Northeast Historical Archaeology

Volume 18 Article 6

1989

Pollen Record Formation Processes at the Isles of Shoals: Botanical Records of Human Behavior

Gerald K. Kelso

Faith Harrington

Follow this and additional works at: http://orb.binghamton.edu/neha

Part of the Archaeological Anthropology Commons

Recommended Citation

Kelso, Gerald K. and Harrington, Faith (1989) "Pollen Record Formation Processes at the Isles of Shoals: Botanical Records of Human Behavior," *Northeast Historical Archaeology*: Vol. 18 18, Article 6.
https://doi.org/10.22191/neha/vol18/iss1/6 Available at: http://orb.binghamton.edu/neha/vol18/iss1/6

This Article is brought to you for free and open access by The Open Repository @ Binghamton (The ORB). It has been accepted for inclusion in Northeast Historical Archaeology by an authorized editor of The Open Repository @ Binghamton (The ORB). For more information, please contact ORB@binghamton.edu.

Pollen Record Formation Processes at the Isles of Shoals: Botanical Records of Human Behavior

Cover Page Footnote
Many individuals have contributed to this research effort. We particularly wish to thank Roger Larochelle for the use of his maps, Leslie Mead for drafting support, and Elisa McClennan for photgraphing the illustrations. Funding for the ME 226-62 pollen study was provided by the Maine Historic Preservation Commission, and laboratory space was provided by the Boston Univeristy Department of Archaeology. Pollen laboratory equipment was procured under National Science Foundation grant No. BNS-7924470 to Boston University.

This article is available in Northeast Historical Archaeology: http://orb.binghamton.edu/neha/vol18/iss1/6

POLLEN RECORD FORMATION PROCESSES AT THE ISLES OF SHOALS: BOTANICAL RECORDS OF HUMAN BEHAVIOR

Gerald K. Kelso and Faith Harrington

Exploratory pollen analysis on Appledore Island at the Isles of Shoals, a group of nine islands located approximately eight miles off the coast of southern Maine and New Hampshire, indicates that pollen preservation is excellent in exposed island soil deposits in the temperate zone and that pollen percolation into deposits from the surface preserves the records of natural and cultural events where deep cultural deposits have not developed. The Appledore pollen spectra registered the establishment of the resort hotel industry on the island in the mid-19th-century, the virtual abandonment of the island after a major fire in 1914, and the chestnut blight of ca. 1925 on the mainland. The high rate of pollen percolation, ca. 1 cm in 4.2 years, in the loose, organic soils and the shallow deposits on the island limit the palynological land-use record in exposed soils to ca. 175 years. Because pollen is protected from leaching by large flat stones, evidence for 17th-, 18th-, and early 19th-century land use should be recovered by seriating pollen profiles taken from under surface-laid foundation stones and from under foundation stones cast down during dismantling of structures.

L'analyse exploratoire de pollens provenant de l'île Appledore, l'une des neuf qui constituent les Isles of Shoals à quelque huit milles au large de la côte méridionale du Maine et du New Hampsire, démontre l'excellent état de conservation des pollens dans les sols exposés de la zone tempérée. On peut croire que leur infiltration à partir de la surface a permis de conserver les témoins d'événements naturels et culturels même là où les accumulations anthropiques sont demeurées peu profondes. Le spectre pollinique de l'île Appledore refléte l'éstablishement d'une industrie hôtelière au milieu de XIXe siècle, l'abandon presque complet de l'île suite à un incendie majeur en 1914 et la maladie du châtaigne qui sévit sur la terre ferme vers 1925.

Le taux élevé de percolation (approximativement 1 cm par 4.2 ans) dans les sols meubles et organiques et la faible épaisseur de ces derniers limitent, pour les sols exposés, le témoignage palynologique à l'utilisation des lieux au cours des 175 dernièrnes années. Toutefois, en raison de la protection accordée aux pollens qui se trouvent sous les larges pierres, l'utilisation du site au cours du XVIIe, du XVIIIe et au début du XIXe siècle pourrait être révélée par lasériation des profiles de pollens qui se trouvent sous les pierres de fondation posées au sol ou encore sous celles y ayant été jetées lors du démantelement de constructions anciennes.

Introduction

This article reports the results of an exploratory pollen study of soil samples recovered from the alleged William Pepperrell site (ME 226–62) on Appledore at the Isles of Shoals, an archipelago located approximately eight miles south of Portsmouth, New Hampshire, in the Atlantic Ocean (FIG. 1A). This group of nine islands was occupied by 1623 on a seasonal basis to exploit the nearby cod-fishing grounds and was inhabited year-round by the 1640s. The fishing here continued to be viable until the first few decades of the 19th century. By the 1850s, the building of hotels on the two largest islands of Appledore and Star ushered in the resort era and saw a general decline in the fishing industry. The resorts prospered until after the 1890s when competition stiffened as a result of the building of new retreats on the mainland more accessible by motorcar. In 1914 a fire destroyed most of the buildings, including a major hotel, on Appledore and ended intensive occupation of the island (Bardwell 1989: 113). Today the Shoals Marine Laboratory operates a marine field station on Appledore Island, and the Star Island Corporation hosts religious conferences throughout the summer on nearby Star Island.

Archaeological Research at the Isles of Shoals

Archaeological investigations at the Isles of Shoals have been conducted as part of a long-term interdisciplinary research project by Harrington since 1986 (Harrington 1987, 1988, 1989, 1990, 1992; Harrington and Kenyon 1987). These investigations indicated that cultural

