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Cover Page Footnote

The success of the Johnston Cemetery Project was the result of the cooperative efforts of many interested and experienced individuals including Deborah Cox of PAL, Dr. James Garman now of Salve Regina University, Thomas Crist and Arthur Washburn of Kise, Straw, & Kolodner, and the PAL field crew. I am indebted to Lauren Cook and Thomas Naughton for compiling the lion's share of the historic background data for the project. Alan MacIntyre took all project photographs. I would especially like to thank the Rhode Island Resource Recovery Corporation for funding the archaeological investigations of Johnston Historical Cemeteri~s 86 and 88, as well as the descendant Luther, Fenner, and Waterman family members who supported us in all of our endeavors. Special thanks go to Dr. Sally McBrearty, Tim Kardatzke, David Robinson, Alan Leveillee, my wife Melyssa, and two anonymous reviewers for reading earlier drafts of this manuscript. Any errors contained within this manuscript are solely my responsibility.

"Ashes to Ashes and Dust to Dust": Observations on Human Skeletal Taphonomy at Two Historic Cemeteries in Northern Rhode Island

Joseph N. Waller, Jr.

This paper reports on a study of human bone taphonomy at two historic period cemeteries in northern Rhode Island. The analyses demonstrate that various local factors contributed to the degradation of human bone at the two cemeteries under investigation. Factors investigated as part of this study include soil pH, soil texture, time elapsed since burial, and the age of the deceased at the time of death. The study concludes that soil texture and soil permeability were more correlated with bone deterioration at the two historic cemeteries than soil acidity, which is commonly assumed to cause rapid bone deterioration in southern New England soils.

Cet article rend compte d'une étude de taphonomie d'ossements humains de deux cimetières datant de la période historique, dans le nord du Rhodes Island. Les analyses démontrent que divers facteurs locaux ont contribué à la dégradation des ossements humains aux deux cimetières sous examen. Les facteurs examinés pour les besoins de cette étude incluent le pH du sol, la texture du sol, le temps écoulé depuis l'inhumation ainsi que l'âge de la personne décédée. L'étude conclut que, dans les deux cimetières historiques, la texture et la perméabilité du sol sont davantage liés à la détérioration des ossements que l'acidité du sol qu'on suppose généralement être la cause de la détérioration rapide des ossements dans les sols du sud de la Nouvelle-Angleterre.

Introduction

Multiple studies have attempted to trace the effects of taphonomic processes on animal bones exposed on land surfaces (Behrensmeyer and Boaz 1980; Behrensmeyer 1975; Hill 1979, 1989). These studies have concluded that relative humidity, moisture, temperature, skeletal element, exposure to weathering, carnivore scavenging, as well as a host of other factors contribute to the deterioration of exposed bone. Fewer studies have explored the variables contributing to bone dissolution in buried contexts (i.e. Linse 1992; Nicholson 1996, 1998; Price et al. 1992; Sillen and Parkington 1996; White and Hannus 1983), with many of these studies focusing on post-burial changes in bone chemistry. This paper attempts to document variables that contributed to the dissolution of buried bone in southern New England archaeological contexts. This was accomplished by considering the remains of approximately seventy individuals exhumed from two historic cemeteries. These individuals together formed a small agricultural community in 19th-century northern Rhode Island. Archaeological investigation provided appropriate data for investigating post-burial taphonomic factors affecting human bone degradation at these Northeastern cemeteries. Variables investigated as part of this study included soil pH, soil texture, and the age of the deceased at the time of death. Time elapsed since death (and presumably burial) was calculated from data recorded on gravestone markers, coffin plates, or in state and town vital records.

Project History

The Rhode Island Resource Recovery Corporation (RIRRC) was considering alternatives to meet increasing demands for waste disposal needs by Rhode Island's residents. Final project design plans called for the expansion of the state's central landfill in south-central Johnston (FIG. 1). Unfortunately, expansion of the existing landfill would result in either physical and/or visual impact to two historic cemeteries: Johnston Historic

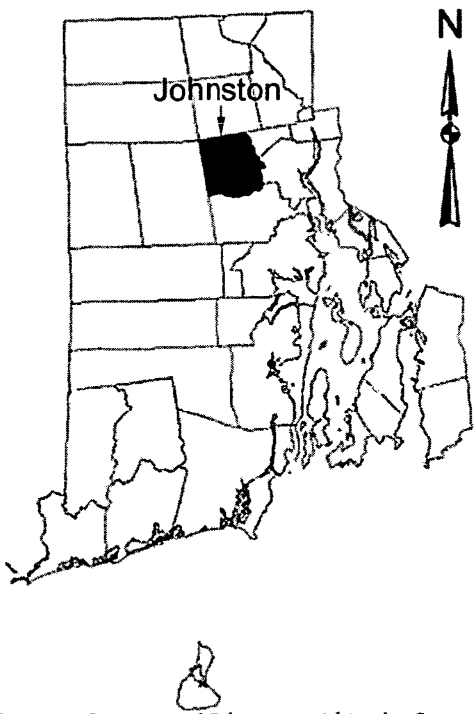


Figure 1. Location of Johnston within the State of Rhode Island and Providence Plantations.

