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Cover Page Footnote

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THE USE OF OPAL PHYTOLITH ANALYSIS IN A COMPREHENSIVE ENVIRONMENTAL STUDY: AN EXAMPLE FROM 19TH-CENTURY LOWELL, MASSACHUSETTS

William F. Fisher and Gerald K. Kelso

The value of opal phytolith analysis is demonstrated in a comprehensive environmental study of an historical site, the Kirk Street Agents' House, Lowell, Massachusetts. A method to measure phytolith degradation percentages is tested and shown to yield similar results to pollen corrosion indices; further research on this new method is suggested, however. Fluctuations in two classes of grass phytoliths indicate changing environmental conditions that support and expand upon changes noted in the pollen spectra. The results of the phytolith analysis are integrated with information derived from documentary research, artifactual analysis, stratigraphic interpretation, and other ethnobotanical methods to arrive at conclusions based on a truly multicomponent strategy. All lines of evidence point to a series of discrete occupational episodes at the Kirk Street Agents' House coupled with concomitant changes in the use of yard space.

La valeur de l'analyse du phytolithe opalin est démontrée dans le cadre d'une étude environnementale approfondie d'un site historique, la Kirk Street Agents' House de Lowell, au Massachussetts. Une méthode de mesure des pourcentages de dégradation du phytolithe est testée et donne des résultats semblables aux indices de corrosion du pollen. Il y aurait lieu, cependant, de soumettre la méthode à d'autres recherches. Les fluctuations de deux catégories de phytolithes d'herbe indiquent que la nature de l'environnement a subi des changements qui confirment d'emblée ceux notés dans le spectre pollinique. Les résultats de l'analyse des phytolithes sont intégrés à des renseignements fournis par la recherche documentaire, l'analyse des artefacts, l'interprétation stratigraphique et d'autres méthodes ethnobotaniques afin d'en arriver à des conclusions fondées sur une stratégie vraiment à base d'éléments multiples. Toutes les données laissent supposer qu'il y a eu une série d'épisodes d'occupation discontinues à la Kirk Street Agents' House ainsi que des changements concomitants dans l'emploi fait de la cour.

Introduction

Recently, opal phytolith analysis has played an increasingly important role in environmental reconstruction and in the interpretation of archaeological deposits on sites throughout the Americas (Miles and Singleton 1975; Carbone 1977; Rovner 1982; Starna and Kane 1983; Piperno 1984, 1988; Pearsall 1982; Kurmann 1985; Lewis 1985, 1987; Fisher, Jenkins, and Fisher 1987). Historical archaeologists have been slow to integrate this new aspect of ethnobotanical analysis into their research.

The purpose of this article is to acquaint the historical archaeologist and ethnobotanist with the utility of opal phytolith analysis and its place in ethnobotanical studies at historical sites. It does so using a specific site, the Kirk Street Agents' House in Lowell, Massachusetts, as a case study. The article also examines a method for arriving at relative corrosion indices for phytolith samples.

Opal phytoliths are microscopic bodies that vary in size from 1 to 1,000 microns. Phytoliths are formed in plants when hydrated silicon dioxide precipitates out and is deposited along cell walls and intercellular spaces where it forms a hard, durable opaline fossil cast (Rovner 1983: 226). Opal is a non-crystalline form of quartz, known as amorphous opal A, which weathers like rock (Jones and Segnit 1971: 58). Phytoliths are produced in most plants under a variety of soil and drainage conditions. Production of phytoliths is usually heaviest in the epidermal tissue of the stems and leaves, although it also occurs in root, flower, and fruiting cells. Phytoliths make their way into the soil when a plant or plant parts die and decompose. Phytoliths have been shown to be relatively stable components in soil, susceptible to the same depositional and post-depositional translocational processes as pollen but resistant to other processes such as percolation (Rovner 1986: 23).

There are basically two methods used in phytolith analysis; they are based on differential production and individual morphology of phytoliths. Jones and Beavers (1964: 711) noted that grasses contributed more opal to the soil than did trees. By extracting and weighing phytoliths from weighed soil samples it is possible to determine the percentage of phytolith by weight in the soil. The difference in gross production between grasses and trees can then be used in determining whether a soil was formed under grassy or arboreal conditions. This method has been shown to be of great utility in the reconstruction of the vegetative histories of forest and grassland areas (Witty and Knox 1964; Wilding and Drees 1968; Verma and Rust 1969; Miles and Singleton 1975; Fisher, Jenkins, and Fisher 1987).

Use of this method in archaeological contexts must take into consideration aspects of the depositional process relating to human behavior that studies of natural contexts do not need to consider. Because of the added factor of human behavior, differences in opal phytolith content in archaeological deposits may not be solely related to vegetative patterns but also to such human activities as garbage disposal, latrine deposits, mulching, fertilizing, land fill, land reclamation, or charcoal manufacturing to name just a few. The number of variables that affect phytolith concentration in archaeological contexts is so great as to render this method nearly useless when applied alone. By integrating the data gleaned from historical sources, stratigraphy, associated artifacts, and—most important—from soil, pollen, and macrobotanical analysis, however, it is possible to reconstruct more accurately the vegetative histories and human activities indicated by concentrations of phytoliths in archaeological deposits.

Since phytoliths are casts of plant cells, they may be morphologically distinct at the family, genus, or species level. By extracting phytoliths from plant specimens taken from identified herbarium collections, it is possible to develop a collection of phytoliths that when compared by morphological variation establishes diagnostic types identifying given plant families, genera, or species. Several such studies have already been done. Twiss, Suess, and Smith (1969: 111) identified morphological differences in the phytoliths of three groups of grasses, Geis (1973: 115) separated 36 species of trees and shrubs at the family and genus level, and Klein and Geis (1978: 148) described the differences in phytoliths from 15 taxa of the family Pinaceae.

Regional comparative collections are necessary for identification of phytoliths from archaeological sites. Pearsall (1982: 868) and Rovner (1983: 257) both suggest that the development of comparative collections of opal phytoliths is of primary concern as they are an integral part of archaeological phytolith analysis. There are relatively few regional comparative collections of phytoliths, however; they include those by Starna and Kane (1983), Piperno (1984), and Brown (1986). These collections add significantly to the number of plants that can be identified from phytoliths in soil deposits. The identification of individual phytoliths to family, genus, or species designation has been accomplished successfully at archaeological sites (Piperno 1984: 373). Phytoliths have also been used to illuminate changing climate and vegetation (Robinson 1980; Lewis 1985: 45; Lewis 1987: 451).