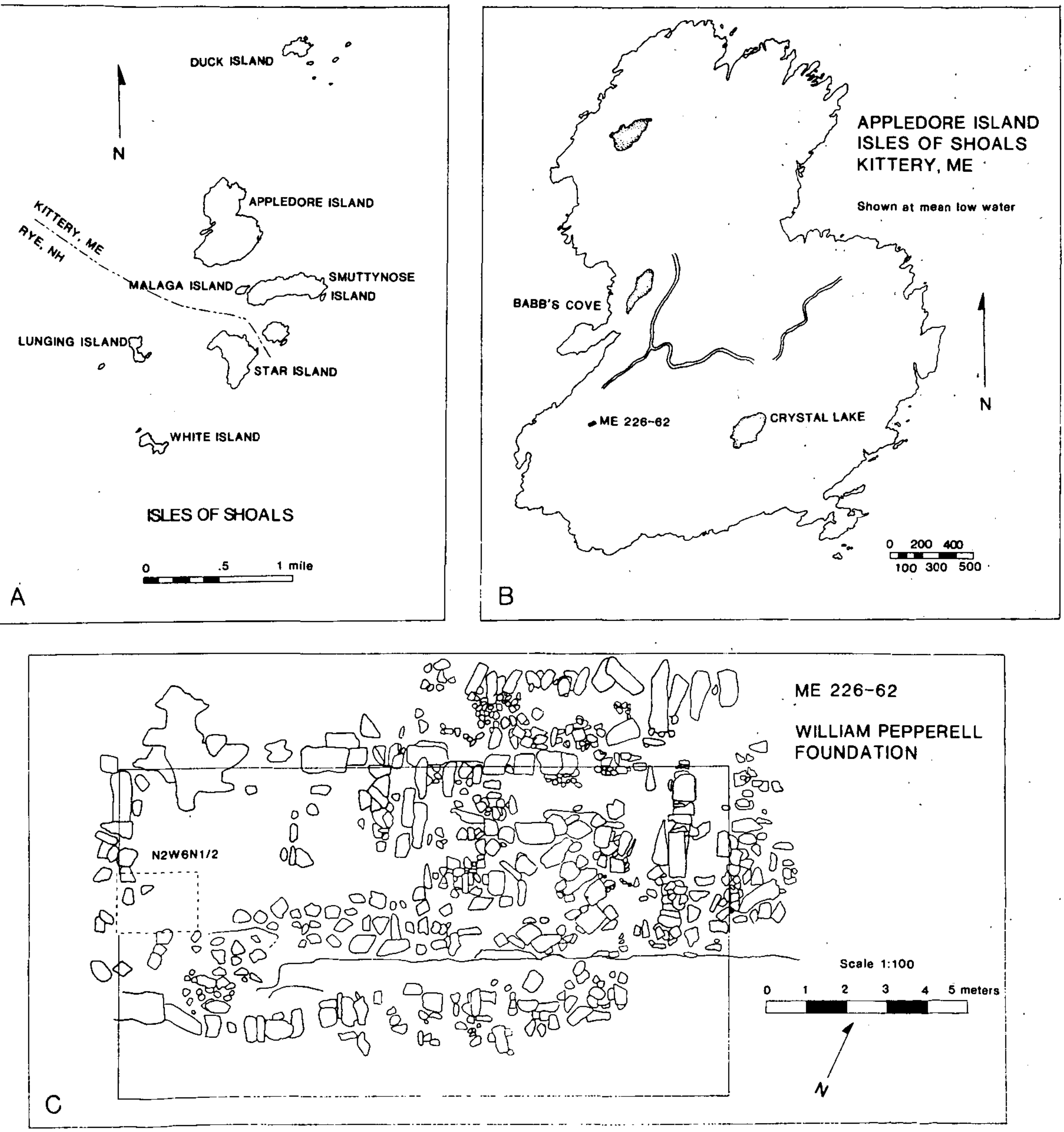

Figure 1. Location of the Isles of Shoals (A), Appledore Island (B), and the sampled locus at the William Pepperrell house (C).

resources at the Shoals are extensive, intact and date from as early as the colonial period. During the 1988 and 1990 field seasons on Appledore Island, teams of participants from Earthwatch, Boston University, and the University of Southern Maine inventoried 51 historical sites for the Maine Historic Preservation Commission, one of the continuing project sponsors. Subsurface testing has been conducted at three stone foundation sites on the southwest end of Appledore. All three structures proved to be domestic sites that were occupied initially in the second or third quarters of the 17th century and abandoned prior to, or during, the Revolutionary War Period. The archaeological evidence thus corroborates secondary historical sources that suggest that the islands were evacuated by the British during the Revolutionary War, partly for the protection of the Shoalers and partly because the British were unsure of their loyalty (Rutledge 1971: 44).

Site ME 226–62 is alleged to have been the home of William Pepperrell, father of the victor at Louisbourg, William Pepperrell, Jr. The site became the focus of intensive excavation during the 1990 season, after the discovery of a rich kitchen midden deposit that provided our first detailed look at material life at the Isles of Shoals in the last decades of the 17th century and the first few decades of the 18th century (FIGS. 1B, C). The archaeological record of the site begins about 1675, and the *terminus post quem* for site abandonment is approximately 1760, based on the presence of several types of English white salt-glazed stonewares and the absence of later creamwares and pearlwares. There is no evidence of any later occupation at the Pepperrell site. Eighteenth-century materials were recovered within 3 cm of the surface in some units and a scattering of 19th- and 20th-century artifacts was found on the surface.

Subsistence and the Environment at the Isles of Shoals

Since many major research questions focus on the subsistence base of the early fishing community at the Shoals, several different approaches are being employed to study the plant materials on these sites. The topic of this paper is pollen analysis at the Pepperrell site, but this is only one of several avenues being explored to gain a greater understanding of the cultural uses of plants at the Shoals, the success or failure of certain crops, and the reconstruction of the historic environment.

A feasibility study was performed in 1989 to determine the presence or absence of phytoliths at the Pepperrell site. Dr. Lawrence Kaplan of the University of Massachusetts at Boston reported the presence of phytoliths in deeply stratified deposits at the Pepperrell site (personal communication, 1989). These samples contained no evidence for maize, beans nor squash, but the presence of phytoliths deep in the profile is encouraging. Phytolith analysis will remain an integral part of interdisciplinary research at the Shoals.

Macrofloral remains are also being studied at the Shoals. Approximately 200 soil samples representing soils from all strata, levels, and zones encountered during excavations at the Pepperrell site, were processed in a flotation tank. Preliminary results indicate excellent recovery of seeds, nuts, pits, and seed casings (as well as numerous small fish and bird bones, gun shot, sewing pins, and even a human baby tooth). Analysis is in process.

The present flora of Appledore Island was surveyed during 1988 to determine species composition, dates for species introduction and cultural uses of plants (Sweeney 1988). Contemporary plant materials (including seeds) were collected and preserved as part of a comparative collection for macrofloral analysis. Dendrochronological cores were taken from apple trees in the vicinity of the three colonial sites on the southwest end of Appledore in 1990. All of the apple trees are growing within enclosed stone walls that may represent early gardens or orchards. The tree rings, however, indicated that none of the trees were older than approximately 70 years. It is possible that apple trees were planted early in the island's history and that the extant trees are the result of natural revegetative processes.

