ABSTRACT

Michell J. Gilman. LAKE PHELPS DUGOUT LOG CANOES: CONSERVATION, RETREATMENT, AND PUBLIC DISPLAY. (Under the direction of Dr. Charles R. Ewen) Department of Anthropology, December 2015.

During the latter part of the 1980s, nearly thirty prehistoric dugout log canoes were discovered at Lake Phelps, in eastern North Carolina. Of those reported, four of these canoes were retrieved and conserved with a sugar solution while the rest were left *in situ*. Two of the canoes were stored and displayed at the Information Center at Pettigrew State Park located near the lake. The environment in which they were stored was not conducive for their long-term storage and display, and over time, crystallized surface deposits developed, contributing to their further degradation. They were relocated to the East Carolina University (ECU) West Research campus under the management of North Carolina Department of Cultural Resources Underwater Archaeology Branch (NCDCR UAB) for analyses and stabilization until they could be re-conserved. In fall 2014, a formal study was developed focusing on their re-conservation and eventual return to their "home" at Pettigrew State Park. Several chemical and mechanical conservation techniques were tested and results indicated further trials would be beneficial. While collaborating with conservators how to best proceed with this study, a misting technique modelled after the ultrasonic misting method was developed. Ultrasonic misting was developed as a way to consolidate artworks and other artifacts where unstable pigment was present and had not been previously tested to conserve wooden artifacts where crystallized sugars had leached onto the surface. The technique developed in this study was tested and shown to substantially improve the condition of the wooden objects used for testing. Further improvement and testing of this technique could add to conservators' selection of techniques for those wishing to conserve objects such as those presented in this thesis.

LAKE PHELPS DUGOUT LOG CANOES: CONSERVATION, RETREATMENT, AND PUBLIC DISPLAY

A Thesis

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by

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The agencies who took part in this project are East Carolina University Department of Anthropology; East Carolina University Department of History; East Carolina University Department of Biology; East Carolina University Department of Physics; North Carolina Department of Cultural Resources Underwater Archaeology Branch; Queen Anne's Revenge Laboratory; and the National Park Service at Pettigrew State Park.

Finally, thank you to my family and friends who have supported me in so many ways ever since I began this journey a little more than two years ago

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CHAPTER 1: INTRODUCTION

Two prehistoric dugout log canoes discovered in 1986 were in desperate need of conservation in order to be displayed for the public once again. Both canoes had been previously displayed at the Information Center located at Pettigrew State Park; however, the uncontrolled environment (extreme variations in temperature and humidity) in which they were located was not conducive to their long-term display and storage. The environment contributed to the current condition of the artifacts where crystallized sugars, from a previous attempt at conservation formed on the surface of all of the wooden fragments. In 2011, both canoes were transported to their current location at the East Carolina University (ECU) West Research Campus in Greenville, North Carolina. They were stored in a controlled environment, awaiting retreatment.

The artifacts presented in this study are two (PHL0003 and PHL0004) of four prehistoric dugout log canoes retrieved from Phelps Lake, Creswell, NC (Figure 1) (site numbers 31WH13 and 31WH12, respectively; however, the site is usually referred to as 31WH12) adjacent to Pettigrew State Park in Eastern North Carolina (Figure 2). Twenty-six prehistoric canoes were left *in situ* at Lake Phelps.

The primary purpose of this project was to learn what conservation technique(s) can be used to re-conserve and stabilize the canoes, and to determine the best environmental conditions that would allow for long-term storage, research, and display of both canoes. This thesis will provide a framework for how future conservation projects might proceed should additional canoes be retrieved from the lake or the remaining canoes that were previously conserved need re-conservation treatments. After discussions and collaboration with ECU faculty (Dr. Charles Ewen and Susanne Grieve) and the North Carolina Department of Cultural Resources Underwater Archaeology Branch (NCDCR UAB) staff (Sarah Watkins-Kenney), there was the potential for transforming this project beyond the experimental stages of conservation treatment methods.

Although this research focuses on conservation, it would be unjust to ignore other contexts these artifacts represent. These artifacts are important to the fields of anthropology, archaeology, and conservation for several reasons. First, people who once inhabited the Lake Phelps, NC region built these artifacts. They provide modern scholars as well as the interested public the opportunity to have a better understanding about the culture of these former inhabitants. Second, they were discovered and archaeologically excavated in modern times, and, in a sense, represent two "histories." They were excavated and conserved using accepted archaeological and conservation methods of the time and therefore provide a reflection of how technologies have (or have not) changed since their retrieval. Third, once they are returned and displayed for the public once again, they provide a sense of "tangibility" that can encourage further interest, research, and education about the human past in eastern North Carolina as well as current and developing scientific methods in archaeological conservation.

This study focuses on the re-conservation of two canoes retrieved from the lake; however, it is important to provide a discussion of the events that led them to their current location. Chapter 2 presents the context of the discovery, excavation, and conservation of these artifacts. Presenting an historical background of the artifacts not only adds to existing research and documentation, but it makes available, for those interested, an opportunity to appreciate the motivation, dedication, and expertise of the many individuals whom have had some level of involvement with the "Phelps Canoes" as they are affectionately known. The bulk of the information regarding the timeline of these artifacts and their initial conservation is derived from in-house reports, timeline notes, internet reports, and database documentation.