Morphological differences in phytoliths found in different grass species are an important source of paleobotanical information, as pollen grains from nearly all grass species are indistinguishable from one another. While Faegri and Iverson (1964) and Kelso and Schoss (1983) identify some species of European domesticates and corn pollen by size attributes, native North American grasses tend to be lumped into one large category. Grass phytoliths can be separated into three classes, each containing a number of tribes and genera: the Festucoid, the Chloridoid, and the Panicoid (Twiss, Suess, and Smith 1969: 111; TABS. 1, 2, 3). A fourth class called the Elongate is also noted by Twiss, Suess, and Smith (1969: 111); identifications using the Elongate class, however, are possible only with detailed phytolith typologies, as Elongate-type phytoliths occur in most grasses.

The use of opal phytolith analysis in conjunction with pollen and macrobotanical analysis has been suggested by Pearsall (1982: 862), who noted that "the technique [phytolith analysis] is strongest when applied as one component of a

Table 1. Grass species occurring in Massachusetts that produce Festucoid (trapezoid) phytoliths. Based on phytolith data from Brown (1986) and Mulholland (1986) and habitat data from Hitchcock (1971).

Species	F	C	P	Description of Habitat
Bromus commutatus	x			weed in waste/fields
Bromus mollis	x			weed in waste/cult. soil
Bromus tectorum	x			waste places/roadsides
Bromus ciliatus	x			moist woods/rocky slopes
Festuca rubra	x			meadows/bogs/marshes
Festuca octaflora	x			open sterile ground
Poa compressa	x			open ground/waste places
Poa pratensis	x			lawn grass/woods/meadows
Dactylis glomerata	x			field/meadow/waste areas
Lolium perenne	x			lawn/pasture/meadow/waste
Schizachne purpurascens	x			rocky woods
Distichlis spicata	x			seashores
Spartina pectinata	x			fresh water marshes
Sporobolus cryptandrus	x			sandy open ground
Agropyron repens	x			meadow/pasture/waste areas
Agropyron subsecundum	x			moist meadows/open fields
Agropyron trachycaulum	x			mountain meadows
Elymus canadensis	x			prairies
Hordeum jubatum	x			meadows/open ground/waste
Triticum aestivum	x			cultivar/fields
Avena sativa	x			cultivated
Hierochloe odorata	x			bogs/meadows/moist places
Phalaris arundinacea	x			marshes/river banks
Agrostis scabra	x			mountain meadows/fields
Calamagrostis canadensis	x			marshes/wet places
Cinna latifolia	x			moist woods
Phleum pratense	x			cultivar/fields/roadsides
Phragmites communis	x	x		banks of lakes/streams
Eragrostis cilianensis	x	x		cult. ground fields/waste
Eragrostis pectinaceae	x	x		fields/open ground/waste
Eragrostis spectabilis	x	x		sandy soil
Glyceria borealis	x		x	wet places/shallow water
Danthonia spisata	x		x	dry sterile rocky soil
Brachyelytrum erectum	x		x	moist/rocky woods
Oryzopsis asperifolia	x		x	wooded slopes/dry banks
Aristida tuberculosa	x		x	open sandy woods

Key: F = Festucoid; C = Chloridoid; P = Panicoid.

Table 2. Grass species occurring in Massachusetts that produce Chloridoid (saddle) phytoliths. Based on phytolith data from Brown (1986) and Mulholland (1986) and habitat data from Hitchcock (1971).

Species	F	C	P	Description of Habitat
Phragmites communis	x	x		banks of lakes/streams
Eragrostis cilianensis	x	x		cult. ground fields/waste
Eragrostis pectinaceae	x	x		fields/open ground/waste
Eragrostis spectabilis	x	x		sandy soil
Bouteloua gracilis		x		plains
Bouteloua curtipendula		x		plains/prairies/rocky hill
Cynodon dactylon		x		open grassland/waste
Leptochloa fascicularis		x		brackish marshes

Key: F = Festucoid; C = Chloridoid; P = Panicoid.

Table 3. Grass species occurring in Massachusetts that produce Panicoid (bilobate) phytoliths. Based on phytolith data from Brown (1986) and Mulholland (1986) and habitat data from Hitchcock (1971).

Species	F	C	P	Description of Habitat
Glyceria borealis	x		x	wet places/shallow water
Danthonia spisata	x		x	dry sterile rocky soil
Brachyelytrum erectum	x		x	moist/rocky woods
Oryzopsis asperifolia	x		x	wooded slopes/dry banks
Aristida tuberculosa	x		x	open sandy woods
Digitaria sanguinalis			x	field/gardens/waste places
Echinochloa crusgalli			x	cult. fields/waste places
Panicum capillare			x	cult. fields/waste places
Panicum virgatum			x	prairies/open ground/woods
Setaria lutescens			x	cult. fields/waste places
Andropogon gerardi			x	prairies/open woods
Sorghastrum nutans			x	prairies/open woods
Sorghum halepense			x	open ground/fields
Zea mays			x	cultivar
Zizania aquatica			x	marsh/stream banks
Tridens flavus			x	old fields/open woods

Key: F = Festucoid; C = Chloridoid; P = Panicoid.

paleoethnobotanical study." Rovner (1983: 258) concurs, suggesting that "the most productive use of phytoliths should be in conjunction with collateral paleobotanical methods." Rovner (1983: 258) also notes that using phytolith, pollen, and macrobotanical studies in concert "allows phytolith data to be matched against both microbotanical and macrobotanical remains." Comparing results from pollen, soil, and macrobotanical studies with the phytolith study