Historical Landscape Analysis: The Pollen Record

Historical landscape analysis is a critical element in any archaeological investigation of the Euroamerican era. Each generation has

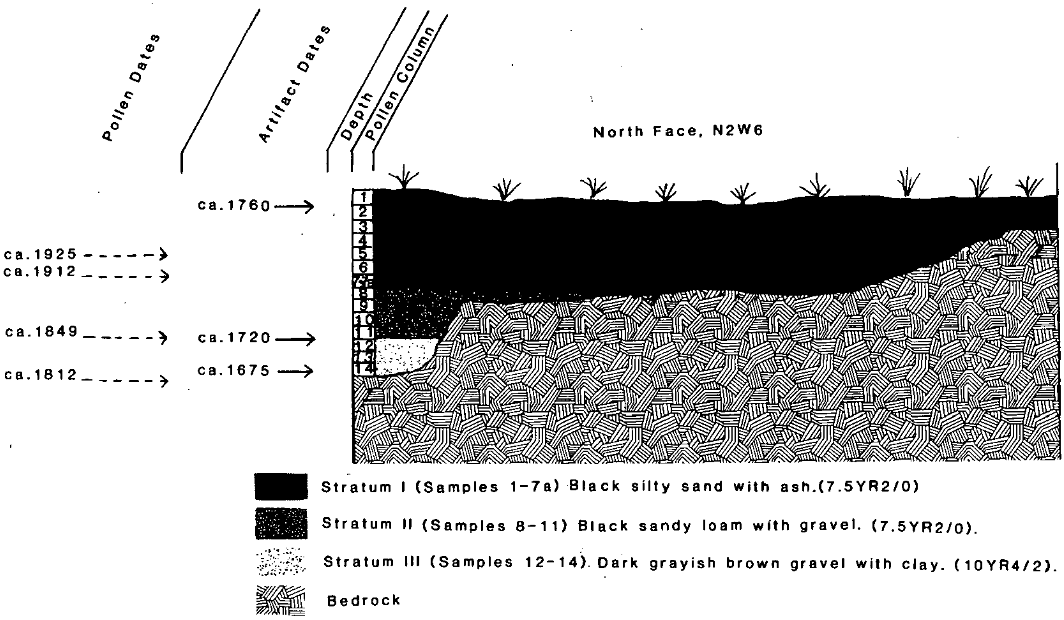

Figure 2. Stratigraphy, sample location, and chronometric dates, north wall of excavation unit N2W6, Pepperrell Site (ME 226-62).

modified its environment characteristically, and the ways in which the environments were modified can reveal much about economics, life styles, and values of the period. Structures and gross geographical features may remain from particular historical periods, but the accompanying flora, a few specimens of long-lived taxa excepted, has been modified beyond recognition by the activities of succeeding generations and by natural processes of vegetational succession. Paleobotanical research methods must be employed in concert with archival and archaeological studies to effectively reconstruct the floral elements of historic environments.

The majority of archaeologists and palynologists consider pollen to be too poorly preserved in most temperate zone soils to warrant analysis (King, Klipple, and Duffield 1975), and it has been demonstrated that pollen is moved post-depositionally by natural processes (Dimbleby 1985). The rate of pollen movement and degradation varies with the nature of the matrix and changing human activities (Kelso 1991: 5). Before pollen analysis could be applied to questions about the 17th- and 18th-century fishing communities on Appledore, it was necessary to determine whether pollen was preserved in this unique island environment and whether the archaeological and pollen records could be correlated. There were, consequently, three objectives to this exploratory pollen study on Appledore:

1) to ascertain whether pollen preservation at the Isles of Shoals is adequate to permit meaningful interpretation of the pollen spectra;

2) to ascertain whether land-use data may be recovered by pollen analysis on Appledore Island; and

3) to ascertain the age of the pollen record that may be recovered from exposed profiles on the island.

Methods

A pollen column of 14 contiguous 3-cm samples (FIG. 2) was collected from the north wall of excavation unit N2W6 adjacent to the foundation of the structure (FIG. 1C). Three natural stratigraphic deposits were evident in this excavation unit (FIG. 2). Stratum I (samples 1–7a)

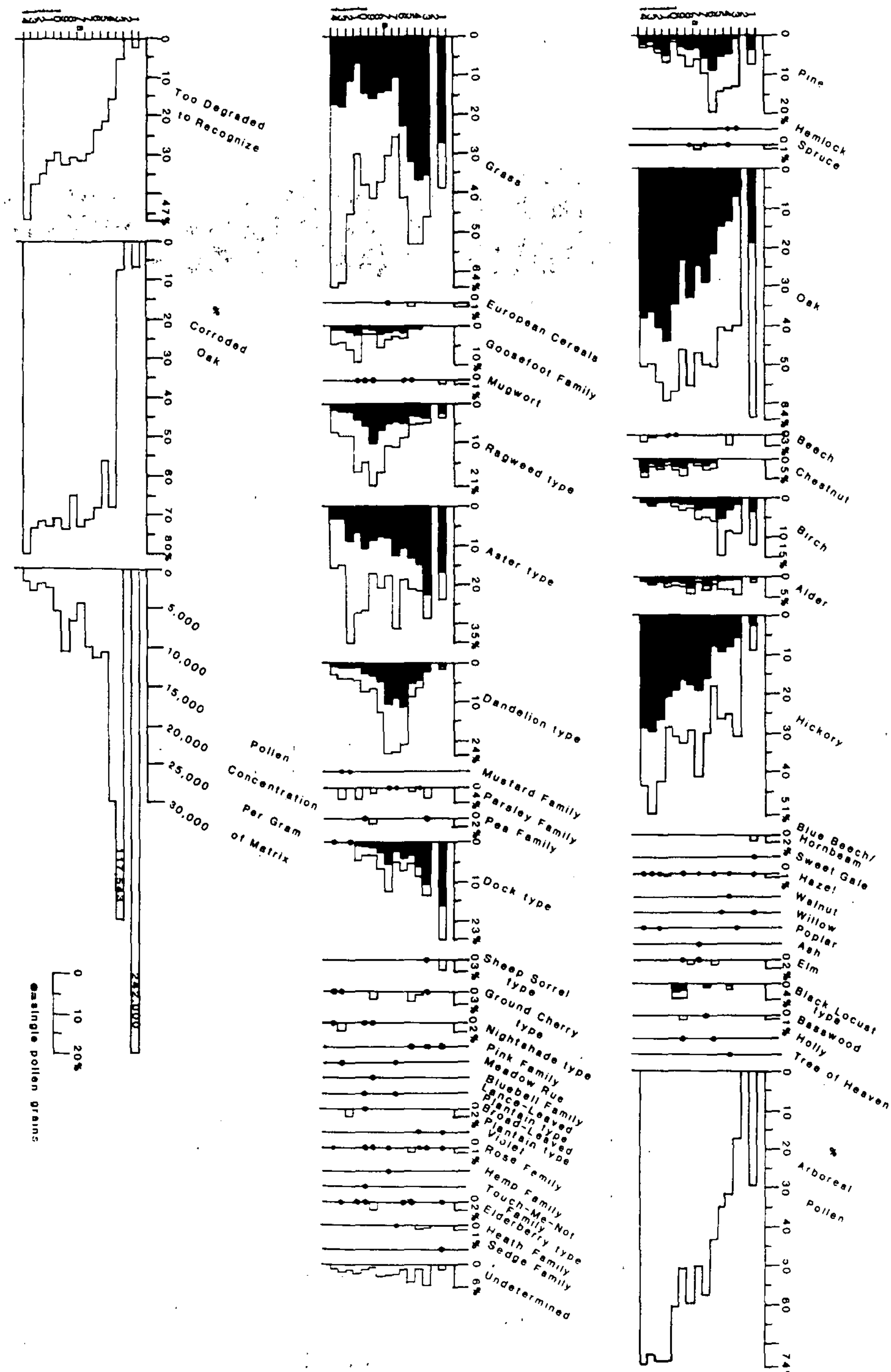

Figure 3. Relative pollen frequencies, Pepperrell Site, north wall of excavation unit N2/W6.