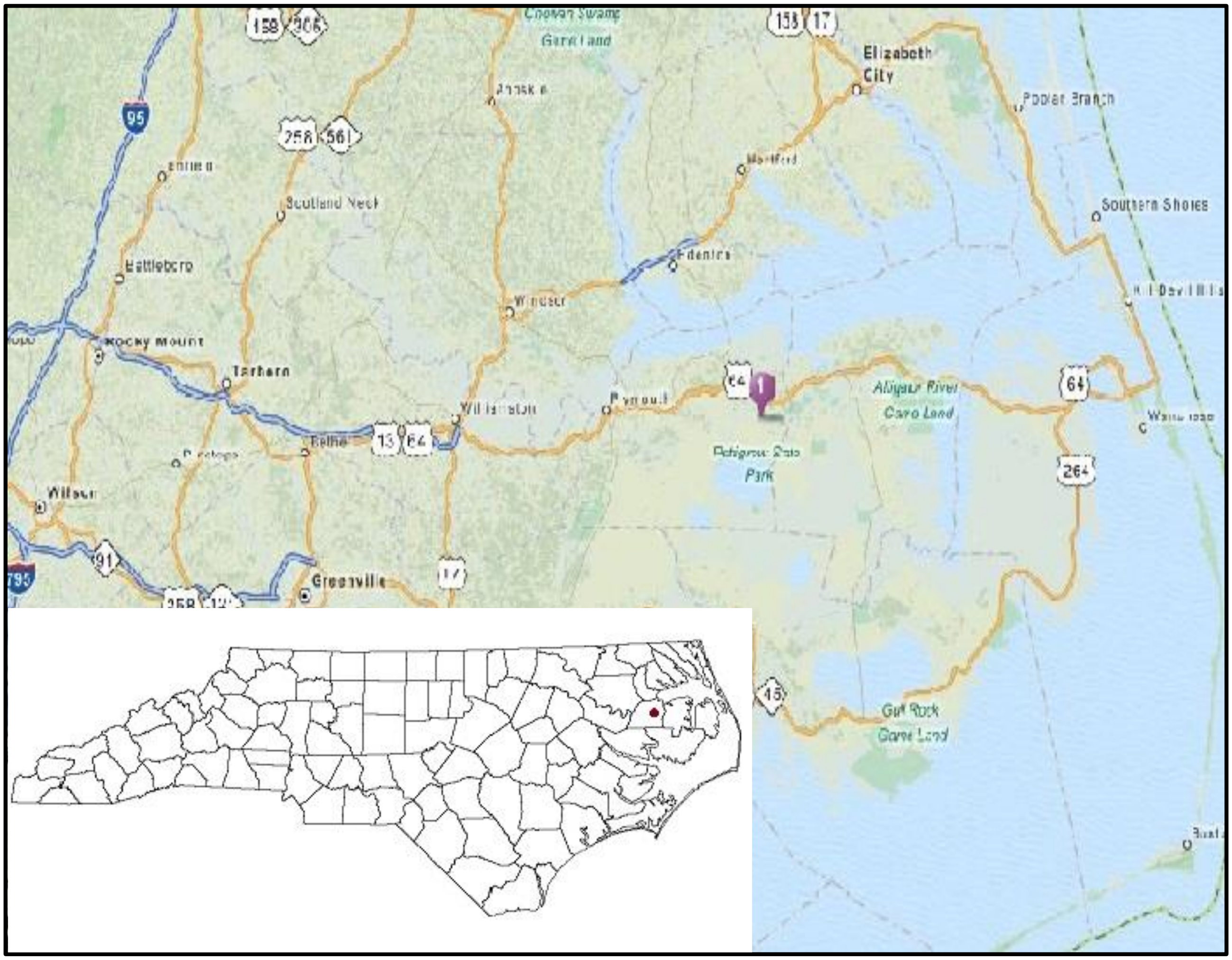


Figure 1: Location of Lake Phelps, North Carolina (Google Maps 2015; University of Alabama 2015).

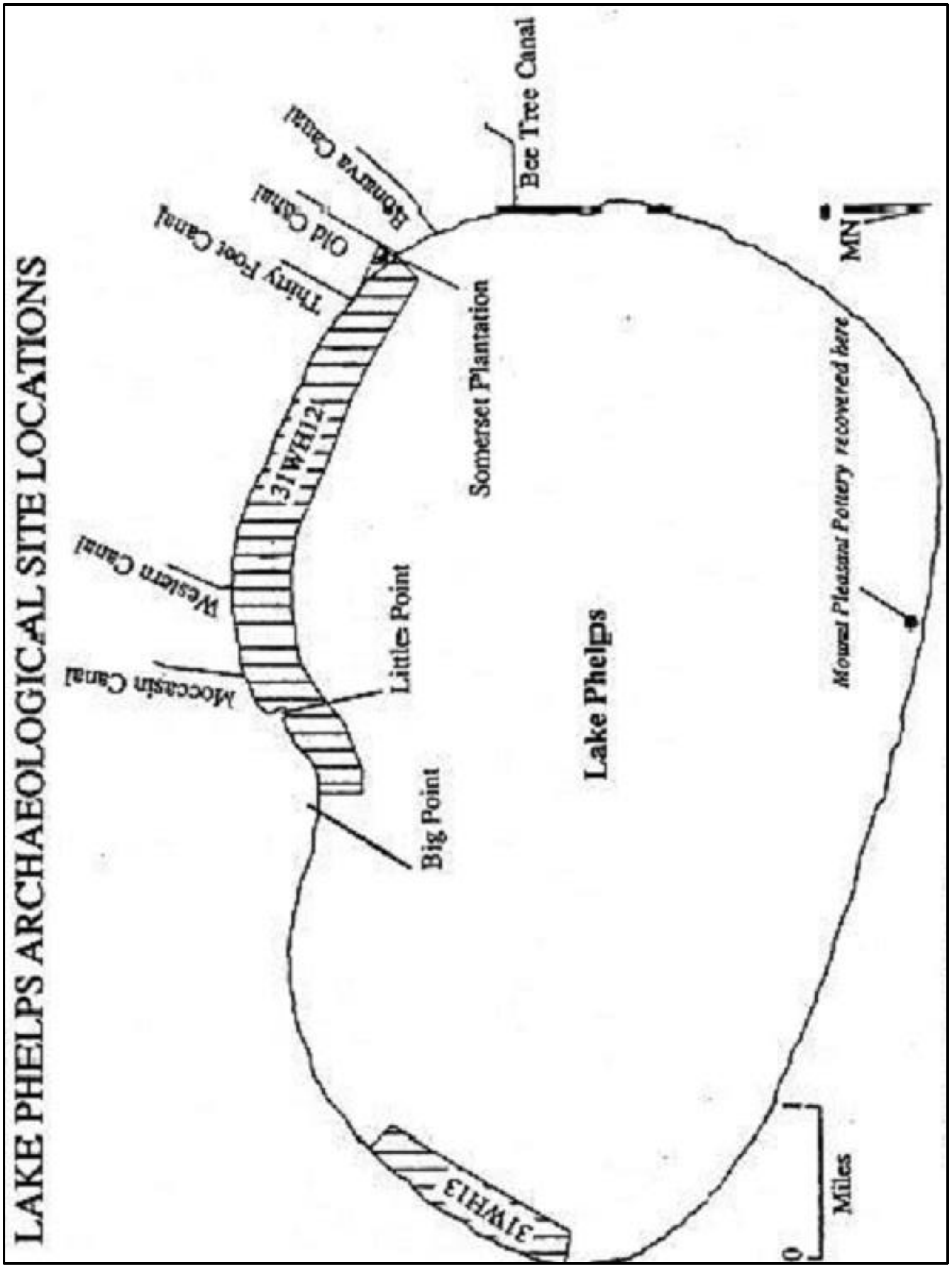


Figure 2. Location of the Lake Phelps archaeological site locations (Holley 1989; Shomette 1993).

Chapter 3, will discuss the environmental and cultural contexts in which these artifacts were found. The number of canoes found and the remarkable condition in which they remain is a result of the environmental conditions of the lake itself. Thirty canoes have been documented, 19 of which were radiocarbon dated (Beta Analytic Inc 1987; Eastman 1994; Phelps 1989; Pierce 2010; Watkins-Kenney 2008). Many of the canoes are in fragments as in the case of the two discussed in this thesis, while a few remain intact. While radiocarbon dating places the entirety of the collection into the age range of 2400 BC through AD 1400, Canoe 3 and Canoe 4 represent the Middle and Late Woodland periods of eastern North Carolina, respectively (Phelps 1989; Pierce 2010; Watkins-Kenney 2008). A discussion of these cultural contexts will help to understand the cultural history in which these canoes represent.