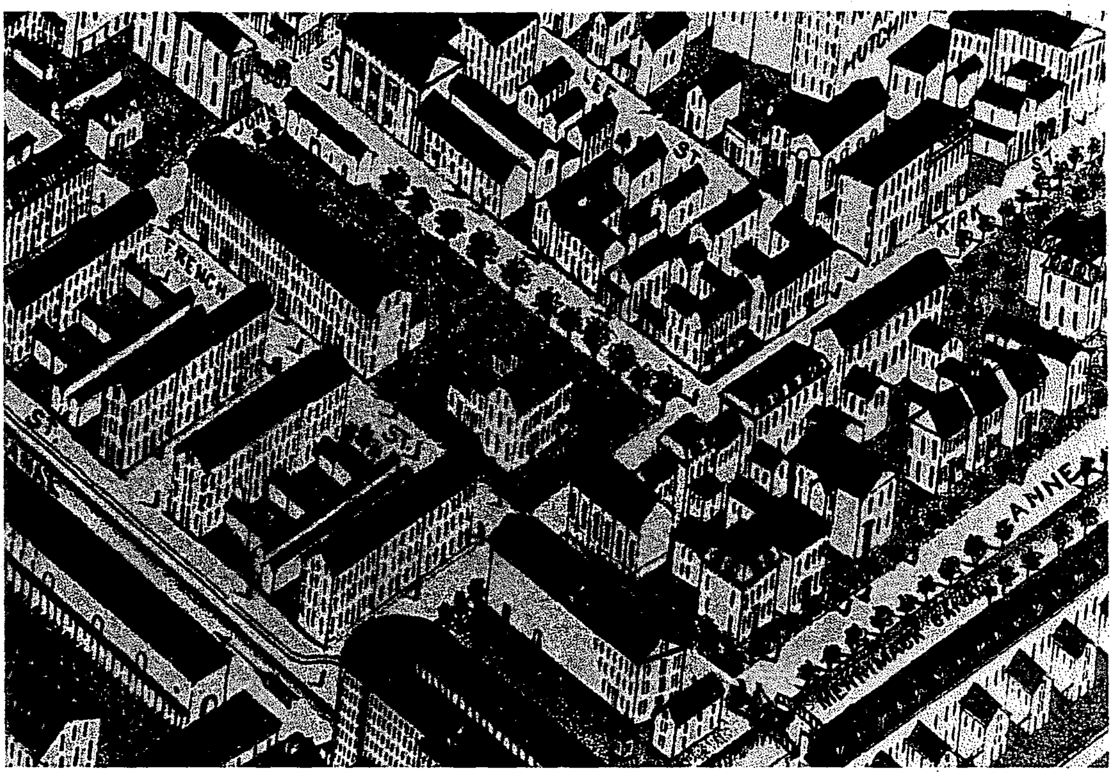

Figure 1. Detail of the 1876 bird's-eye view of Lowell, by Bailey and Hazah; the Kirk Street Agents' House is at the center. Reproduced courtesy of the Lowell Historical Society.

from the same site provides a check on results and allows for the development of new analytical techniques and the refinement of old methods. The ideal testing ground for such an all-encompassing environmental study would be a historical site with good botanical preservation and a useful documentary data base.

The Kirk Street Agents' House

The archaeological record of the Kirk Street Agents' House of the Boott and Massachusetts mills has recently been the object of intensive study. The Agents' House research is one phase of a comprehensive study of the Boott Mills in Lowell, Massachusetts, being undertaken by the National Park Service and Boston University. The investigations reported in Beaudry and Mrozowski (1987a) are, according to Beaudry, intended "to provide a contrasting perspective on mill personnel and mill housing in 19th-century urban industrial communities to that described for the Boott Mills' boardinghouses" (Beaudry 1987: 1).

The Kirk Street Agents' House was built between 1845 and 1847 as a cooperative effort of the Massachusetts and Boott cotton mills (Bell 1987: 7). Located at 63-67 Kirk Street in Lowell, the duplex was the residence of the agents for both mills. Figure 1, an 1876 bird's-eye view of Lowell, shows the Agents' House (center) and the surrounding boardinghouses. Figure 2 shows the Agents' House façade as it appears today. Beaudry (1987: 2) notes that "agents were often the most powerful on-site representatives of mill management," and "their families thus enjoyed income and status in keeping with their elevated position in the corporate hierarchy, a position reflected initially by the specially-designed houses provided for them at corporation expense."

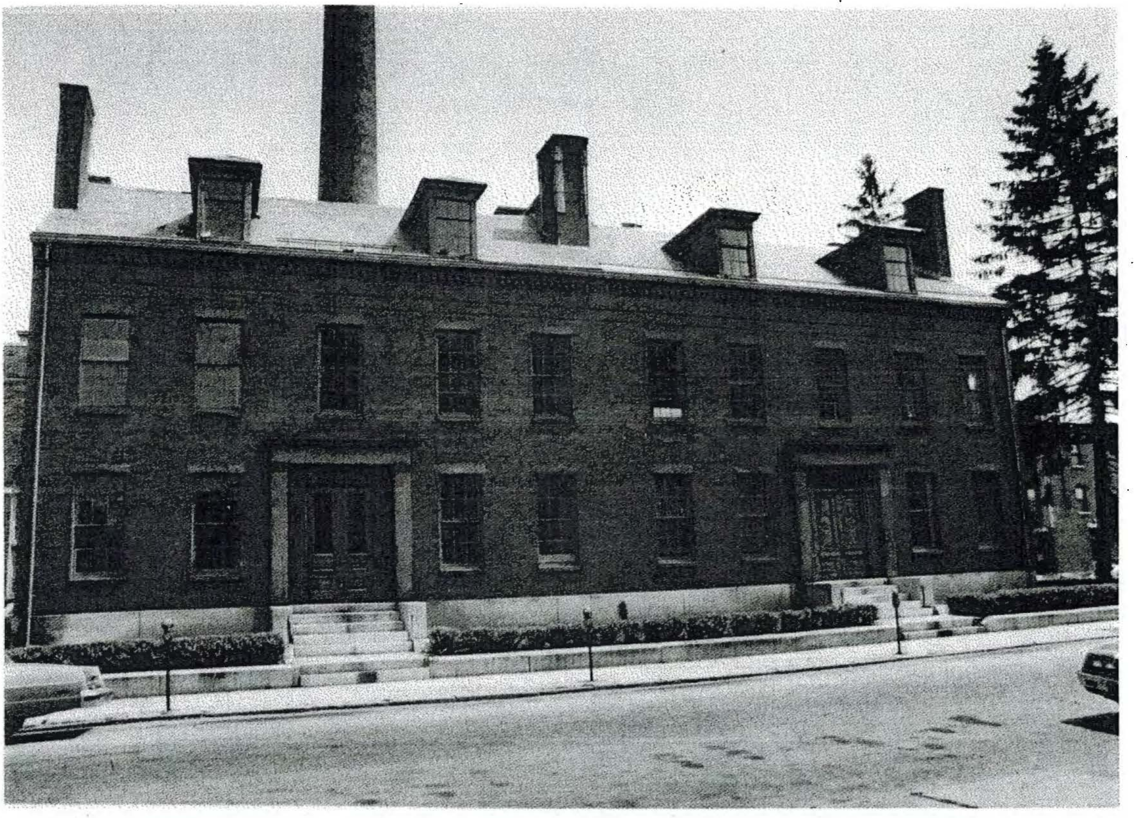

Figure 2. Recent view of the front of the Kirk Street Agents' House; the left half was the home of the Boott Mills' Agent, the right was the residence of the Massachusetts Mills' Agent. Photo by Edward L. Bell.