Cemeteries No. 86 and 88, hereafter referred to as JN 86 and JN 88, respectively. No prudent or feasible design alternative existed for the RIRRC as the property adjacent to JN 86 and JN 88 is the only area certified by the State of Rhode Island for certain solid waste disposals, so the RIRRC contracted PAL to exhume and relocate the individuals interred within the cemeteries in the spring of 1998. Archaeological investigations were conducted in compliance with Rhode Island's comprehensive burial ordinance Rhode Island General Law 23-18-11.

Historic Background

Throughout the 18th century, Johnston's developing systems of roads served to link Rhode Island's interior farmlands with the commercial markets of the state's more urban areas. These developing transportation networks enticed settlement in the town's backwoods in areas where there was a large untapped land base for the developing agrarian class.

Thomas Williams of Providence moved to Johnston with his wife Amy and child following an inheritance of land in 1798 (Garman et al. 2000). A portion of Williams' land was soon sold to a Mr. Harris Kelton. The Williams-Davis-Kelton Cemetery Lot (JN 86) appears to have been established soon after this purchase with the first recorded burial of two year old Adia Davis in 1825. Miss Davis was the daughter of Sion Davis and Mercy (Kelton) Davis, daughter of Harris Kelton. The Davis's were undoubtedly descendants of one of the regional Davis households that settled in nearby Scituate, during the mid to late-18th century (Bartlett 1984).

Sometime in the mid-18th century following the establishment of JN 86, Consider Luther (II), progenitor of the Luther family in Rhode Island, left Swansea, Massachusetts (Luther 1976). Soon after his arrival in Johnston, he began acquiring farmland. Established farmers of the Williams, Kelton, and Davis families were undoubtedly aware of newly arrived Luthers and their descendants, and began to construct social ties with them. As the years passed, the inevitable occurred and members of the Luther family died, leaving the farm and its lands to successive generations of Luthers and their extended families. These deceased individuals were interred in one of two family burial plots established on the Luther lands: the Consider Luther Lot and the Calvin Luther Lot (JN 88).

Calvin Luther (Sr.) received title to the land on April 26, 1802 upon transfer of the property from his father Consider II (Johnston Land Evidence 3: 407–408). Over the next century and a half Calvin Luther and his descendants worked the family farm producing grain, livestock, fruit, and vegetables for the Providence and Johnston markets. As the Luther family members died, many of them were interred in the Calvin Luther family burial lot until 1890 when Henry Fenner and wife Amy R. [Luther] Fenner, granddaughter of Calvin Luther Sr., lost the farm at auction as a result of their inability to settle a series of debts (Garman et al. 2000). Following the loss of the farm, Luthers and Fenners alike removed themselves to other parts of Johnston and nearby

Scituate, Warwick, and Providence. However, despite the loss of the lands, provision was made to permit interment within the burial plot by family members, with the last documented interment occurring in 1936. Here the cemetery remained until it was evicted in 1998 for industrial purposes.

The Johnston Cemetery Project

Archaeological investigation associated with the Johnston's cemeteries relocation project involved the systematic excavation, exhumation, and bioarchaeological analysis of JN 86 and JN 88. Historical cemetery JN 88, the more recent of the two cemeteries under investigation, was situated atop a large terrace overlooking a wetland system associated with Cedar Swamp Brook to the northeast and an unnamed wetland and feeder stream to the northwest (FIG. 2). JN 88 contained eleven headstones and six footstones enclosed by a mortared stone wall. Historic documentation and archaeological investigations date the usage of JN 88 between 1854 and 1936.

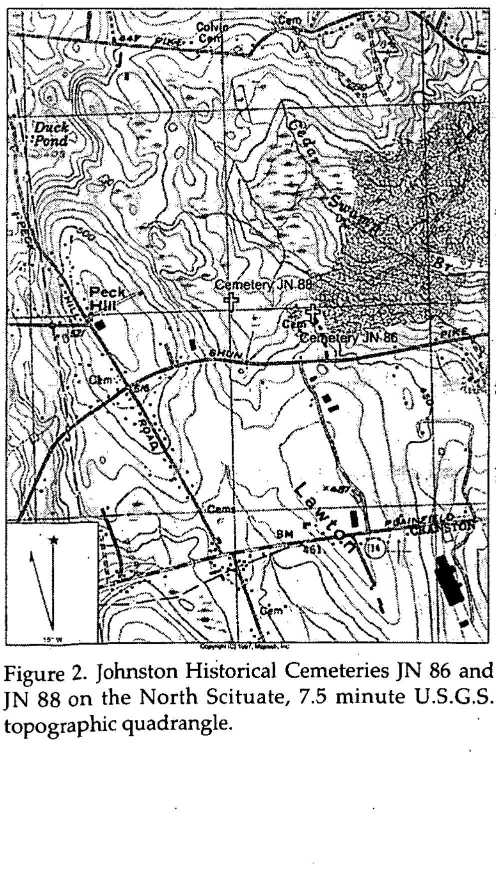


Figure 2. Johnston Historical Cemeteries JN 86 and JN 88 on the North Scituate, 7.5 minute U.S.G.S. topographic quadrangle.