Chapter 4 will present the theoretical applications that will assist in providing an appreciation for the foundations from which conservation of archaeological materials is conducted and reflect upon reasons archaeologists preserve material culture. Chapter 5 begins the discussion of the conservation retreatment of the canoes by first describing the structure of wood, the chemical changes in waterlogged wood that occur during initial treatment processes, and the chemical composition of the surface deposits that have formed on these artifacts. Additionally, it presents the details of previous analyses and reports of the canoes since their relocation to the ECU West Research Campus. The methodology used for mechanical and chemical conservation techniques in initial trials and scanning electron microscope (SEM) analysis will be discussed in addition to the treatment determined to be successful for re-conservation treatment of the canoes. In Chapter 6, the results of the "misting" application are presented and identifies that further trials should be done in order to re-conserve the most fragile wooden fragments where surface deposits are "caked."

Chapter 7 concludes this thesis with a summary of this project then discusses the importance of these artifacts within the context of public archaeology, explaining their archaeological relevance, and finally discusses how approaches used here might benefit future conservation undertakings.

CHAPTER 2: HISTORICAL BACKGROUND

During a period of drought in the latter half of the 1980s, thirty dugout log canoes were discovered and reported at Lake Phelps, located at Pettigrew State Park in Eastern North Carolina (site number 31WH12). Of those thirty canoes, four were recovered and in 2011, two were transported to the East Carolina University (ECU) West Research Campus in Greenville, North Carolina. They are under the management of the North Carolina Department of Cultural Resources Underwater Archaeology Branch (NCDCR UAB), and were sent to ECU for retreatment and eventually to be returned to Pettigrew State Park for storage and public display. These canoes have been documented and referred to in the following ways: their site number (0003PHL or PHL0003 and 0004PHL or PHL0004); LP 3 and LP 4; the Butler Canoe and Pond Canoe, respectively; and more commonly Canoe 3 and Canoe 4 (Gilman 2014; Hauck 2011; North Carolina Department of Cultural Resources Underwater Archaeology Branch [NCDCR UAB] Greenville, NC 2014: Queen Anne's Revenge Laboratory database [QAR DB]; Johnston 2007; Phelps 1989; Shomette 1993; Watkins-Kenney 2008). They will be referred to as Canoe 3 and Canoe 4 throughout this document for the sake of clarity.

These artifacts were recovered in 1986 and subsequently received sucrose solution treatments to stabilize and prevent their further degradation. Sucrose solution treatments were a relatively new method for treating waterlogged wooden artifacts at this time and the methods employed were based on the results and recommendations of Parrent's (1985) study where results showed sucrose solution to be a viable bulking agent to conserve waterlogged wood. Parrent (1985:71) recommended preparing a low sucrose solution of 1% - 5% w/v, adding a biocide to prevent microbial growth, and then increase sucrose incrementally to a 50% solution. If necessary, an insecticide should be added and monitoring should be conducted throughout the treatment process. Once the wood reaches an "equilibrium with the highest solution desired" the objects should be removed from the solution and slowly air-dried within a controlled high humidity environment, gradually decreasing the humidity to less than 70% for storage conditions. Bright (1987) describes how the Lake Phelps canoes were conserved with sucrose.

> The canoes were placed in 15 gallons of water, with sugar added to form a 20 percent solution by weight. Sugar was added weekly at the rate of 10 percent by weight until a 100 percent solution by weight was reached. One pint of phenol was added to the solution at the beginning of treatment to prevent fermentation. To conserve sugar and cut cost, the canoes and solution were sealed between two pieces of 6-mil polyethylene film in the preserving tank. This was accomplished by filling the tank approximately half full of water, covering it with polyethylene film, and putting the canoe and solution on top. After the second layer of polyethylene film was placed over the canoe, the tank was completely filled with water. This squeezed out air bubbles, allowing the sugar solution to completely envelop the canoe. This phase lasted 9 weeks.
>
> The fragments first recovered were allowed to dry inside the laboratory at ambient temperature and humidity [Bright 1987:90].

It is important to describe the details of how Canoe 3 and Canoe 4 were conserved because it will help to clarify their conservation history, although documentation of the methods used for these canoes differs from those presented by Bright (1987) above. Canoe 3 had been stored dry and Canoe 4 had recently been removed from the pond where it was kept and cleaned. Both canoes were put into a large tank of 50% sucrose solution where the large, intact, 30-foot canoe had just been removed on August 7, 1986 (Johnston 2007:4; Lawrence 1986). The canoes remained in the sucrose solution until October 24, 1986 (Lawrence 1986). Documents do not specify the posttreatment drying conditions. Sometime during March 1987, the canoes were transported to the preservation office in Fort Fisher, NC where one of the canoes (documents do not specify which) was given a treatment of polyethylene glycol (PEG) and allowed to dry on a rack that was constructed to support them (Johnston 2007:7). Documentation is unclear as to when and under what circumstances the canoes were returned to Pettigrew State Park, but they were on display for "Indian Heritage Days" by September 1987 (Johnston 2007:8).

After receiving conservation treatments, both canoes were put on display at the Information Center at Pettigrew State Park where environmental conditions varied in extreme changes in temperature and humidity, and were not conducive to their long-term storage. Over time, crystallized surface deposits became manifest on their surface (NCDCR UAB 2014: QAR DB; Watkins-Kenney 2008). Although utilizing sucrose to "stabilize" wood was not a new concept at the time the canoes were treated, there were no extensive studies or publications concerning the use of sucrose to conserve waterlogged wood. Furthermore, it was not fully understood as to how environmental conditions might affect wooden objects treated with sucrose for long-term storage and display (Parrent 1985).

In 2011, both canoes were moved to an environmentally controlled room where the relative humidity (RH) is kept at around 50% - 55%. All of the wooden fragments of both canoes had a white or brown, crystalline-like substance on their surface that could be viewed without the aid of magnification. Canoe 3 was observably in better condition than Canoe 4, presumably due to the difference in their age. These artifacts were in such a fragile state that conservation retreatment was necessary for their long-term storage and display for public viewing. Two premises of archaeological conservation are that conservation methods should limit any damage to objects and they should be reversible so that when technological advances within the field occur, they might be applied to previously conserved objects (American Institute for Conservation of Historic and Artistic Works [AIC] 2015; Cronyn 1990; Sease 1998).