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

Arboreal Vernacular - Latin	*Non-Arboreal* Vernacular - Latin
Pine - *Pinus*	Grass - Gramineae
Hemlock - *Tsuga*	European cereal grass - Cerealia
Spruce - *Picea*	Goosefoot family - Chenopodiaceae
Oak - *Quercus*	
Beech - *Fagus*	Ragweed family - Compositae
Chestnut - *Castanea*	Mugwort - *Artemisia*
Birch - *Betula*	Ragweed-type: *Ambrosia*-type (wind-pollinated Compositae)
Alder - *Alnus*	Aster/sunflower/goldenrod-type: *Aster*-type (insect-pollinated Compositae)
Hazel - *Corylus*	Dandelion-type Compositae: Liguliflorae
Hornbeam - *Ostrya*	Mustard Family - Cruciferae
Blue beech - *Carpinus*	Parsley family - Umbelliferae
Hickory - *Carya*	Pea family - Leguminoseae
Walnut - *Juglans*	Sheep-sorrel-type: *Rumex acetosella* - type
Willow - *Salix*	Dock-type: *Rumex mexicanus*-type
Sweet gale - *Myrica*	Rose family - Rosaceae
Poplar/cottenwood - *Populus*	Nightshade family - Solanaceae
Ash - *Fraxinus*	Groundcherry-type: *Physalis*-type
Holly - *Ilex*	Meadow rue - *Talictrum*
Black locust - *Robinia*	Bluebell Family - Campanulaceae
Elm - *Ulmus*	Hemp family - Cannabinaceae
Tree-of-heaven - *Ailanthus*	Touch-Me-Not family- Balsaminaceae
	Honeysuckle family - Caprifoliaceae
	Elderberry-type: *Sambucus*-type
	Lance-leaved plantain-type: *Plantago lanceolata*-type
	Broad-leaved plantain-type: *Plantago major*-type
	Violet - *Viola*
	Heath family - Ericaceae
	Sedge family - Cyperaceae

consisted of black silty sand with ash (7.5YR 2/0) and Stratum II (samples 8–11) consisted of a black sandy loam with gravel (7.5YR 2/0). Stratum I and Stratum II contained diagnostic artifacts dating to ca. 1720–1760, based on the presence of English white salt-glazed stonewares, Astbury wares, Nottingham stonewares, Iberian wares, and mottled wares. Although some of these ceramic types post-date 1760, the absence of creamwares and pearlwares suggests a date prior to about 1770. Stratum III (samples 12–14), on the other hand contained no imported ceramics. Stratum III dates of ca. 1675 to 1720 are suggested by pipe fragments and redwares and are corroborated by archival sources. Pollen sample 2 (-3 to -6 cm) was inadvertently not collected and is not represented on the pollen diagram. The deepest 1.5 cm of sample 7 was originally thought to be a feature and was collected as a separate sample, 7a. The total interval of samples 7 and 7a is 3 cm.

Mehringer's (1967) mechanical/chemical pollen extraction method was employed, but was modified by eliminating the HNO_3 step and reducing the NaOH strength to 1% to mini-

mize oxidization of the already degraded and fragile pollen characteristic of the deeper portion of temperate zone soil profiles. Pollen residues were mounted in glycerol for viewing. Counting was done at 430¥, with problematical pollen grains examined under oil immersion at 970¥. Four hundred pollen grains were tabulated per sample. The greatest diameter of all intact grass pollen grains in all samples was measured in microns.

Five lycopodium tablets containing 11,300 +/- 400 spores were added to each sample to permit computation of pollen concentrations per gram of sample with Benninghoff's (1962) exotic pollen addition method. Pollen concentration figures were not calculated for individual taxa, because these would not be meaningful where pollen has moved post-depositionally in soil deposits.

All pollen grains too degraded to be identified were tabulated to provide further control over corrosion factors. These unidentifiable pollen grains were not incorporated in any sum from which the frequencies of other types were computed, but the data for this pollen group, as a percentage of total identifiable and unidentifiable pollen, are presented for each profile. Corroded oak pollen grains, a prominent type that retains its identity while readily degrading (van Zeist 1967: 49), were also tabulated. The terms "corroded" and "degraded" are used interchangeably and refer to any kind of pollen deterioration other than tearing. They are not intended as references to the specific classes of deterioration defined under these terms by Cushing (1964) and Havinga (1984).

Percentages based on two kinds of sums are presented in the pollen diagram (FIG. 3). The open line bars are based on relative frequencies (percentages) computed from separate sums for arboreal and non-arboreal pollen types, while the solid colored portion of the diagram reflects percentages computed from the total sum of all pollen types (AP, NAP, and undetermined) present. This separation serves to differentiate regional and local pollen sources to some extent and makes it possible to recognize the statistical distortions that the contributions of pollen types reflecting different phenomena induce in each other. By comparing the two kinds of sums for the same pollen type it is often possible to determine whether a shift in the representation of the type records real change in the pollen contribution of the parent taxon or statistical response to a change in some other pollen type within the fixed numerical sum upon which the percentages are based.

Plants are most frequently encountered under English names in historical documentary sources; to maintain perspective for historical archaeologists, the common New England names for plant taxa are employed in both the text and the diagrams. A conversion table (TAB. 1) of Latin and vernacular names is provided.

Results

The results of pollen analysis at the William Pepperrell House Site are presented in Figure 3. Pollen preservation was very good throughout the profile, and pollen concentrations were high at the bottom of the profile relative to most pollen sequences from dry soil in New England (Kelso, Mrozowski, and Fisher 1987: figures 6–2, 6–3, 6–4; Kelso et al. 1989: figures 12–9, 12–10; Kelso 1989: figure B–4). The presence of a few grains of European cereal pollen in the profile indicates that the upper half of the deposit, at least, post-dates European colonization of the island. Four trends are evident among the pollen spectra of this diagram. One of these trends reflects natural post-deposition pollen record formation processes in the deposit at the site. A second trend registers the effect of an alien pathogen on mainland vegetation, while the third trend reflects land-use patterns on the mainland. The fourth trend records vegetation response to changes in local land use.