Historical cemetery JN 86 was located atop a relatively level bench terrace situated north of Shun Pike Road, approximately a half mile southeast of JN 88 (FIG. 2). Historic cemetery JN 86 contained twenty-nine headstones and twenty-seven footstones (FIG. 3). A dry laid agricultural fieldstone fence marked the eastern boundary of the cemetery. The topography of JN 86 sloped noticeably from the northeast to the southwest. Historic documentation placed the cemetery's use from the early- to mid-19th century (ca. 1825–1850).

Archaeological investigation of the cemeteries commenced with photographic documentation of each of the burial areas prior to ground alteration disturbances. Each site was then prepared by removing burial monuments and marking their position with survey stakes, which maintained appropriate provenience information. Surface elevations were then taken at each gravesite relative to a site datum. Subsurface archaeological investigations commenced with the removal of topsoil by heavy machinery to expose grave shafts. All grave shafts were then mapped onto master site plans. Excavation proceeded at each burial location using clean masonry trowels, wooden sculpting tools, and dental equipment, and was limited to exposing skeletal remains and any associated artifacts within respective coffins or caskets. Skeletal elements and artifacts were then collected and transported in acid-free paper containers to PAL's facility in Pawtucket, Rhode Island for bioarchaeological analysis by Thomas Crist and Arthur Washburn of Kise, Straw, & Kolodner. The remains were later re-interred at Highland Memorial Cemetery in Johnston in a ceremony that included descendants, project proponents, friends, and archaeologists, alike.

Nineteenth-Century Burial Practices

Nineteenth-century funerary ritual involved the relatively expedient preparation of a corpse and relatively rapid interment of the deceased following his or her death. Early-19th-century interments at cemetery JN 86 revealed that the dead were wrapped in common burial shrouds, which were secured around the body by a series of copper or brass

Figure 3. View northwest of Johnston Historical Cemetery JN 86 prior to archaeological exhumation.

straight pins, prior to their placement in nondecorative plain hexagonal wooden coffins. This pattern is in marked contrast to the openly extravagant funerals and extended mourning rituals characteristic of the late-19th century.

Throughout the 19th century, crowded churchyard and family cemeteries were replaced by landscaped cemeteries with elaborate and beautifully carved monuments (Harris 1977). This cemetery movement was coincident with the newly developing sentiment regarding life and death of the Romantic Age. According to Farrell (1980: 32–33), the Romantic belief in the correspondence of God, humanity, and nature made death the ultimate communion with the universe. Changing conceptions of Heaven paralleled this sentiment with Heaven becoming viewed as a "domesticated haven" (Pike and Armstrong 1980: 17). Consequently, views of death evolved from a belief in supernatural wrathful judgment towards faith in an eventual reunion with loved ones long since passed (Pike and Armstrong 1980). This belief consoled grieving family members by assuring them that separation from their family members and friends was only temporary.

Late-19th-century mourning was a public matter with families of the deceased expected to grieve in a prescribed manner. Adherence to this prescription assured proper respect towards the deceased in the eyes of others (Farrell 1980; Pike and Armstrong 1980). Ornamentation of coffins and extravagance in caskets, as well as extensive wakes, elaborate dress, and mortuary art, became outward expressions of "appropriate" mourning. This so-called "beautification of death" phenomenon (Bell 1990, 1991; Little et al. 1992) is evident at JN 88 through the presence of decorative tombstones, ornamental caskets, and the elaborate dress for a number of the deceased. This pattern of the treatment of the deceased clearly differentiates JN 86, the earlier of the two cemeteries under investigation, from JN 88.

Historic Cemetery JN 88

Archaeological exhumation of the two historic cemeteries commenced at JN 88, the younger of the two cemeteries. Thirty burial shafts were identified and investigated at JN 88 as part of the Johnston Cemetery Project. Of these, only twenty-four actually contained human remains. The remaining six shafts were either historically emptied burial pits or mortared brick burial vaults. Burial containers

from JN 86 and JN 88 could be separated into two categories: coffins or caskets. The distinction between coffins and caskets was based upon a consideration of overall shape, construction, and the degree of burial container ornamentation.

Four hexagonal coffins were identified at JN88. Coffins were determined by a hexagonal stain in the soil, the presence of functional artifacts (nails and screws), and the relative absence of ornamental funerary artifacts. A series of cut iron nails, iron slotted wood screws, or rarely, white-metal coffin screws secured the lid to the sideboards. Lids were commonly plain but sometimes adorned with glass view plates, simple butt hinges, brass screws, and/or white-metal coffin screws and tacks. Following the introduction of the Fisk Metallic Coffin in 1848, rectangular or more decorative hexagonal caskets were adopted as preferential burial containers (Habenstein and Lamers 1955; Lang 1984). The remaining 13 burial containers from cemetery JN88 were classified as caskets. Caskets were rectangular in shape and commonly painted or varnished. Caskets were more elaborate than coffins, oftentimes adorned with plain or decorative thumbscrews and escutcheons, slotted wood screws, nails, white-metal coffin screws/tacks, handles, glass view plates, and/or coffin plates.