The residential history of the Boott Mills' half of the Agents' House began with Linus Child, who lived in the house between 1846 and 1861 with his wife and three children (Bell 1987: 13). Between 1864 and 1870 Andrew Moody, a widower, was the next Boott resident. Alexander Cumnock lived in the house from 1872 to 1885 with his wife and five children. Between 1885 and 1892 there was a hiatus in the occupation of the Boott Mills portion of the house. Nathaniel Kerr occupied the house between 1899 and 1901 with his wife and three children. In 1906 the Boott portion of the house was sold and subsequently run as a boardinghouse from 1906 to 1912, as a lodginghouse from 1909 to 1929, and as part of the Lowell high school after 1929 (Bell 1987: 17).

The Massachusetts portion of the house also saw a succession of residents. Between 1846 and 1861 Homer Bartlett and his wife occupied the house. Frank Battles and his wife and her mother shared the house from 1861 to 1889 (Bell 1987: 20). The house then became the residence of William Southworth and his wife from 1890 to 1905. The property was sold in 1901, and between 1906 and 1914 was used as a boardinghouse, after which it was converted into an annex for the high school (Bell 1987: 25).

Most of the residents of the Agents' House were married, about half with children. All had at least one domestic, and some had as many as five (Bell 1987: 25). Bell (1987: 25) notes that "the conscious desire to exhibit and maintain social status was a large part of hiring domestics." The history of occupation of the Kirk Street Agents' House is rather short, with most of its use devoted to the housing of the upper middle class mill agents.

Figure 3. Gerald Kelso taking a pollen profile at the Kirk Street Agents' House. Photo by Mary C. Beaudry.

An important aspect of the overall Boott Mills research design involves the study of the changing urban industrial landscape. Beaudry (1987: 2) suggests that "landscape is . . . the totality of the built environment, including architectural elements and their distribution in space, landscape alteration and earth-moving, as well as the biotic community of plants and weeds." The analysis of the Kirk Street Agents' House deposits included a comprehensive environmental reconstruction strategy using pollen, macrobotanical, soil, and phytolith analyses. Each aspect of the study helped in assessing the evolving landscape and the processes that contributed to the formation of the archaeological record. The omission of one aspect of the environmental archaeology study would be akin to the omission of an artifact group such as glass or pottery from the material analysis of a site.

Methods

Samples for opal phytolith analysis were taken from the contiguous pollen profile used by Kelso (1987: 100) for the pollen analysis (FIG. 3). Eight samples were chosen for phytolith analysis based on preliminary findings from pollen and macrobotanical analyses. These represented a sample from each of the six levels identified archaeologically as well as an additional sample from each of levels 3 and 4. The provenance of the samples is shown in Table 4. It became obvious during analysis that it would be far better to have a phytolith sample for every pollen sam-

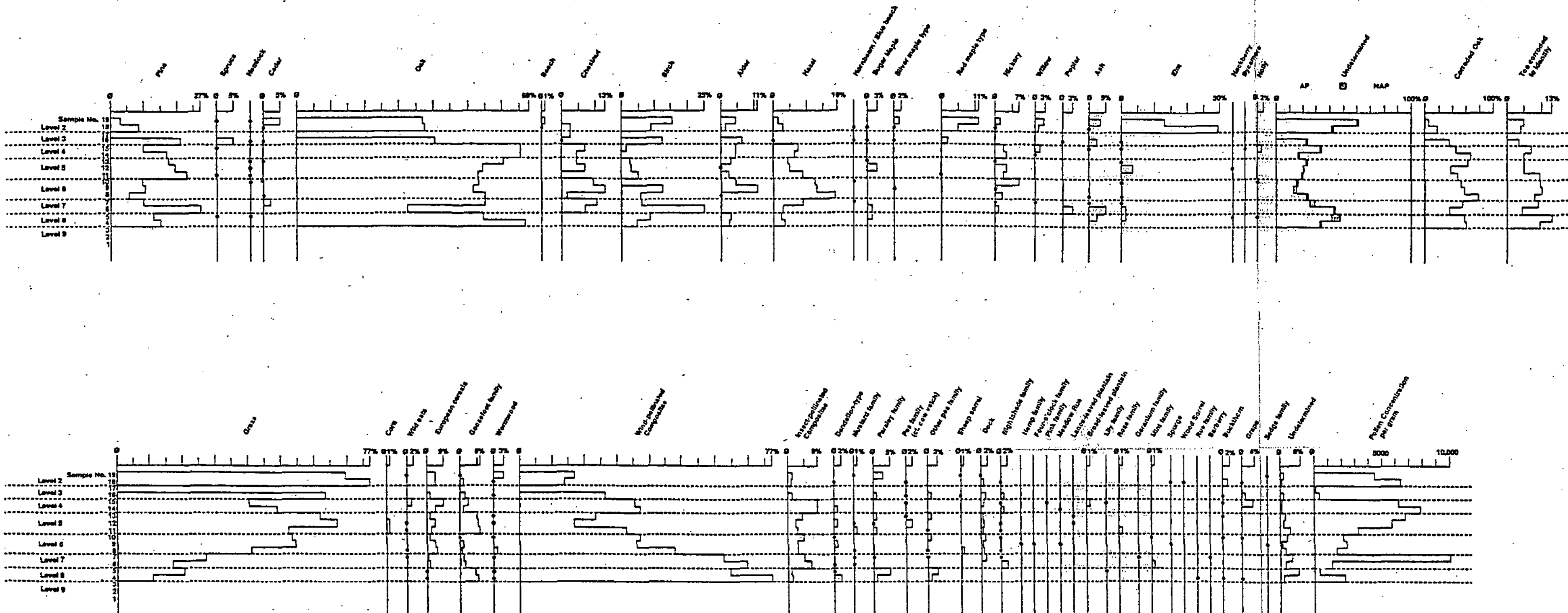

Figure 5. Results of pollen analysis of the north profile of Square E. Solid dot = single pollen grain.