Pollen Record Formation Processes

The most basic trend in the Pepperrell Site pollen spectrum is the steady decline in pollen concentrations, and the regular increase in the quantities of pollen that was too degraded to recognize and corroded oak pollen from the top of the profile to the bottom. These patterns are the product of normal pollen record formation processes. Pollen is annually deposited on the surface of the ground. This pollen is carried down into the profile by percolating rainwater. This percolation produces a pattern in which most of the oldest pollen is at the bottom, the

majority of the intermediate age pollen grains are in the middle of the profile, and most of the recent pollen grains are at the top (Dimbleby 1985: 5). Dimbleby's (1985: figure 3) schematic diagram of this distribution is presented in Figure 4A.

As pollen moves downward, it is attacked and progressively destroyed by aerobic fungi (Goldstein 1960) and by free oxygen in the percolating groundwater (Tschudy 1969). This produces patterns of pollen concentration and degradation in which the highest pollen concentrations are located near the surface and the largest proportion of pollen grains that are too degraded to recognize are situated near the bottom of the profile. A schematic of this sequence is presented in Figure 4B. Very similar pollen concentration and pollen degradation patterns have been seen in 15 profiles from 10 Euroamerican period archaeological sites in the Northeastern United States (Kelso, Stone, and Karish 1990; Kelso 1989, 1990a–d; Kelso, Mrozowski, and Fisher 1987; Kelso et al. 1989), and there is no doubt that pollen percolation and degradation are normal post-depositional soil processes affecting pollen spectra.

These pollen concentration and preservation measures are important in the interpretation of pollen spectra because the presence of these characteristic concentration and degradation patterns indicate that the profile has developed naturally (i.e., soil processes have not been interrupted or disrupted) and that the succession of pollen spectra visible in the profile have leached down to their present positions from the surface. Where human activity was intense, as in urban situations, rapid profile aggradation and soil compression often prevent pollen leaching and oxygen penetration, and these characteristic patterns are not found (Kelso 1991: 5).

The presence of these normal pollen concentration and degradation patterns in the Pepperrell House excavation unit N2W6 profile indicates that the sediment has not been disturbed and that human activity on the site was not intense during the period of pollen deposition. The pollen sequence is a normal pollen profile developed by pollen percolation into the soil from the ground surface. This normal percolation pattern will permit dating various parts of the spectrum when the pollen percolation rate is established.

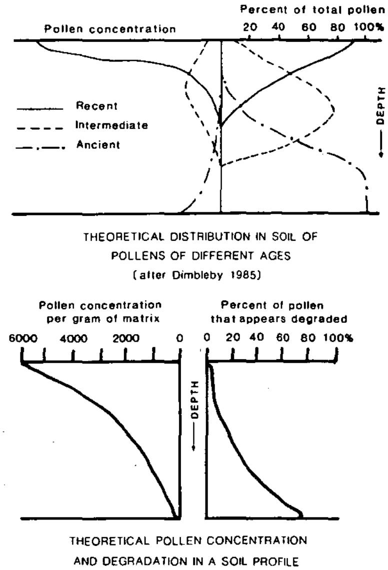

Figure 4. Theoretical distributions of percolated pollen, pollen concentrations, and degraded pollen in a soil profile.

Mainland Pathogenic Vegetation Changes

Chestnut (*Castanea*) pollen was not found in level 5 or above in the Pepperrell House profile (FIG. 3), despite several hours spent scanning slides in search of the type in samples 1–5. Chestnut trees are not now present on the island (Borror 1988: 8–13) and may never have been (Gross 1988: 3). These trees are wind-pollinated, and the chestnut pollen in samples 6 and below probably originated on the adjacent mainland. The disappearance of the type in the pollen record appears to register the virtual extermination of the native American chestnuts (*Castanea dentata*) by a foreign pathogen during the first half of the 20th century.

The blight was introduced in the New York City area around 1904. It had destroyed most of the chestnuts south and west of New Hampshire by 1920 (Anderson 1974: 679, figure 1) and was deep into Maine by 1930 (Davis 1967: 144). It should have reached the coast opposite the Isles of Shoals by about 1925. This can be used to establish the leaching rate for the Pepperrell House profile.

The absence of chestnut pollen in sample 5 suggests that its pollen spectra dates to ca. 1925. The bottom of sample 5 was 15 cm down in the profile (allowing for missing sample 2). The samples were taken in 1988, and the

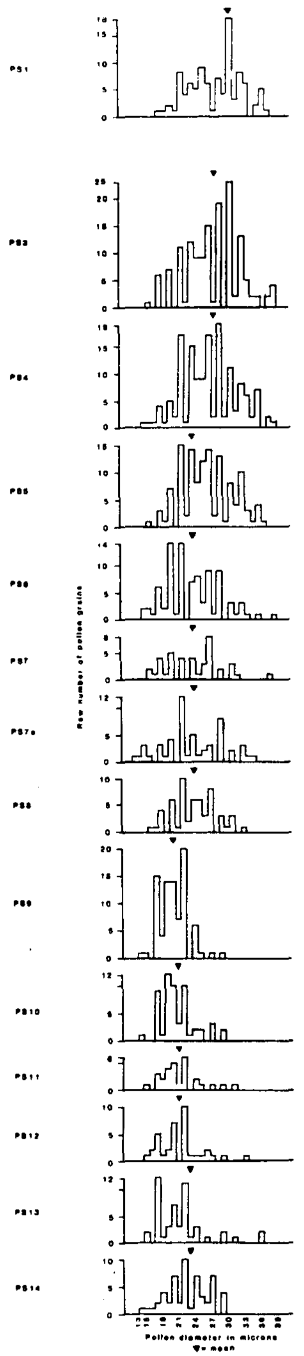

Figure 5. Grass pollen grain sizes in microns at the William Pepperell House Site.

elapsed time since the deposition of the 5 sample sediment in ca. 1925 is 63 years. The pollen percolation rate in the upper portion of the profile, at least, is ca. 4.2 years per centimeter or 10 centimeters every 42 years.

The Mainland Land-Use Record

None of the primary trees contributing to the pollen diagram are currently present on Appledore Island (Borror 1988: 8–13). The absence of timber from the islands was noted early in the occupation (Rutledge 1971: 9), and the soil has probably always been too shallow to support tall growth (Gross 1988: 3). Most of the arboreal pollen in the sampled deposit was wind-transported from the mainland. The Pepperrell House arboreal pollen spectrum is part of the regional rather than the local pollen rain.