Preservation of Human Remains at JN 88

Skeletal preservation at JN 88 was, for the most part, exceptional. However, little other than skeletal elements, mortuary furniture, or the occasional item of personal adornment (hair pins, buttons, rings, etc.) was recovered from JN 88 (or JN 86 for that matter) with a few notable exceptions to be discussed below. Table 1 lists the criteria used to assign preservation classification. Nineteen (27%) of the individuals interred at the cemetery exhibited "good" skeletal preservation, defined as indicative of between 75–100 percent skeletons (TAB. 2). Only Burial 88-23 contained less than twenty-five percent of her skeletal elements, resulting in a "poor" skeletal classification. Detailed analyses of JN 88's subsurface physical soil characteristics, such as soil pH and sediment grain size, were not conducted since relatively good bone preservation at the cemetery precluded the need to examine intra-site variation in the degree of skeletal preservation. Therefore, data that might have been useful for comparative purposes with cemetery JN 86 (discussed below) were not collected. However, the information recorded on standardized field forms does enable preliminary assessments regarding skeletal preservation at JN 88. These assessments and impressions formed the hypotheses that were formulated and tested at cemetery JN 86.

Table 1. Criteria employed in assessing preservation class.

Preservation Classification	*Percentage of Skeletal Recovery*
Excellent	100 percent
Good	75 to 99 percent
Fair	50 to 74 percent
Poor	25 to 49 percent
Extremely Poor	0 to 24 percent

Although preservation at JN 88 was generally quite good, there was some degree of variation in preservation. In general, it appears that skeletal preservation increased with an individual's age with adults being better preserved than children. For example, Burials 88-5 (Ann M. Luther), 88-18 (Calvin L. Fenner), and 88-32 (Annie L. Fenner), representing a young child and two infants respectively, were not as well preserved as most of the adults interred at the cemetery. Many noted researchers have reported that skeletal attrition is related to bone structure and can vary with the part of the body and age of the individual at the time of death (Cruz and Elkin 2003; Lubinski 1996; Lyman 1984; and Nicholson 1996). Therefore, it is conceivable that the relatively poor preservation of some of the children's remains at JN 88 was a consequence of partial or incomplete fusion of bone elements or lower bone mass in young children as compared to adults. However, this interpretation remains hypothetical.

Apparent factors contributing to differential skeletal preservation at JN 88 include the time elapsed since burial, as well as the type of burial chamber into which the deceased were

Table 2. Johnston Historical Cemetery JN 86 burial data.

Burial	*Preservation Classification*	*Weighted pH*	*Time between burial and exhumation (years)*	*Age at death (years)*	*Soil texture*
86-1	Good	6.9	159	28	Silty coarse sand and gravel
86-2	Poor	6.7	159	6 mos.	Silty coarse sand and gravel
86-3	Good	6.7	Unknown	3 mos.	Silty coarse sand and gravel
86-4	Poor	6.7	Unknown	Unknown	Silty coarse sand and gravel
86-5	Fair	6.7	172	2	Silty medium sand and gravel
86-6	Fair	6.6	165	3	Silty medium sand and gravel
86-7	Extremely poor	6.6	Unknown	12–14 mos.	Silty medium sand and gravel
86-8	Good	6.9	153	52	Silty fine sand
86-9	Poor	6.8	Unknown	Unknown	Fine sandy silt
86-10	Excellent	6.9	165	45	Silty coarse sand and gravel
86-11	Good	6.9	151	57	Silty medium sand and gravel
86-12	Good	6.7	153	29	Silty
86-13	Fair	6.7	Unknown	30–35	Silty medium sand and gravel
86-14	Poor	6.7	Unknown	30–40	Silty fine sand
86-15	Extremely poor	6.7	Unknown	5–6	Fine sandy silt
86-16	Extremely poor	6.8	Unknown	20–30	Fine sandy silt
86-17	Extremely poor	6.8	151	73	Fine sandy silt
86-18	Extremely poor	6.9	168	58	Fine sandy silt
86-19	Poor	6.8	151	76	Fine sandy silt
86-20	Excellent	6.9	162	71	Silty coarse sand and gravel
86-21	Fair	6.8	144	85	Silty medium sand and gravel
86-22	Poor	6.5	Unknown	35–40	Silty fine sand
86-23	Poor	6.6	Unknown	20–30	Fine sandy silt
86-24	Poor	6.7	Unknown	40–50	Fine sandy silt
86-25	Poor	6.8	Unknown	Unknown	Fine sandy silt
86-26	Poor	6.5	163	57	Fine sandy silt
86-27	Fair	6.5	144	76	Fine sandy silt
86-28	Poor	6.5	164	18	Fine sandy silt
86-29	Extremely poor	6.6	Unknown	Unknown	Fine sandy silt
86-30	Poor	6.8	Unknown	40–50	Fine sandy silt
86-31	Poor	6.8	Unknown	20–30	Silty medium sand and gravel
86-32	Good	6.8	Unknown	20–30	Silty medium sand and gravel
86-34	Poor	6.7	Unknown	16–18 mos.	Silty medium sand and gravel
86-35	Good	6.8	Unknown	1.5–2	Silty medium sand and gravel
86-36	Good	6.8	Unknown	23	Silty medium sand and gravel
86-37	Fair	6.8	Unknown	70–75	Silty medium sand and gravel
86-39	Extremely poor	6.7	Unknown	40–45	Fine sandy silt
86-40	Extremely poor	6.8	Unknown	55–60	Fine sandy silt
86-41	Extremely poor	6.8	Unknown	70–75	Fine sandy silt
86-42	Poor	6.8	Unknown	16–20	Fine sandy silt
86-44	Poor	6.8	Unknown	Unknown	Fine sandy silt
86-45	Poor	6.8	Unknown	10–12 mos.	Fine sandy silt