Previous Archaeology

Archaeological research of Lake Phelps concerning the dugout log canoes has been, and remains, a collaboration of work between East Carolina University (ECU), North Carolina Department of Cultural Resources Underwater Archaeology Branch (NCDCR UAB), and Pettigrew State Park that includes professionals and graduate students. The late Dr. David S. Phelps from the ECU Department of Anthropology, state archaeologists, and conservators from the NCDCR UAB coordinated much of the fieldwork at the lake; however, the site and artifacts are currently under the management and care of the NCDCR UAB and Pettigrew State Park. Until the discovery of the canoes, the archaeological research of the lake was concentrated on a nearby historic period plantation, Somerset Place (Pierce 2010).

As has been previously stated, these dugout log canoes were discovered due to unusually low water levels of Lake Phelps (Phelps 1989; Pierce 2010; Shomette 1993; Watkins-Kenney 2008). During 1984, water was pumped from the lake to fight a nearby forest fire, and a drought the following year further lowered the water level. It was the discovery of the first canoe in November 1985 and subsequent discoveries of many canoes that seem to have spurred an interest in the archaeological potential of the region (Phelps 1989; Shomette 1993). According to Phelps (1989:1), it is the largest collection of dugout log canoes "in the southeastern United States still in association with the sites where they were manufactured and used."

Thirty canoes have been located and 19 radiocarbon dated (Beta Analytic Inc 1987; Beta Analytic Inc 1988; Eastman 1994; Phelps 1989; Shomette 1993; Watkins-Kenney 2008). Four canoes were retrieved from the lake for preservation in 1986 (Johnston 2007; Lawrence 1986; Shearin 1986;

Watkins-Kenny 2008). Some of the canoes were found intact and, some in fragments, as is the case with the canoes presented in this thesis. Canoe 3 is in four fragments and Canoe 4 is in eleven fragments. The canoes that were radiocarbon dated range in age from 2430 BC to AD 1400; Canoe 3 was dated to 550 + / - 60 BP (AD 1400) and Canoe 4 dated to 1610 + / - 60 BP (AD 340) (Beta Analytic Inc 1987; Beta Analytic Inc 1988; Eastman 1994; Phelps 1989; Shomette 1993; Watkins-Kenney 2008). Figure 3 provides a visual interpretation of the cultural sequence for the lake. The canoes left *in situ* were excavated, their measurements and location documented, then reburied (Curci 2006).The sites of the canoe locations are distributed along the northern and northwestern shores of the lake (Phelps 1989; Shomette 1993; Watkins-Kenney 2008), some in association with pottery sherds from the Woodland periods of the North Carolina Coastal Plain (Phelps 1989).

Canoe 3 (Figure 4) was found on the property of Michael Butler located nearby Pettigrew State Park, retrieved June 1986, and stored dry at the Furlow House (presumably a storage building located on the premises of Pettigrew State Park) (Lawrence 1986; Johnston 2007; Shearin 1986; Watkins-Kenney 2008). Canoe 4 (Figure 5) was found "sitting out of water near "wind easements" and "put into Elwood Barnes' pond" June 1986 (Shearin 1986:1). It was removed from the pond and cleaned in August 1986. File notes state that worms had considerably damaged the surface, but do not specify the species (Lawrence 1986). It is more likely the damage was caused by wood-boring insect larvae, as this is often the case in circumstances where waterlogged wood is subject to biological deterioration (see A. Unger, Schniewind, and W. Unger 2001). The conservation treatment for both canoes began in August 1986.

Although interest in the archaeology of the area grew with the discoveries of the canoes and pottery in the lake, further fieldwork has been limited to monitoring of those left *in situ* (Curci 2006; Pierce 2010). While the discovery of these artifacts adds to the archaeological record, helping us to better understand the cultural history of the region prior to European contact, future archaeological investigations could answer questions that arose because of the discovery of these canoes. For example, the pottery, lithic artifacts, and canoes suggest the lake has been used by a past people spanning at least 11,000 years, but no direct links have been established connecting these artifacts to known permanent settlements, suggesting this site was used seasonally (Phelps 1989). As of 2015, an extensive study of the lake and the region has yet to be done.

Previous Conservation

The conservation process of the canoes began August 1986. Canoe 3 was removed from the Furlow House where it was being stored dry, and Canoe 4 removed from the pond and placed into the 50% sugar (sucrose) solution left over from the 30-foot canoe (presumably Canoe 2/PHL0002) that had just been removed from treatment (Johnston 2007; Lawrence 1986; Shearin 1986; Watkins-Kenney 1986). Canoe 3 is in four fragments, Canoe 4 is in eleven fragments. Sketches were constructed of both canoes illustrating the location and measurements of each fragment prior to this study (see Figures 3 and 4). Table 1 provides a size comparison of the canoes and Tables 3 and 4 provide the measurements of each fragment. Detailed measurements and weights for each fragment are documented in the QAR database (see NCDCR UAB Greenville, NC 2014: QAR DB).

Table 1. A comparison of the size of the canoes

Canoe	Maximum Width (inches)	Maximum Height (inches)	Total Length (all fragments combined in inches)	Total Weight (all fragments combined in kilograms)
Canoe 3	22 7/8	14	148 1/2	25.74
Canoe 4	23 1/4	16	201 1/2	42.6

Table 2. Canoe 3 fragment measurements in inches

LP 3/1	LP 3/2	LP 3/3	LP 3/4
37 1/2 x 17 1/8	48 3/4 x 16 1/8	62 1/4 x 22 7/8	20 7/8 x 6 7/16

Table 3. Canoe 4 fragment measurements in inches

LP 4/1	LP 4/2	LP 4/3	LP 4/4	LP 4/5	LP 4/6	LP 4/7	LP 4/8	LP 4/9	LP 4/10	LP 4/11
59 x 22	11 x 2 1/2	29 x 7 1/2	46 1/2 x 23 1/4	62 x 22	3 x 1 1/4 x 1	17 1/4 x 3 x 2 1/2	8 x 4 1/4 x 3	34 x 9	29 1/2 x 12 1/2	17 x 3 1/2 x 5

Both canoes were removed from the sugar (sucrose) solution in October 1986 and stored at the Furlow House until March 1987 when they were transported to the state preservation office at Fort Fisher for further storage and treatment. One of the canoes apparently received a treatment of polyethylene glycol (PEG), but records do not identify which one. Both canoes were returned to Pettigrew State Park September 1987. Documentation is unclear, but the canoes were apparently stored and displayed at the Information Center (which has since been demolished) at the park sometime during 1990 (Watkins-Kenney 2008).

In 2007, the NCDCR UAB staff and conservators examined both canoes at Pettigrew State Park due to reports of white and brownish surface deposits developing on the wooden fragments, predominantly on the Canoe 4 fragments. Canoe 3 is visibly in much better condition than Canoe 4 (see Figures 5 and 6). The Information Center, where they had been stored and displayed was not a controlled environment. Extreme variations in humidity due to North Carolina climate patterns and varying degrees of exposure to natural sunlight have contributed to their degradation. In 2011, both canoes were relocated to their current location at the ECU West Research Campus under the management of the NCDCR UAB staff and stored in an environmentally controlled room (see Figures 7 and 8) where they have been awaiting re-conservation (NCDCR UAB Greenville, NC 2014: QAR DB; Watkins-Kenney 2008).