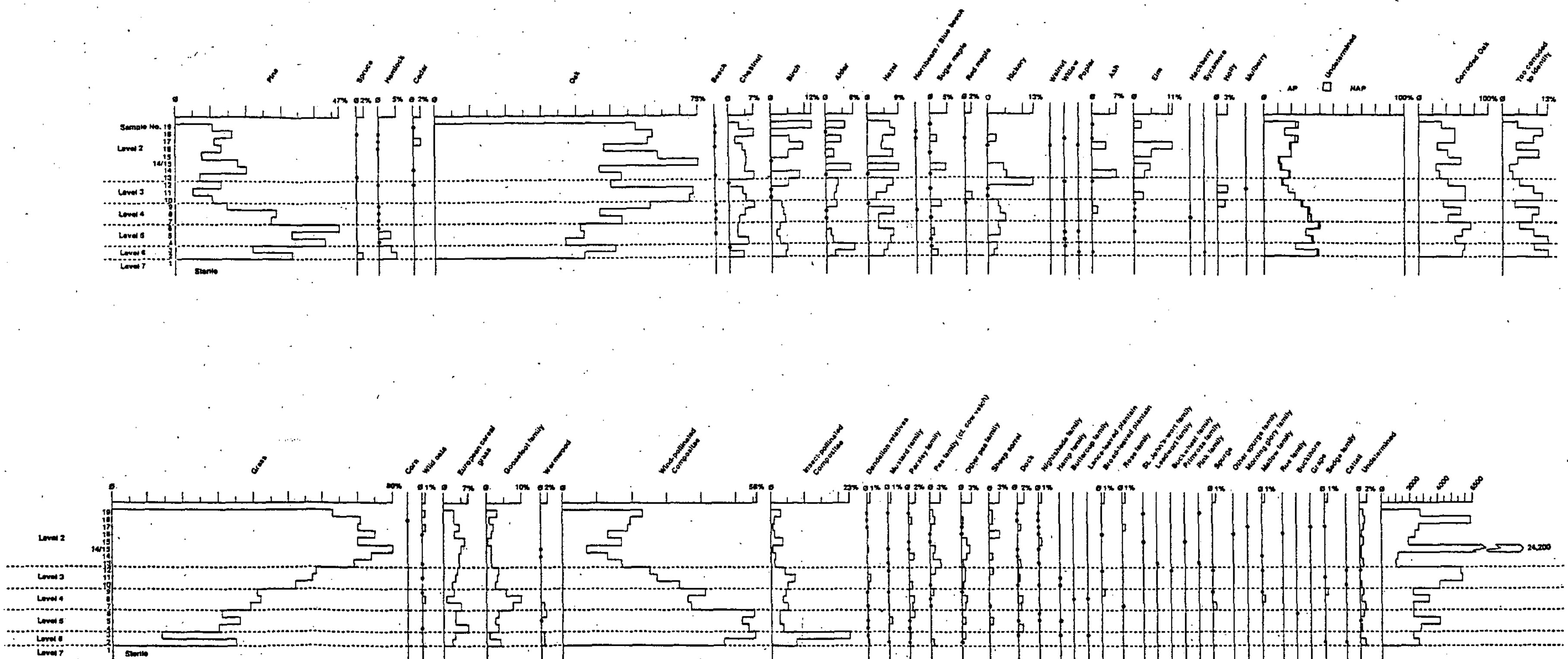

Figure 6. Results of pollen analysis of the west profile of Square J. Solid dot = single pollen grain.

Table 4. Kirk Street Agents' House sample provenances and percentages of opal phytoliths per unit volume of soil.

Sample	Percent Phytolith
1. Square J, West Wall Level 2 (PS 15)	1.99
2. Square E, North Profile, Level 3a (PS 18)	2.25
3. Square E, North Profile, Level 3b (PS 14)	1.48
4. Square E, North Profile, Level 4a (PS 11)	2.01
5. Square E, North Profile, Level 4b (PS 9)	3.00
6. Square E, North Profile, Level 5 (PS 8)	3.23
7. Square E, North Profile, Level 6 (PS 6)	1.57
8. Square E, North Profile, Level 7 (PS 1)	3.13

The a and b designations refer to the top and bottom samples from levels 3 and 4.

ple to facilitate comparison of the data and to improve the overall data base.

A weighed amount of soil between 1 and 2 grams was analyzed for the percentage of opal phytoliths by weight. The procedure for extraction followed Rovner (1971: 347) with one exception: a solution of 30% hydrogen peroxide, instead of a dilute solution of hydrochloric acid, was used to remove organic matter. The final amounts of opal were inspected under a compound microscope to assure uniform purity and were then weighed to determine the soil's phytolith content. The phytoliths from each sample were mounted in Permount and analyzed under a compound microscope for morphological characteristics. Permount is not an ideal mounting media because it hardens and prevents the turning of phytoliths. This can lead to misidentification as some phytolith types are similar in side view but not in top view. In order to prevent misidentification, only phytoliths that could be positively identified were counted. Identifications of the phytoliths were made following Twiss, Suess, and Smith (1969: 111), Geis (1973: 115), Klein and Geis (1978: 148), Mulholland (1986: 51), and Brown (1986).

Pollen in exposed deposits is subject to degradation by oxygenated surface waters (Tschudy 1969: 95) and aerobic fungi (Goldstein 1960: 544). This produces a normal soil pollen profile in which pollen concentrations are highest in the upper four centimeters and progressively decline in deeper, longer exposed sediments (Erdtman 1969: 147; Dimbleby 1985: 5). The proportion of visibly degraded grains among surviving pollen increases in the deeper samples (Kelso 1987a: figs. 1, 2, 3; Kelso 1987b: 108). In an episodic fill the opposite occurs. Pollen at the bottom of the deposit is afforded the protection of an instantly applied overburden. The agents of pollen degradation must work their way down from the top resulting in a higher proportion of visibly degraded pollen grains at the top, provided the fill is not rapidly colonized by vegetation. Pollen concentration will be somewhat greater at the bottom (Kelso and Beaudry n.d.). A variant on this has been recognized in which high pollen concentration and high corrosion at the top of the deposit combine with evidence from pollen leaching, reflecting development of a ground cover on an episodic fill (Kelso 1987b: 112). A combination of pollen concentration and pollen degradation data has considerable potential for delineating deposits of different origins at archaeological sites. In this study, amount of total pollen to corroded pollen and proportions of degraded oak, a prominent pollen type which retains its identity while readily degrading (van Zeist 1967: 49), have been selected as measures of pollen preservation.

Phytoliths are formed by different processes than pollen and are composed of silicon, which weathers differently. Hodson and Sangster (1987: 5) note that "the extent of silification in . . . plants depends on developmental, climatic and edaphic factors." The amount of silification directly affects the strength and completeness of each phytolith. Klein and Geis (1978: 145) found that "all cell types in Pinaceae leaves may become weakly silified, resulting in cellular fragments upon digestion [i.e., extraction]." Hodson and Sangster (1987: 5) also note that "the availability of soluble silica in the substrate for root uptake is of paramount importance [in phytolith formation]."

Phytoliths are weathered by both mechanical and biological activity. Bartoli and Selmi (1977: 279) have found that biodegradation and solubilization of phytoliths occurs in the heavily humic horizon. In podzol (leached soil) with slow biological activity this process is much retarded with little degradation occurring (Bartoli and Selmi 1977: 279). Despite the major differences between pollen and phytolith production and composition, they both are weathered in soil deposits. Therefore, percentages of fragmented phytoliths to non-fragmented phytoliths that are calculated by the same observer may yield valid patterns that indicate differential processes of deposition.