interred. There was generally a slight decline in the degree of skeletal preservation over time at JN 88, the exception being a brief period of extraordinary preservation between the years of 1860 and 1875. This peak in preservation coincides with the period of mortared brick vault construction at JN 88. Preservation in brick vaults at JN 88 was exceptional (FIG. 4) and resulted in the recovery of rarely preserved cultural items that included clothing and dress, desiccated soft tissues and hair, and in one case even a bouquet of flowers placed atop a burial container. Preservation of this type was unequalled for any of the other interment types at JN 88 or JN 86 with evidence for mortuary dress being limited to these few examples. Brick vaults afforded corpses more protection from burrowing animals, microorganisms, and rainwater than conventional graves since they were sealed by a series of 4

to 6 mortared granite or shale slabs. Furthermore, vaults provided a pocket void of soil into which caskets and coffins were interred. Only in the case of Burial 88-8 (Edmund Cady) was preservation in a brick vault poor. In his case the mortared lid to the vault had been broken causing the slabs to fall into the burial chamber atop the coffin. With the seal broken, natural elements such as rainwater and burrowing rodents were able to penetrate the vault.

The mortared floor of the Edmund Cady's burial vault prohibited water drainage allowing acidic New England rainwater to drain through the upper soils and pool around the remains interred inside (FIG. 5). Consequently, periodic "steeping" of the remains in the acidic waters likely contributed to rapid deterioration and poor skeletal preservation of Burial 88-8. This position is supported by the observations of Nicholson (1998: 402) who noted that demineralization of bone will occur in areas where groundwater pH

Figure 4. Representative burial preservation within mortared brick vaults at Johnston Historical Cemetery JN 88.

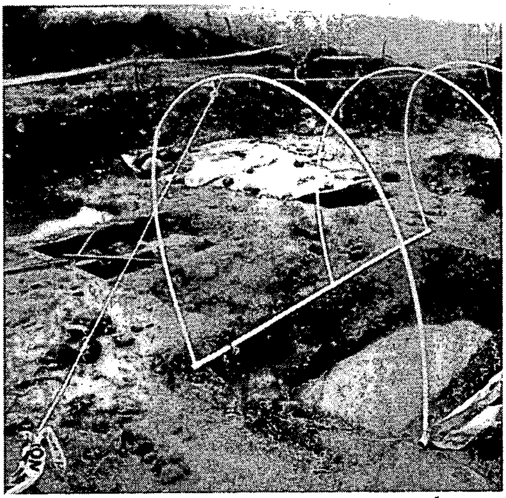


Figure 5. Water retention in a brick vault at Johnston Historical Cemetery JN 88.

falls below 6.0. The United States Geological Survey reports a weighted mean pH value of 4.6 for southern New England precipitation (USGS n.d.). Consequently, the seepage of southern New England acidic rains have certainly decreased localized groundwater pH below 6.0, likely contributing to bone demineralization in the case of Edmund Cady.

The morphology of the grave fill may also have contributed to the overall "good" preservation of skeletons at JN 88. Soils within grave shafts were composites of moderate to coarse-grained sands and stones with little silt or clay. The United States Department of Agriculture Soil Conservation Service maps the soils upon which JN 88 was located as Paxton very stony fine sandy loams. Paxton soils are extremely permeable, affording excellent drainage (Rector 1981: 29). Consequently, those individuals interred in the ground were not subjected to pooling rainwater for prolonged periods of time and hence bone demineralization.

Historical Cemetery JN 86

Experiences gleaned during data recovery investigations at JN 88 caused us to reevaluate the types of data relevant to studying human skeletal dissolution at JN 86. Perceived limitations in the JN 88 data provided a starting point from which appropriate research strategies were developed and explored at JN 86.