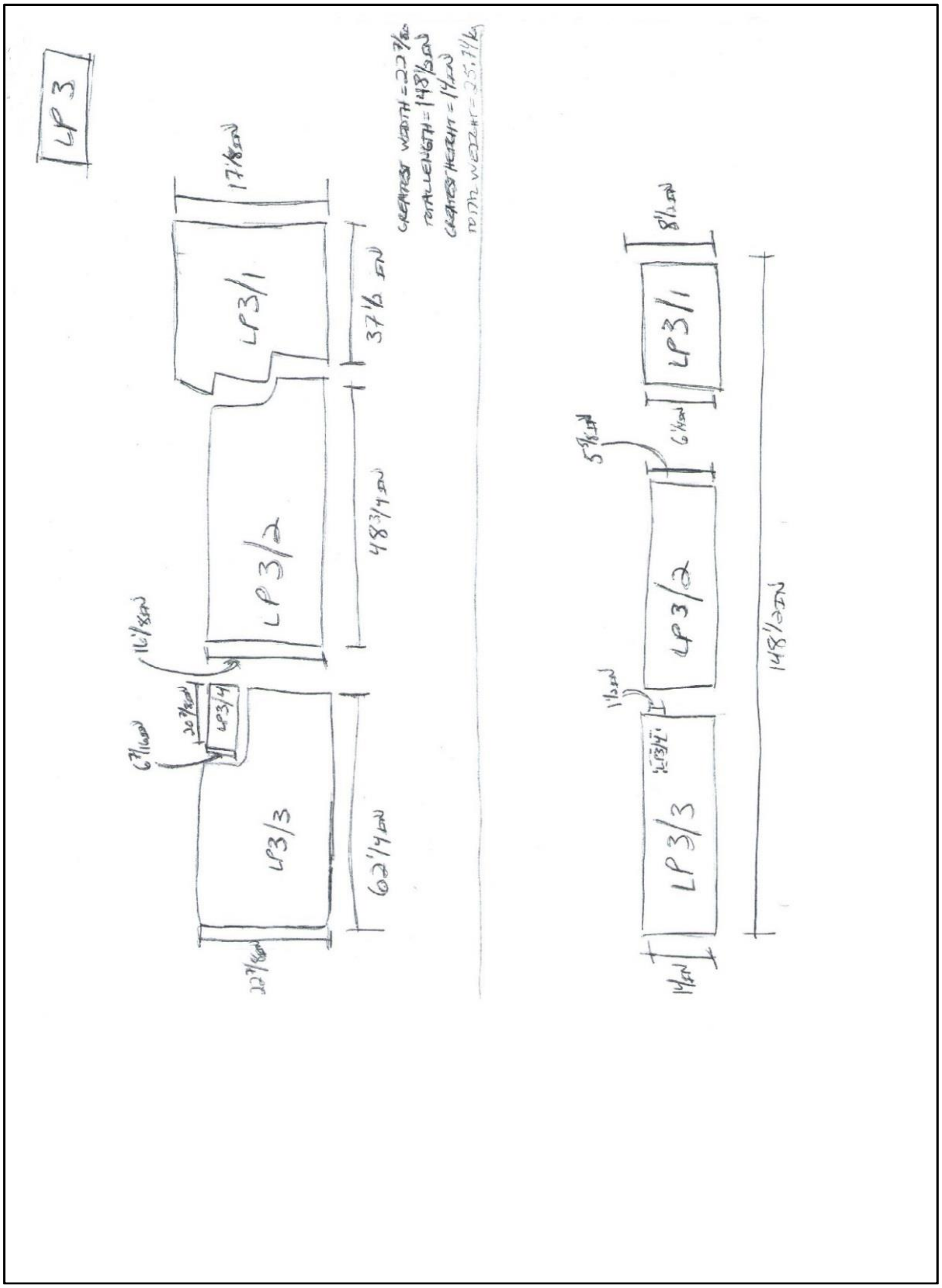


Figure 3: Sketch and measurements of Canoe 3.