The third significant trend among the Pepperrell House pollen spectra in the William Pepperrell House profile is the steady decline in pollen percentages of oak (*Quercus*) and hickory (*Carya*), the two most prominent arboreal pollen types in the spectrum, and in the combined arboreal pollen sum from the bottom of the profile up through sample 3. This pattern is interrupted in samples 10 and 11 by a brief peak of oak that also raised the total percentage of arboreal pollen, but it can only reflect the forest clearance on a regional scale that characterized Euroamerican land use from the third decade of the 17th century into the late 19th century (Carrol 1973: 51; Russell 1976: 460). Pine (*Pinus*) and birch (*Betula*) pollen percentages increase in samples 7 and 7a, respectively. Both of these taxa are recognized secondary succession trees in New England (Barrett 1980: 52; Fowells 1965: 99, 333), and the increase in their pollen contribution records the beginning of secondary forest succession in the area. The Appledore pollen percolation rate of 4.2 years per centimeter that was computed from the chestnut decline suggests that this reforestation began ca. 1900. If a few years are allowed for trees to reach the age of anthesis, this date is consistent with Russell's (1976: 460) statement that Maine reached its highest point of land clearance in 1880.

The Local Land-Use Record

The fourth significant trend in the Pepperrell House pollen sequence is registered among the non-arboreal pollen spectra. Non-arboreal pollen originates close to the ground where wind velocities are relatively low and the possibility of loss through impact with vegetation is relatively high. Little herb pollen is lifted high enough into the atmosphere to be incorporated in the regional pollen rain (Janssen 1973: 33), and most, if not all, of the William Pepperrell House non-arboreal pollen is local in origin. A comparison of the arboreal and non-arboreal sums will provide some information about the relative density of the local groundcover producing the non-arboreal pollen spectrum.

The concentration of airborne arboreal pollen incorporated in the regional pollen rain thins out as it is drawn into the upper atmosphere (Raynor, Ogden, and Hayes 1974), and the regional pollen rain on soils is usually masked by the larger pollen contributions of the local flora. On large bare spaces or in large lakes, where the pollen contribution from local vegetation is much smaller, the regional pollen rain is more visible and may even dominate the spectrum (Martin 1963: figure 2; Tauber 1965: 33). This is significant because the majority of the pollen grains in the deepest nine samples of the William Pepperrell House profile are from trees, and tree pollen clearly dominates samples 11 through 14 (FIG. 3). It is probable that the groundcover in the vicinity of the Pepperrell House during deposition of samples 11 and below was less dense than in later times.

Grass pollen dominates this non-arboreal spectrum throughout the occupation and is particularly prominent at the bottom of the profile (FIG. 3). The proportion of grass pollen decreases above sample 13, and the size of the grass pollen grains in the samples is reduced from a mean of 23 microns to 20 microns (FIG. 5). This last trend either suggests a phenotypic response to physical stress of some sort, or the replacement of one kind of grass by another. As grass declines in importance in samples 12 and 11, the insect-pollinated Compositae (Aster-type), goosefoot-type, dock-type, ragweed-type and dandelion-type contributions to the counts begin to increase. This trend is partially reversed above sample 7. The grass pollen contribution grass increases markedly above sample 7, as grass pollen grains get larger. Goosefoot, ragweed and dandelion-types drop off fairly abruptly in sample 5, but the aster and dock type pollen percentages continue to increase to the top of the profile, and sheep-sorrel pollen (*Rumex acetosella*-type) pollen appears in the spectrum. A local land-use episode appears to be recorded in these changes in the spectra.

Perennial grasses are intolerant of soil disturbance because it destroys their perennating organs (Behre 1983: 229). Higher grass pollen frequencies in historical profiles correlate with relatively stable soil (Solomon and Kroener 1971: figures 8, 9; Kelso and Schoss 1983: 74; Kelso, Stone, and Karish 1990: 10). Ragweed pollen, on the other hand, is the premier soil disturbance indicator in North American historical period pollen spectra. Plants producing this kind of pollen are better able to endure the harsh moisture and temperature regimen of bare ground (Bazzaz 1974: 112) and peaks of ragweed-type pollen have frequently been used as a horizon marker for the advent of European style agriculture in pollen profiles (Solomon and Kroener 1971: 33). The ragweed-type pollen frequencies on Appledore are, however, low relative to those of known agricultural sites (Kelso 1985: figure 43; Kelso, Stone, and Karish 1990: figure 2), and the plants shedding aster-type pollen, dandelion-type pollen, dock-type pollen and the members of the goosefoot family are more prominent on inactive farmland, on pastures, and on waste ground than on tilled soil (Muenscher 1955: 422–505; Fernald 1970: 1357–1567). Goosefoot has a definite preference for rich soil (Behre 1983: 236). Sheep-sorrel prefers poor soil to such an extent that it is best controlled by fertilization (Muenscher 1955: 174; Fernald 1970: 571). Modest soil disturbance, but not cultivation, in the vicinity of the Pepperrell House is indicated in samples 6–11. A more stable, less fertile soil condition is recorded in samples 1–6, but the groundcover did not entirely revert to the pre-disturbance situation. A thicker cover of, possibly, a new variety of grass is indicated by the pollen data, while dock and asters were entrenched in waste ground near the site.

The decline in grass and the increase in aster-type marking the beginning of this trend occurred in sample 12, the initial increase in ragweed-type and chenopodium occurred in sample 11, and dandelion-type counts really

started to increase in sample 10. If the Appledore pollen percolation rate of 42 years per centimeter calculated from the chestnut blight data is applied to these data, grass began its decline and aster-type populations increased sometime between 1837 and 1849, ragweed and dock populations expanded after 1849 and dandelions became prominent after 1862. Construction of the first bay of the hotel on Appledore Island was started in 1848. Two additional hotel bays followed in 1852 (Bardwell 1989: 113). The soil disturbance trend appearing in the mid-19th century (samples 12–10) reflects the inception and development of the resort hotel industry on Appledore Island.

The shifts in the ragweed-type, dandelion-type, and goosefoot family pollen frequencies at the sample 6/5 boundary overlap the change in the grass pollen counts at the sample 7/6 boundary, suggesting that the recorded change in land use occurred sometime early in the deposition of the 3-cm deep sample 6 pollen spectrum. When the pollen percolation rate of 4.2 years per centimeter is applied to the increase in grass frequencies at the lower boundary of sample 6, the change in soil stability suggested by these counts occurred after 1912–1913. The goosefoot, ragweed and dandelion frequencies imply that the shift actually occurred slightly later, some time during deposition of the 3-cm interval of sample 6. The event recorded is undoubtedly the virtual abandonment of the island following the 1914 fire that destroyed the hotel. The decrease in soil fertility indicated by the decline in the goosefoot frequencies and the appearance of sheep-sorrel on the island can reasonably be attributed to a reduction in the amount of organic garbage generated on the island with the closing of the hotel era.