Unfortunately, differences in the types of data collected from JN 86 and JN 88 make comparisons difficult if not impossible between the two cemeteries. Factors investigated as contributing to skeletal preservation at JN 86 included soil acidity, soil texture and permeability, age of the individual at the time of death, elapsed time since death, type of interment, degree of slope, and bioturbation. To facilitate the statistical computations, presented below, many of these variables were transferred to ordinal scales (TAB. 2). Soil texture was determined through a comparison with a W.F. McCollough Sand-Gauge.

Data recovery exercises resulted in the identification of forty-four burial shafts at cemetery JN 86. All of the JN 86 burial containers consisted of hexagonal wooden coffins. Ornamentation was limited to coffin or brass tacks, brass wood screws, stamped coffin studs, and, in one case, white-metal handles. The lids associated with coffins were commonly flat. A series of cut nails, iron slotted wood screws, or white-metal coffin screws secured the lid to the sideboards. Oftentimes the lids were adorned with glass view plates and simple butt hinges.

Of the forty-four burial shafts investigated at JN 86, forty-two actually contained human remains. The two vacant burials consisted of a grave shaft that had been excavated but never used and a historically exhumed individual. The entire range of skeletal preservation from "excellent" to "extremely poor" was witnessed at JN 86 (FIG. 6 & 7). Overall skeletal preservation at JN 86 was much worse than at cemetery JN 88. Twenty-six (62%) of the individuals interred at JN 86 exhibited either "poor" or "extremely poor" skeletal preservation, measured by recovery of less than 25% of the skeletal elements. Although "shades" of the former skeleton were apparent in many cases, very little in terms of actual bone were oftentimes preserved (FIG. 7). Eight of the burials, (19%) at JN 86, maintained "good" preservation while six (14%) exhibited "fair" skeletal preservation. Burials 86-10 and 86-20 exhibited "excellent" skeletal preservation at JN 86. One-hundred percent of the skeletal elements of these two individuals, including normally absent elements such as the hyoid, was recovered.

Figure 6. Representative "excellent" preservation at Johnston Historical Cemetery JN 86 (Burial 86-20).

Preservation of skeletal remains at JN 86 appeared to be non-random. The best-preserved skeletons were located in the northern limits of the cemetery, with a clear demarcation between the better and poorly preserved individuals near the approximate center of the cemetery (FIG. 8). Age of deceased at their respective times of death and the length of time since burial were considered as factors contributing to skeletal preservation at JN 86. A chi-square test using the JN 86 data suggests no significant statistical relationship between

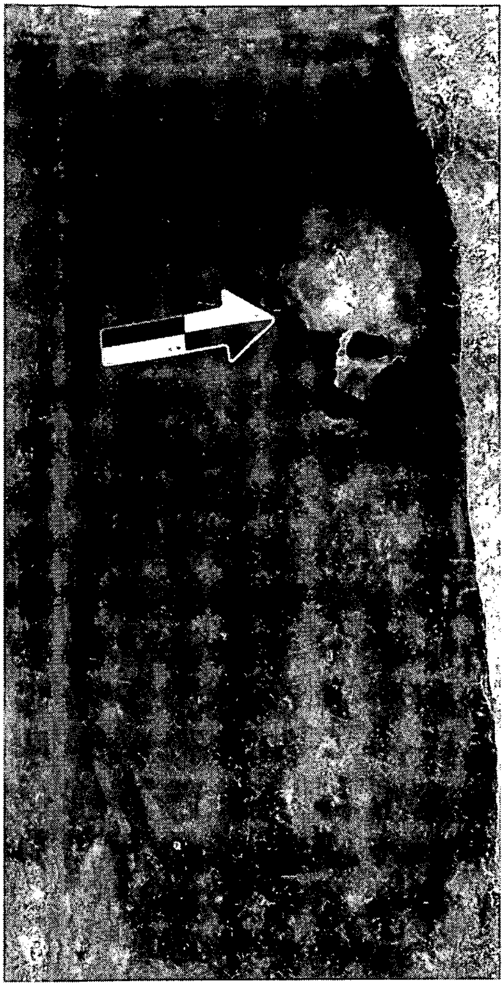


Figure 7. Representative "poor" preservation at Johnston Historical Cemetery JN 86 (Burial 86-14).

the age of the individual at the time of death and the degree of skeletal preservation at JN 86 (X^2=*13.845*, *df* 16, *p*= .610).

Infants, children, and adults were equally represented in all stages of skeletal preservation. The only noticeable exception was that the two "excellently" preserved individuals at JN 86 were adults. Similarly, a chi-square test comparing the time elapsed since interment with the degree of skeletal preservation at JN 86 indicates that time since burial also did not affect preservation at JN 86, at least to any marked degree (X^2=43.333, *df* 36, *p*= .187).