A method of determining phytolith degradation was created and used on the Kirk Street Agents' House samples. Four hundred phytoliths and phytolith fragments were counted for each sample, and the percentages of phytolith fragments and unidentifiable phytoliths to whole identifiable phytoliths were compared between samples and with the pollen corrosion data. Because there are relatively few published typologies of phytoliths, some of the phytolith fragments may have been as-yet unidentified phytoliths.

An important aspect of the environmental study, the phytolith analysis in particular, was the use of a multicomponent strategy. By integrating data generated from the historical research, artifact study, pollen analysis, macrobotanical remains, and soil analysis, it was possible to better understand and interpret the phytolith data.

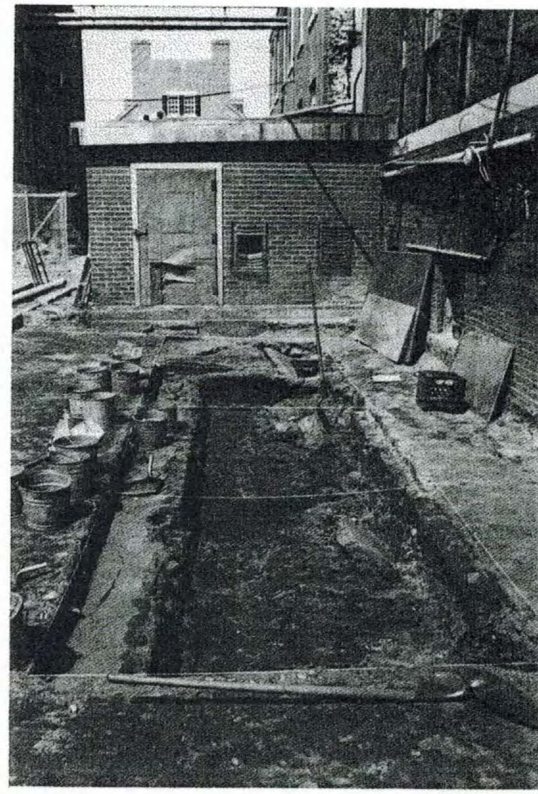

Figure 4. General view of the archaeological excavations at the Kirk Street Agents' House. Photo by Edward L. Bell.

Archaeology

The archaeological methods and results of the Kirk Street Agents' House excavations are presented in Beaudry and Mrozowski (1987b). It should be noted, however, that the excavations, shown in Figure 4, yielded no sealed features. During the excavation six discrete levels were identified by changes in soil color, texture, and composition (Beaudry and Mrozowski 1987b: 50). The material remains from these levels were somewhat helpful in reconstructing past lifeways and depositional processes; the environmental analysis, however, provided a wealth of detail that analysis of the material remains could not provide. The environmental analysis revealed both gradual changes and changes within levels that were not evident from artifactual analysis alone. The details provided by the environmental analysis corroborated conclusions suggested by the artifactual analysis and provided additional interpretations of the site that the artifactual evidence could not supply.

Results

The percentage of opal per unit volume of soil is shown in Table 4. This method of analysis generated some interesting data. Fisher's Least Significant Difference Test (Steel and Torrie 1960: 106) indicated that the percentages for levels 7 (3.13), 5 (3.23), 3a (2.25), and 4b (3.00) were different at a .05 level of significance from the percentages from levels 6 (1.57), 4a (2.01), 3b (1.48), and 2 (1.99). A difference in the percentage of opal phytoliths per unit of soil usually reflects the gross production differences of phytoliths by grasses and trees (Jones and Beavers 1964: 711). The pollen data, however, indicated no such change in the vegetation at the site (FIGS. 5, 6). Kelso (1987: 114) suggests that there was no significant increase in grasses for levels 5, 3a, or 4b shown in the pollen record. An alternative explanation for such differences in phytolith presence involves the addition of vegetal matter to the deposit through human activity. The deposition of vegetable greens or other plant matter in garbage, grass clippings, composting, or any number of human activities may have a profound impact on the amount of phytoliths entering the environmental record at archaeological sites.

The extraction method used in this analysis allows a percentage of non-opal silicates into the phytolith samples. Fredlund (1986: 106) indicates that extracting phytoliths using a heavy liquid with a specific gravity of 2.3 will yield approximately 97% of the phytoliths with included carbon, 80% of the phytoliths, and 37% of the non-opal silicates. Therefore, the high phytolith percentage noted in Level 7 can be attributed to the high percentage of glacial sand that was observed in this deposit.

The identification of individual phytoliths from the Kirk Street Agents' House deposits also provided unique data to the overall environmental study. Recent studies by Mulholland (1986) and Brown (1986) suggest that some grass species contain representatives of more than one of the phytolith classes described by Twiss, Suess, and Smith (1969). For the purposes of this study, however, it is suggested that the shifts in the frequency of the three main grass phytolith classes are not substantially altered by grasses that produce multiple classes of phytoliths and instead accurately represent changes in the environment.

Table 5. Grass phytoliths identified by class from the Kirk Street Agents' House.

Level	Festucoid	%	Chloridoid	%	Panicoid	%	Total
2	12	86%	0	0%	2	14%	14
3a	12	50%	11	46%	1	4%	24
3b	9	32%	12	43%	7	25%	28
4a	3	23%	8	62%	2	15%	13
4b	18	58%	5	16%	8	26%	31
5	14	29%	26	54%	8	17%	48
6	16	55%	10	34%	3	11%	29
7	5	50%	2	20%	3	30%	10
Total	89	45%	74	38%	34	17%	197

By using the grass phytolith counts of each identifiable class, it was possible to illustrate (TAB. 5) the changing patterns of grasses at the Kirk Street Agent's House. Each class of grasses has quite a number of genera, many of differing ecological niches; the Festucoid and Chloridoid classes, however, are represented by grasses indicative of different environmental conditions. Twiss, Suess, and Smith (1969: 110) suggest that in the midwest, the Festucoid class represents the domestic grasses while the Chloridoid are representative of the "short grass" prairie and the Panicoid the "tall grass" prairie. These midwestern definitions, however, are not necessarily applicable to 19th-century Lowell. Since there is no equivalent study for the Lowell area it was necessary to create a new typology from the midwestern studies using the grasses that also appeared in Massachusetts. Tables 1, 2, and 3 show the grasses studied by Brown (1986) and Mulholland (1986) that are also found in Massachusetts. This small typology suggests that the Festucoid class grasses represent agriculturally important genera such as *Triticum, Secale, Hor-*

deum, and *Avena*, and forage species including many of the *Festuca, Dactylis, Poa, Phleum*, and *Bromus* grasses. Lawn grasses and associated weeds are included in the *Festuca, Lolium, Poa*, and *Bromus* genera, while grasses of the genera *Glyceria* and *Phragmites* indicate wet or marshy conditions (Gleason 1968). The Chloridoid class grasses are represented mostly by weed-type grasses found in the genera *Muhlenbergia, Eragrostis,* and *Cynodon*; marsh grasses are represented in the genera *Leptochloa* (Gleason 1968). There are a number of environmental conditions suggested by the presence of either the Festucoid or Chloridoid class of grass phytoliths. By integrating the data on the local environment generated by the pollen and macrobotanical analyses with the phytolith data, it is possible to get a more complete picture of the environmental mosaic.