Summary and Conclusions

Three cultural and natural events are recorded among the William Pepperrell House Site pollen spectra. One of these is the clearance of the New England forest during the Euroamerican era. The second event is the blight that destroyed the chestnut population on the adjacent mainland ca. 1925. The third event is the increase and subsequent decrease in soil disturbance associated with the development of the resort hotel industry on the island in the second half of the 19th century and the abrupt end of the resort era with the fire that destroyed the hotel in 1914.

The sedimentation rate for the William Pepperrell House Site was calibrated from the pollen record of the early 20th-century chestnut blight at 10 cm per 42 years (1 cm per 4.2 years). The mid-19th-century development of the hotel industry and the abandonment of the island following the fire of 1914 occur at depths in the profile that suggest that this rate is fairly accurate. When this sedimentation rate is applied to the total length of the profile it suggests that the pollen in the deepest sediment was deposited ca. 1812.

There are major conflicts between the dates for portions of the profile derived from artifacts and dates indicated by the pollen spectra. The material culture recovered from the William Pepperrell House indicates that samples 14, 13, and 12, were deposited between 1675 and 1720, and that samples 11 through 2 were deposited between 1720 and 1760 (FIG. 2). The associated pollen spectrum originated considerably later. When the known age of the pollen spectra of the stratigraphic excavation levels are plotted against the known age of the artifacts recovered in the same levels (FIG. 2, right), the ca. 1925 and 1912–1914 pollen spectra are seen to occur in sediment that accumulated during the early to mid-18th century, while the pollen deposited on the surface ca. 1849 was recovered from sediment dating to the early 18th century. The oldest pollen in our profile should date to ca. 1812, but it was found in sediments that accumulated during the last quarter of the 17th century. There is only one explanation for this phenomenon. More recent pollen deposited on the surface has percolated down through the undisturbed earlier archaeological deposit.

This finding has significant methodological implications. Some North American palynologists have questioned the validity of the Dimbleby model (1985: 5, figure 3) presented in Figure 4. The essence of these criticisms, as expressed by Schoenwetter (1987: 205), is that palynologists working in Southwestern and Mesoamerican sites normally assume that items (including pollen) embedded in a deposit were trapped as the deposit was formed and that Dimbleby's evidence that pollen spectra are altered by post-depositional processes is too limited to be convincing. The association between undisturbed 19th- and 20th-century pollen spec-

tra and undisturbed 17th- and 18th-century artifact deposits at the Pepperrell site cannot be doubted. Earthworms move pollen up and down, tending to homogenize the spectra of deposits, and pollen only moves down in their absence (Walch, Rowley, and Norton 1970). Bioturbation did not produce the Pepperrell site pollen distribution. It can only be the product of pollen percolation. Dimbleby's (1985: 5) model works in temperate zone settings, like Appledore Island, where cultural activities do not interfere with natural soil processes. Given the amount of time that has passed since the demise of most Southwestern and Mesoamerican archaeological cultures, it is probable that pollen percolation has biased the pollen spectra of exposed sites in those regions as well.

The William Pepperrell House pollen study has established that pollen can be well preserved in the exposed environment of Appledore Island, that normal pollen percolation processes prevail there, and that the intensity, at least, of land use by the inhabitants of the island is recorded among the spectra of the non-arboreal pollen types. This study indicates, however, that 17th- or 18th-century land-use pollen records will probably not be recovered from exposed soil profiles on Appledore Island. The island soils are highly permeable and deposits are too shallow to contain a record of much more than 175 years duration. This does not mean that older land-use data cannot be preserved on Appledore.

The remains of structures spanning the occupation of the island have been recognized on Appledore. These range from stone house foundations through stone animal enclosure pens to stone retaining walls for garden soil (Harrington 1990). Soil deposits on the island are shallow, and the foundations of structures were not normally laid in builder's trenches. In most structures the bottom stones appear to have been laid directly on the ground surface at the time of construction. Pollen under large flat stones is protected from percolation (Dimbleby 1985: 57). Our pollen leaching data suggest that a pollen record of ca. 175 years preceding construction will be preserved under the foundation stones of each edifice. The same principle should apply to the pollen records under wall stones placed on the ground during the dismantling of a structure. By arranging such records chronologically into a profile and comparing the pre-occupation (subfoundation) record with the occupation period record preserved under stones thrown down at dismantling, we should be able to ascertain the nature of the land use during the occupation from changes in the vegetation and in the pollen percolation and degradation records.

Acknowledgments

Many individuals have contributed to this research effort. We particularly wish to thank Roger Larochelle for the use of his maps, Leslie Mead for drafting support, and Elisa McClennan for photographing the illustrations. Funding for the ME 226–62 pollen study was provided by the Maine Historic Preservation Commission, and laboratory space was provided by the Boston University Department of Archaeology. Pollen laboratory equipment was procured under National Science Foundation grant No. BNS–7924470 to Boston University.

References

Anderson, T. W.
1974 The Chestnut Pollen Decline as a Time Horizon in Lake Sediments in Eastern North America. *Canadian Journal of Botany* 11: 678–685.

Bardwell, John D.
1989 *The Isles of Shoals: A Visual History*. The Portsmouth Marine Society, Peter E. Randall, Portsmouth, NH.

Barrett, J. W.
1980 The Northeastern Region. In *Regional Silviculture of the United States*, ed. by J. W. Barrett, 25–66. Wiley-Interscience, New York.

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

Borror, Arthur C.
1988 Checklist of the Marine Flora and Fauna, Including the Birds of the Isles of Shoals and the Vascular Plants of Appledore Island. Manuscript on file, Shoals Marine Laboratory, Appledore Island, Isles of Shoals, Kittery, ME.

Carrol, C. F.
1973 *The Timber Economy of Puritan New England.* Brown University Press, Providence, RI.

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

Davis, Ronald B.
1967 Pollen Studies of Near Surface Sediments in Maine Lakes. In *Quaternary Paleoecology*, ed. by E. J. Cushing and R. B. Webb, 143-173. Yale University Press, New Haven.

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

Fernald, M. L.
1970 *Gray's Manual of Botany.* 8th ed. Van Nostrand Reinhold Co., New York.