There was some variation in the ways that the deceased were interred at JN 86. For example, most of the coffins interred at JN 86 were placed directly into the ground. However, archaeological excavation demonstrated that others were interred into wooden "rough" or shoring boxes, which in turn were interred in the grave shafts. Shoring boxes were typically of simple nail and wood construction. Shoring or rough boxes may represent precursors of the more elaborate and sound brick burial vaults witnessed at JN 88. Known dates of death for three of the individuals interred in rough boxes fix their occurrence at JN 86 between 1845 and 1847. I therefore elected to test the relationship between skeletal preservation at JN 86 versus the method of interment. The chi-square results comparing the type of interment with the degree of skeletal preservation suggests no statistical relationship between method of interment and skeletal preservation at the cemetery (X^2=*4.936*, *df* 4.0, *p*= .294). However, these conclusions are limited in interpretive strength given the extremely small sample size considered in the calculations.

Studies have shown that high soil acidity contributes to the dissolution of bone (Linse 1992; Lubinski 1996; Nicholson 1996, 1998; White and Hannus 1983). Accordingly, I elected to examine the relationship between soil acidity and the degree of skeletal preservation at JN 86, testing the long-held assumption that relatively rapid deterioration of bone in New England is causally linked to regional soil acidity. Twenty-two soil pH samples were collected from three linear transects across the cemetery. JN 86 soil pH, measured using a Rapitest handheld pH meter, demonstrated surprisingly neutral soil pH levels ranging from 6.9 to 6.5. These results were unexpected considering the Soil Conservation Service describes the soils into which the burials associated with JN 86 were interred were strongly to moderately acidic (Rector 1981). Following pH diagnosis, a weighted pH value was obtained for each burial location by weighting and averaging the pH values of all surrounding soil samples. The degree of weighting was directly proportional to a collected sample's distance from each burial

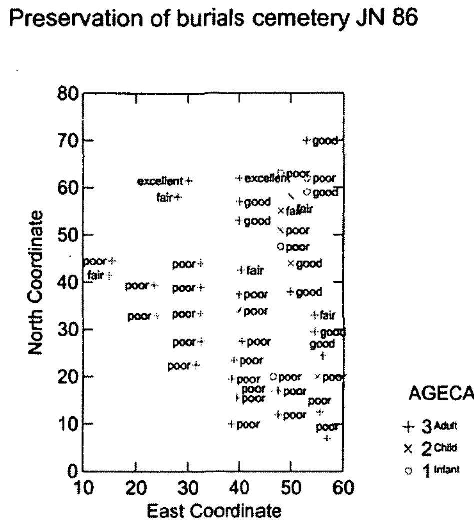


Figure 8. Degree of skeletal preservation across Johnston Historical Cemetery JN 86.

shaft. A chi-square test examining the strength of the relationship between weighted soil pH and the degree of skeletal preservation at JN 86 suggests a tenuous relationship between burial preservation and soil pH (*X^2=24.822, df* 16, *p*= .072).

The result however is not robust at a 95% confidence level suggesting that other factors, in combination with localized soil pH, undoubtedly contributed to skeletal degradation and thus preservation at JN 86.

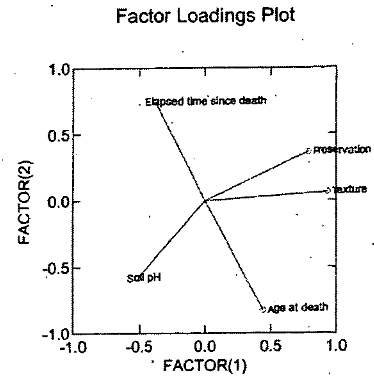
Doran and Dickel (1988: 273) note "rapid burial and burial below the water table would ensure the chemical preservation of the burial remains as well as the physical protection from scavengers." Although burials within portions of JN 86 appear to have been periodically inundated, fluctuations between wet and dry conditions were apparently detrimental to skeletal preservation within the cemetery. Both Bisel (1988) and Behrensmeyer (1978) note that highly fluctuating environmental conditions contributed to rapid bone decay at Herculaneum and in Kenya, respectively. Extraordinary preservation of corpses in wet environs, such as those in the bogs of northern and western Europe and from peat deposits in south-central Florida, result from "exceptional circumstances" that according to Coles (1988: 223–224) include: 1) the deposition of bodies in oxygen deficient waters deep enough to prevent assault by organisms; 2) water pools with enough tannic acid to tan the outer layers of the body; and 3) water temperature cool enough to refrigerate the body preventing decay and rot. None of these criteria were met at JN 86.

The southern limits of JN 86 exhibited the poorest preservation. This area is topographically the lowest point in the site, contains the highest degree of rodent disturbance, and exhibits the poorest drainage. Soils in the low-lying areas of the cemetery were finely textured, composed primarily of very fine silts and clays with very little fine sand, whereas soils in the highest areas consisted of silty very coarse sands with gravel. The distribution of sediment grain size across the site reflects the site's geological history on a highly localized scale, with the finer sediments having been transported or migrating down slope. Differential elevations resulted in the transportation of less permeable fine sediments down slope and a lag of more permeable better-drained sediments upslope. A Chi-square test was performed examining the strength of the relationship between soil texture and bone preservation at JN 86. The results indicate a perfect statistical relationship supporting the conclusion that preservation at JN 86 was related to soil texture, and that skeletal preservation was best in areas of coarser, more permeable, and thus better-drained sediments (*X^2=37.098, df* 12, *p*=0). These results are very robust indicating that soil texture and skeletal preservation at JN 86 are causally related.

