in the Netherlands. *Review of Palaeobotany and Palynology* 4: 45–65.

Virginia Land Office
1679– Virginia Land Office Patent Book 7: 701.
1689 Virginia State Library Archives, Richmond.

Wodehouse, R. P.
1971 *Hayfever Plants*. Hafner, New York.

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