Fowells, H. A.
1965 *The Silvics of Forest Trees.* USDA Forest Service Handbook 271. United States Department of Agriculture, Washington, D.C.

Goldstein, S.
1960 Degradation of Pollen by Phycomycetes. *Ecology* 41: 543-545.

Gross, Laura B.
1988 Geologic Contributions to the Field Report, Isles of Shoals Archaeology Project. Ms. on file at the New England Studies Program, University of Southern Maine, Portland.

Harrington, Faith
1987 Field Report, Isles of Shoals Archaeological Project, Summer 1987. Ms. on file, New England Studies Program, University of Southern Maine, Portland.
1988 Archaeology at the Isles of Shoals. *Context* (the newsletter of the Center for Archaeological Studies at Boston University) 6(3–4): 13–16.
1989 New England's First Settlers. Preliminary Report of the 1988 Field Season of EARTHWATCH, New England's Settlers Archaeological Project. Report on file at the New England Studies Program. University of Southern Maine, Portland.
1990 Preliminary Report on the 1990 Field Season of the Isles of Shoals Archaeology Project. Report on file at the Maine Historic Preservation Commission, Augusta.
1992 The Dynamics of the Fishing Community at the Isles of Shoals. In *The Art and Mystery of Historical Archaeology: Essays in Honor of James Deetz*, ed. by Anne Yentsch and Mary C. Beaudry. CRC Press, Boca Raton, FL.

Harrington, Faith, and Victoria Kenyon
1987 New Hampshire Coastal Sites Survey, Summer 1986. *The New Hampshire Archaeologist* 28(1): 52–62.

Havinga, A. J.
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.

Janssen, C. R.
1973 Local and Regional Pollen Deposition. In *Quaternary Plant Ecology*, ed. by H. B. J. Birks and R. G. West, 31–42. Blackwell Scientific, London.

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. Luedtke, 360–399. Occasional Publications in Archaeology and History 4. Massachusetts Historical Commission, Boston.
1989 Exploratory Pollen Analysis of Central Artery Sites. In *Phase II Archaeological Investigations of the Central Artery/Third Harbor Tunnel Project in Boston, Massachusetts, Volume One: Text and Illustrations*, ed. by Ricardo J. Elia, 101–105. Office of Public Archaeology, Boston University, Boston.
1990a Report of Exploratory Pollen Analysis in the Pequot Refuge, Ledyard, Connecticut. Manuscript on file, Division of Cultural Resources, North Atlantic Regional Office, National Park Service, Boston.
1990b Report of Exploratory Pollen Analysis in the "British Woods," Saratoga National Historical Park. Manuscript on file, Division of Cultural Resources, North Atlantic Regional Office, National Park Service. Boston.
1990c Exploratory Pollen Analysis of Historical Matrices at the David Brown Homestead. In *Archeological Investigations of Minute Man National Historical Park, Volume I: Farmers and Artisans of the Historical Period*, ed. by Allen T. Synenki, 85–106. Cultural Resources Management Study 22. Division of Cultural Resources, North Atlantic Regional Office, National Park Service, Boston.
1990d Report of Exploratory Pollen Analysis on Two Profiles from the Carns Site, Coast Guard Beach, Cape Cod National Seashore. Manuscript on file, Division of Cultural Resources, North Atlantic Regional Office, National Park Service, Boston.
1991 Interdisciplinary Research in Historic Landscape Management. *CRM* 14(6) Technical Supplement: 1–11.

Kelso, Gerald K, and Johanna Schoss
1983 Exploratory Pollen Analysis of the Bostonian Hotel Site Sediments. In *Archaeology of the Bostonian Hotel Site*, ed. by James W. Bradley, Neal DePaoli, Nancy Seasholes, Patricia McDowell, Gerald Kelso and Johanna Schoss, 67–76. Occasional Publications in Archaeology and History 2. Massachusetts Historical Commission, Boston.

Kelso, Gerald K., Stephen A. Mrozowski, and William F. Fisher
1987 Contextural Archeology at the Kirk Street Agent's House Site. In *Interdisciplinary Investigations of the Boott Mills, Lowell, Massachusetts. Vol. II: The Kirk Street Agents' House*, ed. by M. C. Beaudry and S. A. Mrozowski, 97–130. Cultural Resources Management Study 19. Division of Cultural Resources, North Atlantic Regional Office, National Park Service, Boston.

Kelso, Gerald K., Stephen A. Mrozowski, William F. Fisher, and Karl J. Reinhard
1989 Contextual Archeology at the Boott Mill Boardinghouse Backlots. In *Interdisciplinary Investigations of the Boott Mills, Lowell, Massachusets. Vol. III: The Boarding House System as a Way of Life*, ed. by M. C. Beaudry and S. A. Mrozowski, 231–278. Cultural Resources Management Study 21. Division of Cultural Resources. North Atlantic Regional Office, National Park Service, Boston.

Kelso, Gerald K., Roger Stone, and John F. Karish
1990 Pollen Analysis in Historic Landscape Studies at Fort Necessity National Battlefield. *Park Science* 10(2): 10–11.

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

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. Nevada State Museum Anthropological Papers 13. Carson City.

Muenscher, W. C.
1955 *Weeds*. 2nd ed. The MacMillian Co., New York.

Raynor, G. S., E. C. Ogden, and J. V. Hayes
1974 Mesoscale Transport and Dispersion of Airborne Pollens. *Journal of Applied Meteorology* 13(1): 87–95.

Russell, Howard S.
1976 *A Long, Deep Furrow: Thee Centuries of Farming in New England*. University Press of New England, Hanover, New Hampshire.

Rutledge, Lyman V.
1971 *The Isles of Shoals in Lore and Legend*. The Star Island Corporation, Boston.

Schoenwetter, James
1987 Review of *The Palynology of Archaeological Sites* (1985) by Geoffrey W. Dimbleby. *American Antiquity* 25(1): 204–206.

Solomon, Allen M., and Duane F. Kroener
1971 Suburban Replacement of Rural Land Uses Reflected in the Pollen Rain of Northeastern New Jersey. *Bulletin of the New Jersey Academy of Science* 16(1–2): 30–44.

Sweeney, Mary Ann
1988 Plant Inventory, Appledore Island. Ms. on file at the New England Studies Program, University of Southern Maine, Portland.

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. S. 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.

Walch, K. M., J. R. Rowley, and N. J. Norton
1970 Displacement of Pollen Grains by Earthworms. *Pollen et Spores* 12: 39–44.

Gerald K. Kelso
Archeology Branch
Cultural Resources Center
North Atlantic Regional Office
National Park Service
15 State Street
Boston, MA 02109

Faith Harrington
New England Studies
University of Southern Maine
11 Granite Street
Portland ME 04103