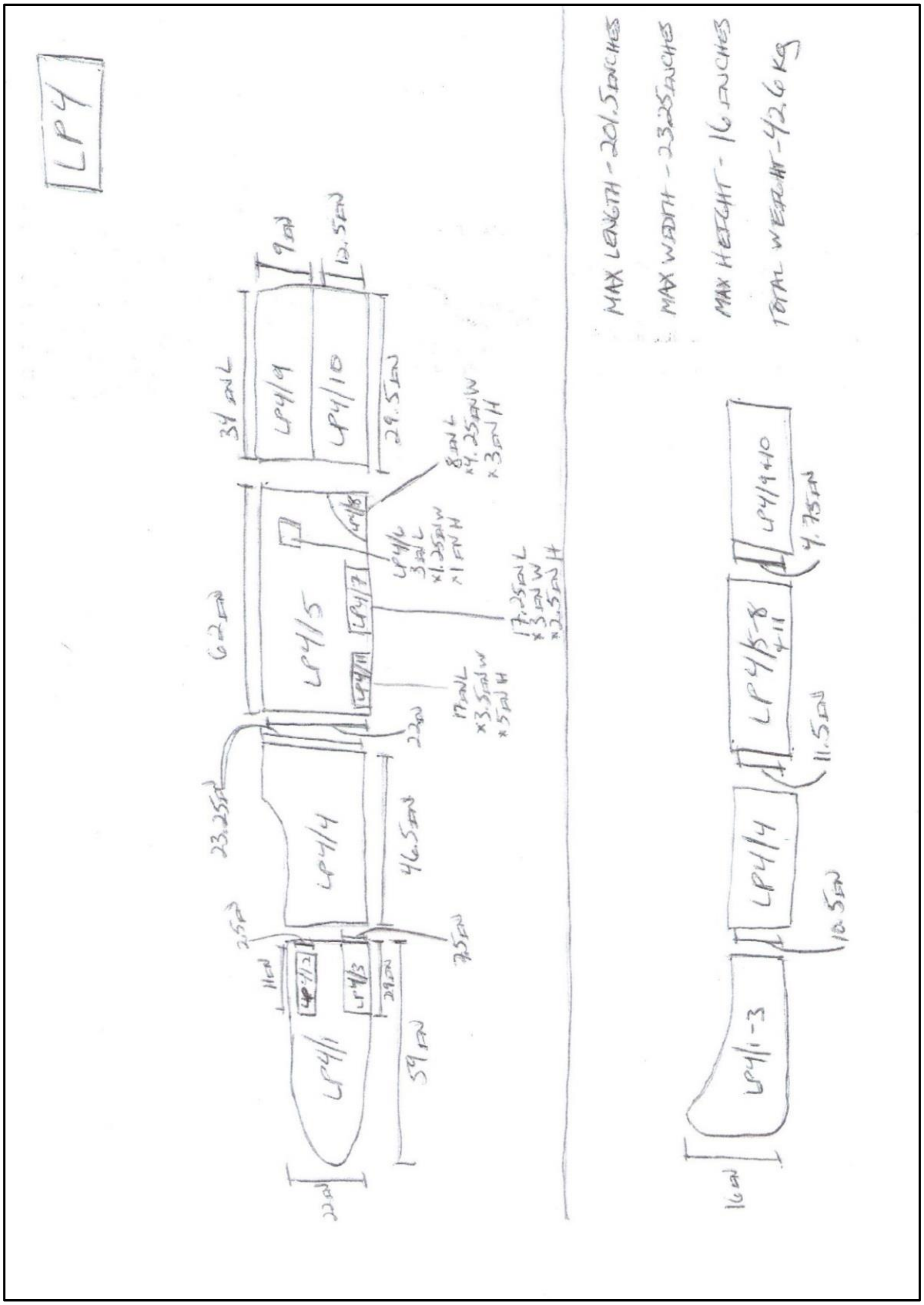


Figure 4: Sketch and measurements of Canoe 4.

Figure 5: Image of Canoe 3 (PHL0003.001) fragment illustrating the condition of the canoe before retreatment.

Figure 6: Image of Canoe 4 (PHL0004.010) fragment illustrating the condition of the canoe before retreatment.


Figure 7: The storage area of Canoe 3 and Canoe 4 at the ECU West Research Campus.


Figure 8: A close-up image of the storage area of Canoe 3 and Canoe 4 at the ECU West Research Campus.

CHAPTER 3: ENVIRONMENTAL AND CULTURAL CONTEXTS

A discussion of the environmental context of Lake Phelps helps to explain factors that have contributed to the preservation of a large number of wooden artifacts over such a long span of time. The condition in which the intact canoes and many canoe fragments were discovered is extraordinary. Indeed, the oldest canoe found was radiocarbon dated to 4380 +/- 70 BP (2430 BC) (Beta Analytic Inc 1987; Eastman 1994; Phelps 1989; Shomette 1993; Watkins-Kenney 2008). This is an unusual circumstance and, as previously noted, referring to Phelps (1989), at the time of their discovery, this was the largest number of prehistoric dugout log canoes within the southeastern United States in relation to where they were used and likely constructed. It should be noted that since that time, a larger collection of dugout canoes was discovered in Florida; however, the Lake Phelps canoes are the largest collection of prehistoric canoes in North Carolina (Curci 2006). The reason for such a rare discovery is that organic matter such as wood usually degrades more rapidly due to a combination of a variety of actions typically associated with a water source, such as weather events, climate, faunal and floral activity, soil, and the potential hydrogen (pH) balance of the water (A. Unger et al. 2001).

The archaeological investigations concerning the canoes was presented in Chapter 2. Archaeological evidence suggests the lake has been occupied at least seasonally by prehistoric peoples from the Late Paleo-Indian period through the Late Woodland period of the Lake Phelps region (Figure 9). A wealth of pottery sherds and some lithic artifacts have been retrieved from the area and have been recorded, curated, and stored at the Office of State Archaeology (OSA). Most of the artifacts that have been found are from the early to late Woodland; however, some of the artifacts are from the Late Paleo-Indian and Archaic periods (Phelps 1989; Pierce 2010). According to Phelps (1989), two small points from the Palmer phase of the Late Paleo-Indian period have been found. Additionally, a spear point from the Kirk phase of the Early Archaic period and one from the

Morrow phase of the Middle Archaic period were found. The Late Archaic period is better represented archaeologically and likely signifies when the area became more frequently used by inhabitants. Three of the prehistoric canoes found date to this period with the earliest dating to c. 2430 B.C. Other artifacts include spear points, a thrower weight, bifacial blades, and soapstone cooking vessels (Phelps 1989). In any case, as evidenced by the presence of prehistoric cultural remains, the region was inhabited for a long time before it was apparently abandoned prior to European "discovery." Historic records do not document the presence of Native American presence at Lake Phelps when settlers Josiah Phelps (for whom the lake is named) and Benjamin Tarkin found it while searching for farming and hunting land in 1755 (Bright 1987). Prehistoric cultural material found and retrieved from the lake represents human occupation from the Late Paleo-Indian to Late Woodland periods. Most of the artifacts found thus far have been identified with the Early to Late Woodland periods (Phelps 1989). A synthesis of what is known about the people of the middle and late Woodland periods in the eastern coastal region of North Carolina will help to place the artifacts studied in this thesis into a cultural historical context.