The distribution of the three phytolith classes representing the different grass types is quite varied throughout the deposits of the Kirk Street Agents' House. The Panicoid class is consistently in a minority and seems to represent a constant background pattern. The Festucoid class and the Chloridoid class phytoliths alternate in dominance throughout the strata. These changes document the use of the property as a cultivated field, construction site, kept yard, active dump, and ill-kept yard.

The percentages of whole identifiable phytoliths and corroded unidentifiable phytoliths are shown in Table 6. The results of the phytolith degradation study match well with the pollen corrosion data (FIG. 7). The relatively higher percentages of phytolith fragments in samples 3a and 4a as compared to the lower percentages of fragmented phytoliths in samples 3b and 4b seem to indicate episodic fill levels. The pollen data from the Kirk Street Agents' House show a similar pattern (Kelso 1987b: 126). The increasing percentages of fragmented phytoliths through levels 5, 6, and 7 seem to reflect a natural degradation profile. While these data tend to indicate that phytolith degradation may help to illuminate depositional processes, it should be noted that this method is highly subjective and has yet to be thoroughly tested.

The cumulative results of the phytolith, pollen, macrofossil, and soil analyses led to an interpretation of the stratigraphy at the Kirk Street Agents' House that included environmental and processual information.

Table 6. Percentages of unidentifiable phytoliths and fragments and identifiable phytoliths from the Kirk Street Agents' House.

Level	UID Fragments	Identifiable
2	83%	17%
3a	74%	26%
3b	69%	31%
4a	83%	17%
4b	74%	26%
5	68%	32%
6	77%	26%
7	88%	12%

Level 7, Pre-1845

The lowest level in the stratigraphic record represents the early historical occupation predating the construction of the Kirk Street Agents' House. The phytolith percentage from this level is biased by the high amount of quartz sand in the deposit. The phytolith data indicate a diverse environment comprised of many different grasses but dominated by Festucoid-type phytoliths. The pollen spectra incorporate a significant amount of European cereals as well as a high percentage of grass pollen and a low percentage of wind pollinated Compositae. Historical evidence reveals that the Agents' House was built between 1845 and 1847 and that previously the property may have seen use as an agricultural field (Bell 1987: 7). The high amount of grass and European cereal pollen as well as the dominance of Festucoid-type phytoliths which are also associated with domestic and forage grasses would seem to support the documentary evidence. Artifacts from this level include only one ceramic sherd, and no iron nails were found (Rodenhiser 1987: 81). The *terminus post quem* of this level determined by the artifactual evidence is 1830, which is in line with both the documentary and the environmental evidence.

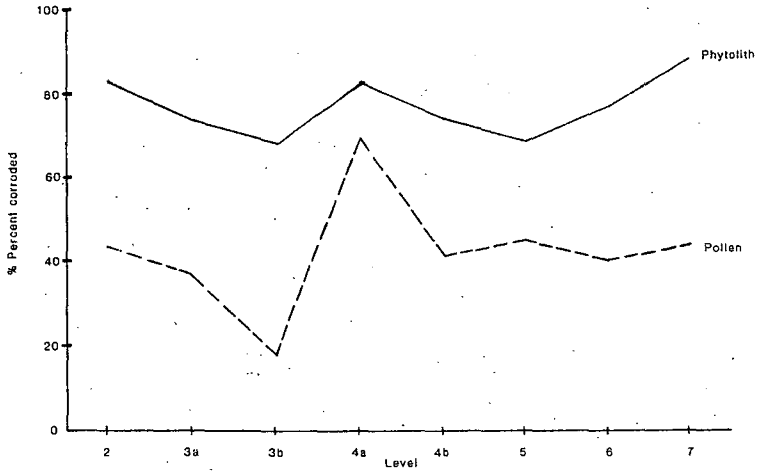

Figure 7. Comparison of corroded Oak (*Quercus*) pollen grains and corroded phytoliths from Kirk Street Agents' House deposits.

Level 6, 1845-1848

The presence of a high number of disturbed soil indicators such as Compositae in the pollen samples from the lower portion of this level indicate a disturbed environment similar to that created during building construction. The phytolith sample was taken from the top portion of the level and indicates an environment dominated by the Festucoid class of grasses. This class of grasses includes species associated with cultivated fields or kept yards. The pollen from the upper portion of this level is a relatively homogeneous series that indicates a more stable environment than the earlier samples from this level. An environment of disturbed soil created by construction activity, followed by stable soil conditions with possibly a yard around the newly constructed building, is indicated by the botanical remains. The documentary evidence indicates that the Kirk Street Agents' House was finished in 1847 and that the first occupants were the Childs and the Bartletts, who left in 1861 (Bell 1987: 11). The *terminus post quem* of this level as determined by the artifactual remains is 1844. There were very few domestic remains in this level (Rodenhiser 1987: 80). The appearance of brick, mortar, and nail fragments indicates that this level represents a construction period. The environmental, documentary, and artifactual evidence seem to support the conclusion that this level represents the construction period of the Kirk Street Agents' House.

Level 5, 1848-1850?

The pollen and phytolith data indicate weedier conditions in this level. Chloridoid-type grass phytoliths are more common than the Festucoid types and represent the weed-type grasses. Pollen data are consistent with an event such as a hiatus in occupation or a rapid fill. The phytolith percentage is high for this level and supports the suggestion of a fill episode with inclusions of vegetal matter. Many more artifacts than in previous strata were found in this thin level; they include combs, buttons, nails, and a variety of glass and ceramic types (Rodenhiser 1987: 80). The presence of personal items beginning in this level indicates the occupation of the house by the Childs and the Bartletts. The pollen, phytolith, and artifactual data indicate that the backyard was used as a dump for material and vegetal waste. This rapid accumulation of trash led to a less well-kept yard dominated by Chloridoid grasses and insect-pollinated Compositae (weeds).