It can be surmised that decreased soil permeability in the southern half of the cemetery prevented rapid rainwater drainage resulting in the repeated temporary inundation of burials. This very phenomenon was witnessed during the archaeological investigation of JN 86 when frequent rainstorms resulted in the pooling and slow drainage of rainwater in the cemetery's western limits. The weighted mean pH of 4.6 for southern New England precipitation reported by the United States

Geological Survey (USGS n.d.) is markedly more acidic than localized JN 86 soil pH. Consequently, those bodies inundated for the longest durations by acidic rainwater were readily demineralized and degraded more rapidly than other interments within the cemetery. Soil permeability and the duration in which skeletons were exposed to acid rainwater appear to have been correlated phenomena contributing to skeletal dissolution at JN 86.

Nicholson (1996: 529) concluded in her seven year study of bone degradation in a compost heap that "the critical mode of degradation at least in the early stages of bone disintegration is microbiological." Therefore, it was expected that animal and microorganism activity contributed to bone degradation at JN 86. The southern limits of the cemetery, which coincided with the poorest skeletal preservation and with the finest site area sediments, exhibited the highest degree of bioturbation. Burrowing animals more easily penetrated these fine soils than the coarser, less cohesive sandy and rocky sediments upslope within the cemetery. McBrearty (1990) reports that termite activity in African sediments contributed to alteration of localized soil chemistry increasing acidity and accelerating the chemical weathering of bone. She notes that "the import of vegetable matter and water raises the organic activity in the nest, and the warm and moist conditions favour high levels of microbial activity" increasing localized acidity (McBrearty 1990: 123). Although similar experiments have not been conducted for southern New England faunal or insect activity, similar changes in localized soil chemistry would be expected in areas of extensive rodent tunneling, burrowing, and nesting at JN 86. Biological activity is expected to have accelerated bone dissolution within such impacted portions of cemetery JN 86. Thus, factors such as elevation, sediment type, and rodent disturbance, although seemingly independent measures, may in fact have been inextricably linked variables contributing to differential skeletal preservation at JN 86.



Component loadings

FACTOR	1	2
Preservation	0.786	0.366
pH	-0.511	-0.584
Elapsed time since death	-0.375	0.747
Age at death	0.441	-0.827
Soil Texture	0.935	0.063

Variance Explained by Components

FACTOR 1	2.088
FACTOR 2	1.720

Percent of Total Variance Explained

FACTOR 1	41.763
FACTOR 2	34.406

Figure 9. Factor loadings plot derived from a Principle Components Analysis of the variables contributing to bone dissolution at Johnston Historical Cemetery JN 86.

Determining which variables contributed most to skeletal dissolution at JN 86 was accomplished using a Principle Components Analysis (PCA). A Factor Loadings Plot produced during the PCA demonstrates a strong correlation between soil texture and bone preservation at JN 86 (FIG. 9). This is not surprising considering the highly significant relationship between bone preservation and soil texture elucidated through the Chi-square test. In fact, Factor '1' calculated during a Principle Components Analysis "explains" 41.763% of the total variance in skeletal preservation at JN 86. Unsurprisingly, Factor '1' includes the texture variable. Factor '2' computed during the PCA contributes to 34.406% of the variance in skeletal preservation witnessed at JN 86. Factor '2' includes both the age of the individual at death and soil pH variables. Thus, factors considered during the course of this study accounted for over 76% of the total variance in skeletal preservation at JN 86.

Conclusion

The variables contributing to skeletal preservation at Johnston Historic Cemeteries JN 88 and JN 86 include soil pH, sediment texture and soil permeability, age of individual at the time of death, interment type, time elapsed since burial, and access of the elements, animals, and microorganisms to the interred remains. All of these factors contributed to skeletal preservation or deterioration at the two cemeteries under investigation, though to different degrees. Interestingly enough, soil pH does not appear to have been the overriding factor influencing bone deterioration at JN 86, contrary to popular belief in New England. Soil texture and permeability appear to have contributed to the excellent preservation of human skeletal elements in the sandier, better-drained sediments of JN 86. Surprisingly, time elapsed since burial does not appear to have markedly affected bone degradation at either of the cemeteries. The results of this study echo the observations of Nicholson (1996, 1998) that post-burial deterioration of buried bone is a complex interplay of multiple variables, and that the taphonomic processes influencing bone preservation and rate of dissolution in the Northeast is related to micro- and macro-regional environmental factors. Thus, the degree of preservation at each Northeastern archaeological site must be studied and understood within its own specific context. Consequently, general uniformities that may explain the taphonomic destruction of buried bone for all sites in a region may remain elusive.

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