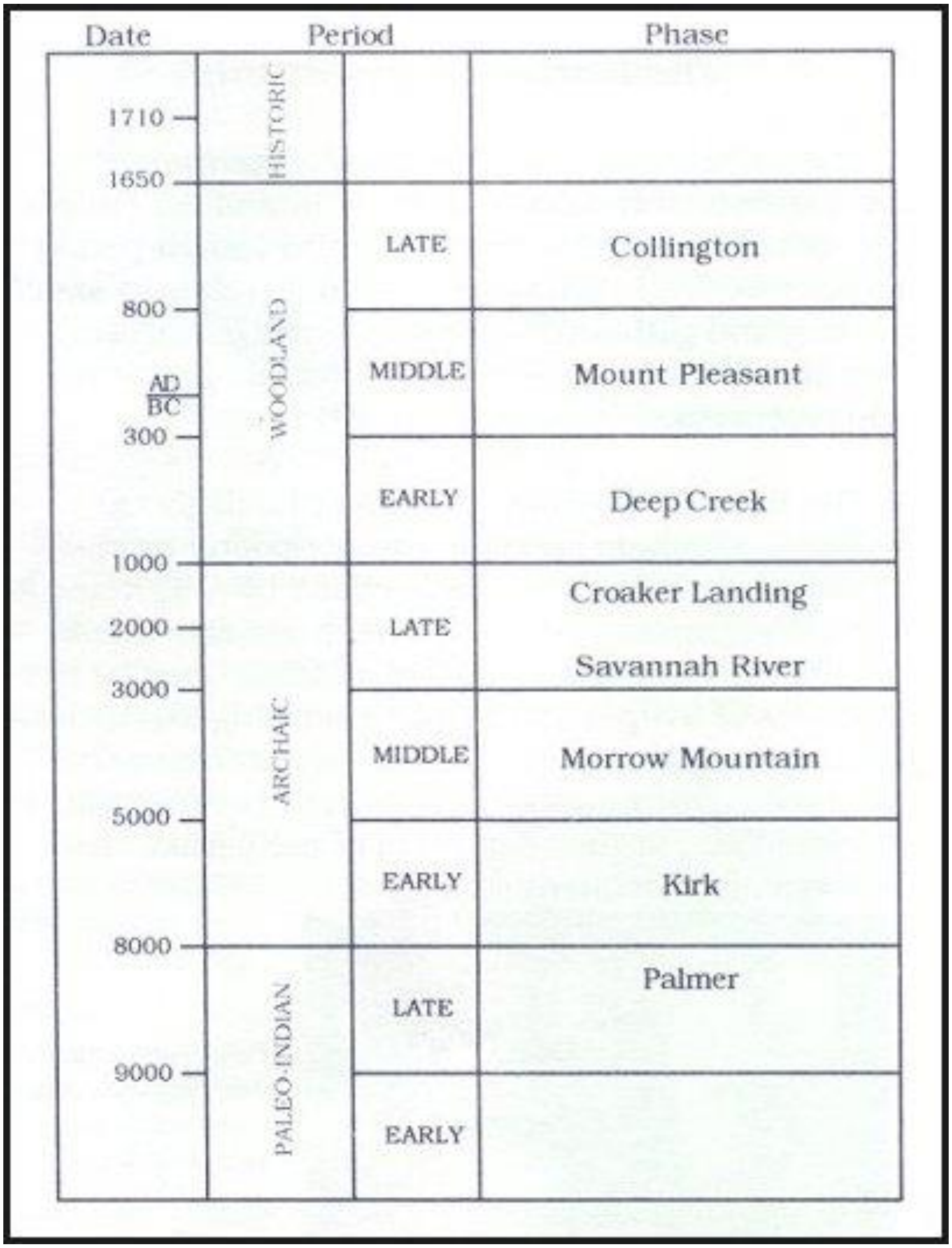


Figure 9: A cultural sequence of Lake Phelps developed by David Phelps (Phelps 1989).

Lake Phelps Environment

The environment at Lake Phelps has allowed for the preservation of wooden artifacts for hundreds, and in some cases, thousands of years. Specific environmental processes are required in order for organic matter to survive long periods of time in relatively exceptional condition, as in the case of the Phelps Canoes. This lake is one of four pocosin (also known as dismal) lakes located in the Albemarle-Pamlico peninsula within the larger North Carolina Coastal Plain. Lake Phelps is a shallow, natural, freshwater lake encompassing a circumference of 20 miles (Heath 1975) and a surface area of 16,600 acres (Phelps 1989) that resides primarily in Washington County, NC with its southwestern portion reaching into Tyrell County, NC. It is a recreational area part of Pettigrew State Park, and includes some private properties, mostly on its western shores (Holley 1989). Extensive analyses and discussion of the geologic age and formation of the peninsula has already been presented (see Heath 1975 and Holley 1989) and will not be discussed here. The focus of this section is the marine environment of Lake Phelps, the region that directly surrounds the lake, and the combination of characteristics that have led to the long-term preservation of wooden artifacts.

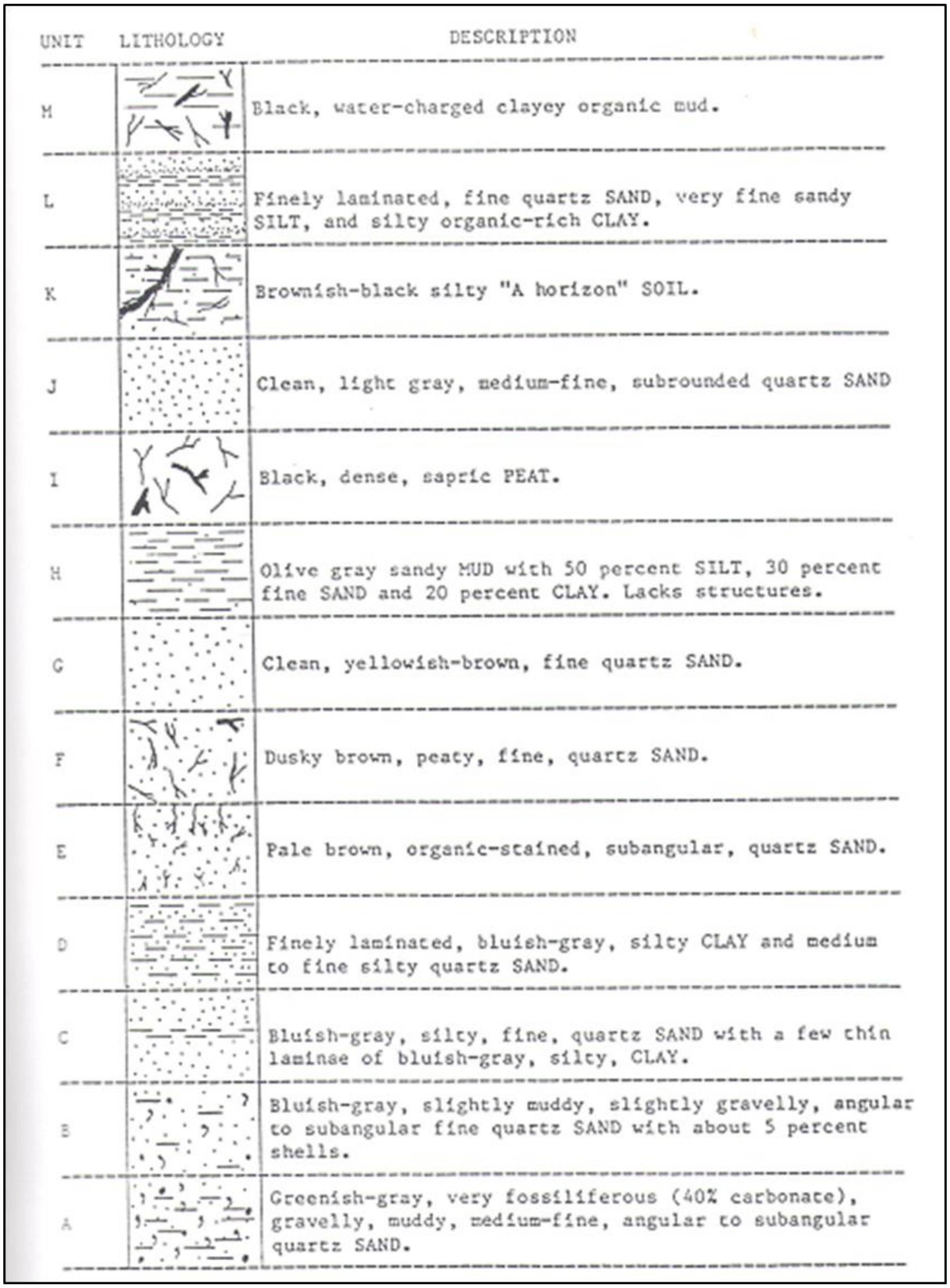
Pocosins are limited to the southeastern Coastal Plain of the United States and span from Virginia into northern Florida with most of them located in the Carolina Bays of North Carolina. They can be generally classified as wetland ecosystems, composed of bogs and swamps, with forested areas of both short (under 6 m) and tall (over 6 m) vegetation. The soil is acidic and the land is subject to varying levels of flooding and soil saturation (Richardson 2003). Tooker (1899:162) traces the etymology of the term to the Algonquian-speaking people, meaning a "marsh or low ground" although several specific definitions have been identified; they all refer to the same type of topographical region.