Level 4, 1850?-1861

This level was considered at one point in the investigation to be the site of a garden

(Mrozowski 1987b: 120). The macrobotanical remains, which were scanty in most levels, included seeds of *Oxalis stricta*, which is commonly found in garden soils and deposits containing domestic refuse (Mrozowski 1987b: 168). Mrozowski (1987b: 121) notes, however, that there were no cultigen seeds recovered from the Kirk Street Agents' House deposits and that "the lack of evidence of any commonly grown garden crops lessens the case for Level 4 being a garden." Phytolith percentages are higher at the bottom of this level and lower at the top, indicating a possible fill episode with included vegetal matter. The phytolith data indicate a shift from Festucoid- to Chloridoid-type grasses. This is somewhat at odds with the pollen data, which reflect a shift from weeds to grasses suggestive of an active dumping area gradually changing into a stabilized surface. Pollen and phytolith degradation data show increased corrosion at the top of the deposit, supporting the conclusion that the lower portion of this deposit was part of a rapid fill episode. The combined analysis thus refutes initial speculation that the level was a garden. The artifacts from this level were quite numerous and include flower pots, combs, buttons, glass, utensils, thimbles, tacks, and nails. The minimum number of ceramic vessels is 427, by far the most of any of the Kirk Street Agents' House deposits. The *terminus post quem* of this level is 1850 (Rodenhiser 1987: 80). The documentary evidence indicates that in 1858 Mrs. Bartlett died and in 1861 both the Childs and the Bartletts left the house and were replaced by the Battles on the Massachusetts Mills side in 1861 and the Moodys on the Boott Mills side in 1864 (Bell 1987: 20). The pollen, phytolith, artifactual, and documentary evidence seem to indicate a period of rapid fill, perhaps in part caused by household disruption after Mrs. Bartlett's death and the changes brought about by the arrival of Homer Bartlett's daughter and son-in-law to look after the house. The stabilized surface of this level as indicated by the pollen and phytolith data conforms with the arrival of the Battles household who seem to have cleaned up and possibly made some attempt at landscaping the yard.

Level 3, 1861-1900?

Pollen and phytolith corrosion indices suggest that the lower portion of this level also represents a fill situation. Although the pollen data seem to suggest a series of incidents rather than a single episode, the phytolith and pollen data also point to the fact that the upper portion of the level was dominated by a lawn-type environment. The artifacts from this level include charcoal, coal, brick, mortar, nails, toys, ceramics, and glass. The *terminus post quem* of this level is 1850 (Rodenhiser 1987: 80). The relative paucity of artifacts as compared to Level 4 seems to indicate different disposal practices after the Childs and the Bartletts left in 1861. The documentary evidence indicates a number of different occupants for each half of the Kirk Street Agents' House during this time period (Bell 1987: 14). It is likely that each group of occupants had their own concept of what the backyard should look like, and each modified it to their own taste. The pollen data seem to indicate that this level represents a series of events—fills, deposits, and landscaping activity—consistent with a series of different occupants.

Level 2, 1900? on

Pollen and phytolith samples from this level are dominated by lawn-type indicators. Pollen data also indicate a series of fills representing activity at the site post-dating its use as an agents' house. Artifacts include coal, glass, few ceramics, tobacco pipes, nails, and textile fragments. The *terminus post quem* of this level is 1903 (Rodenhiser 1987: 80). Documentary evidence indicates that the Kirk Street Agents' House functioned as a boardinghouse on the Massachusetts Mills side from 1906 to 1914 after which it was bought by the City of Lowell and used as an annex to the high school. The Boott Mills side also saw service as a boardinghouse from 1906 until 1929 when it too became part of the high school annex (Bell 1987: 24). Pollen and phytolith data are consistent with the use of the backyard as a lawn with periodic landscaping efforts.

Summary

The data gleaned from the environmental archaeology helped to confirm many of the interpretations reached through the historical, architectural, artifactual, and ethnographic analyses. Basing their comments largely on the environmental data from the site, Beaudry and Mrozowski (1987b: 144) note that the "archaeological evidence suggests that the backlot functioned solely as a utilitarian service yard." Also mentioned by Beaudry and Mrozowski (1987b: 144) is the possibility that the Level 4 deposits "may have been accumulated refuse (a trash pile?) from the Bartlett occupation that was spread out and covered over as part of a yard clean-up or relandscaping when Frank Battles and his household took up residence." Beaudry and Mrozowski (1987b: 144) conclude that "the relative paucity of household refuse in Level 3 compared to Level 4, point toward a greatly reduced use of the backlot for domestic chores and perhaps indicate that municipal refuse collection was more efficient after 1850 or that the Battles household made greater efforts to take advantage of this service than the Bartlett household had." These statements indicate that the environmental analysis can contribute important data toward the historical, social, architectural, household, site formation, and economic interpretations of a site as well as to the reconstruction of land use and landscape.

The use of pollen, phytolith, soil, and macrobotanical analyses in the investigation of the Kirk Street Agents' House archaeological deposits not only facilitated the comparison of data but also assured a complete coverage of the strata. Many of the archaeological samples from the Kirk Street Agents' House deposits yielded few macrobotanical remains. The soil analysis, while valuable, provided little comparative data. If the study had relied on just one or two methods of retrieving botanical data, important information from some deposits would have been lost. The use of all four methods prevents poor preservation or the absence of remains recoverable through one or two methods from adversely affecting the results of the environmental analysis.

Conclusions

Environmental archaeology at the Kirk Street Agents' House involved the analysis of pollen, phytoliths, soils, and macrofossils. Each method of analysis contributed unique data that helped to illuminate the past environment and use of the yard and provided insight into depositional processes. Phytolith analysis, like the other three methods, played an important part in this study. It must be remembered that the strength of the study was the use of the methods in concert and the ability to integrate and compare results. The methods complemented each other and allowed the testing of new techniques of analysis. The use of opal phytolith fragment percentages to indicate past deposition processes compared favorably to similar pollen degradation data and is a technique that warrants further research. The absence of sealed archaeological deposits on the site was a limiting factor in the material analysis of the Kirk Street Agents' House deposits. The environmental analysis provided a baseline of information on both gradual and episodic site formation processes that permitted the archaeologists to link site strata to documented episodes of household stability and transition. This level of detail and control in understanding site formation processes not only provides a means of interpreting the historical site in terms of household structure and composition but also, and most important, provides the mechanism for understanding the urban environment as an artifact of human action or human neglect. The results provided by the environmental analysis of the Kirk Street Agents' House deposits suggest to the historical archaeologist that a proper analysis of discrete cultural levels can provide information as detailed and valuable as information gleaned from other artifacts and sealed features.

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