The water of Lake Phelps is clear, not tannic as is the case with the other lakes of the Albemarle-Pamlico peninsula. The presence of tannins in the lake and soil would not be conducive to the long-term preservation of the canoes; they are the result of the decay of vegetation and promote further decay in other organic materials. The origin of the lake is unknown, although a few explanations have been offered such as peat fires, meteorite impact, and glacial melts. The lake is surrounded by lush peat deposits and located in the East Dismal Swamp, where its water source comes from rainfall and land overflow, as there are no natural streams feeding into it. Because the water in the lake is so clear and pristine, it is unlikely much, if any water comes from aquifers (Heath 1975; Holley 1989). The preservation of the canoes is likely due to the lake water being slightly acidic with the source of the acidity most likely coming from acid rain rather than the tannic peat deposits surrounding its perimeter (Holley 2009; Phelps 1989).

The lake is shallow measuring an average of 7 to 10 feet, setting approximately 10.5 feet above sea level, with water levels around the lake averaging 5 feet (Heath 1975; Holley 1989). Several canals span the northern and northeastern side of the lake that control water levels with gates when water levels reach more than 11 feet as the elevation of the canals are lower than the lake (Heath 1975). It is partially surrounded by a low "ridge" that is not present along the northwester portion of the lake margin (Heath 1975:22).

Water levels were first recorded in 1965 and consistent measurements have been taken since 1970. Prior to this, levels were apparently gauged with a yardstick attached to the dock at the park prior to the installation of a permanent water gauge. In any case, it has been long known the lake water levels have fluctuated significantly prior to them being documented (Heath 1975). Heath (1975) notes that apparently during the 1940s, lake levels were so low hunters were able to drive around the south side edge of the lake to hunt deer. It is interesting that with the substantial water fluctuation at the lake that there have not been any formal reports of canoes being located prior to the mid-1980s. It is possible most of the canoes remained buried under the sediment and had not yet been previously exposed, although Canoe 3 was reportedly being used as some kind of a "path" on Michael Butler's property, where it was located and retrieved (Watkins-Kenney 2008), suggesting at least some people were aware of the existence of some of the artifacts. Another interesting observation is that, if the canoes have experienced repeated exposure and reburial, they have not degraded more than they have.

When the water level of the lake receded low enough for canoe pieces to be exposed during the mid- to latter half of the 1980s, they were at least partially buried in sediment that has protected them from decomposing (Holley 1989). Holley's (1989) study of the lake sediments in the regions where canoes have been found confirm the soil is comprised of fine, rich organic sediments (peaty clay, fine silty sand, and organic mud) resulting from lake processes and land clearing over peat deposits (Figure 10).



UNIT	LITHOLOGY	DESCRIPTION
M		Black, water-charged clayey organic mud.
L		Finely laminated, fine quartz SAND, very fine sandy SILT, and silty organic-rich CLAY.
K		Brownish-black silty "A horizon" SOIL.
J		Clean, light gray, medium-fine, subrounded quartz SAND
I		Black, dense, sapric PEAT.
H		Olive gray sandy MUD with 50 percent SILT, 30 percent fine SAND and 20 percent CLAY. Lacks structures.
G		Clean, yellowish-brown, fine quartz SAND.
F		Dusky brown, peaty, fine, quartz SAND.
E		Pale brown, organic-stained, subangular, quartz SAND.
D		Finely laminated, bluish-gray, silty CLAY and medium to fine silty quartz SAND.
C		Bluish-gray, silty, fine, quartz SAND with a few thin laminae of bluish-gray, silty, CLAY.
B		Bluish-gray, slightly muddy, slightly gravelly, angular to subangular fine quartz SAND with about 5 percent shells.
A		Greenish-gray, very fossiliferous (40% carbonate), gravelly, muddy, medium-fine, angular to subangular quartz SAND.

Figure 10: Soil lithology at Lake Phelps (Holley 1989).

Pre-historic Cultural History of the Region

Lake Phelps is set within the North Carolina Coastal Plain, an area in which Phelps (1983) noted the need for a comprehensive prehistoric cultural-historic chronology to be developed. Ward and Davis (1999) and more recently, Daniel and Moore (2011) have developed more complete cultural chronologies of the region that serve as working models as new archaeological information is gathered. Most of the archaeological finds at Lake Phelps are comprised of pottery sherds and lithic finds; the discovery of the canoes at the lake adds substantially to the cultural contexts of the pre-contact people in that it provides evidence for its use at least as a seasonal settlement.

The prehistoric artifacts found at the lake suggest the area was inhabited at least by 8000 BC during the Late Paleo-Indian period, Palmer Phase (Phelps 1989). The oldest canoe found dates to c. 2430 BC, representing the Late Archaic Period, Croaker Landing/Savannah River Phase. The most recent canoe (Canoe 3) dates to c. AD 1400 representing the Late Woodland Period, Colington Phase (Phelps 1989; Watkins-Kenney 2008). Canoe 4 dates to c. AD 340 representing the Middle Woodland Period, Mount Pleasant Phase. Most of the archaeology of the lake has focused on monitoring of the canoes left *in situ* and conservation of those retrieved from the lake; there remains to be a comprehensive archaeological study of the area (Curci 2006). The lack of a comprehensive archaeological study is problematic because it limits the discussion of the cultural history of the people who lived there.

Phelps (1983) cited the decrease in academic research in favor of cultural resource management (CRM) archaeology and environmental archaeological projects that have limited the "contextual" analyses of cultural materials as key issues preventing a more complete cultural history of the early inhabitants of the North Carolina Coastal Plain (p. 2) (Figure 11). Furthermore, he recognized the need to develop a framework upon which future anthropologists and archaeologists could further develop the cultural histories of past peoples of the region. Ward and Davis (1999) recognized the need to synthesize the wealth of recent archaeological information with previous research of prehistoric North Carolina to revise previous cultural models. A recent study by Daniel and Moore (2011) revised the previous models, acknowledging their chronology is also a working model from which future archaeological evidence will fill current gaps of the culture history of the North Carolina Coastal Plain (Figure 12). Where the Lake Phelps region is concerned, it is reasonable to suggest that development of private homes along the western boundary of the lake, recreational use, and agricultural development have likely destroyed prehistoric cultural contexts. The work of Ward and Davis (1999) shows the locations of Woodland sites of the North Carolina North Coastal Plain (Figure 13). It is from these sources that Canoe 3 and Canoe 4 will be placed into a cultural-historical context, in an attempt to provide a better understanding of the people who inhabited the area long ago.

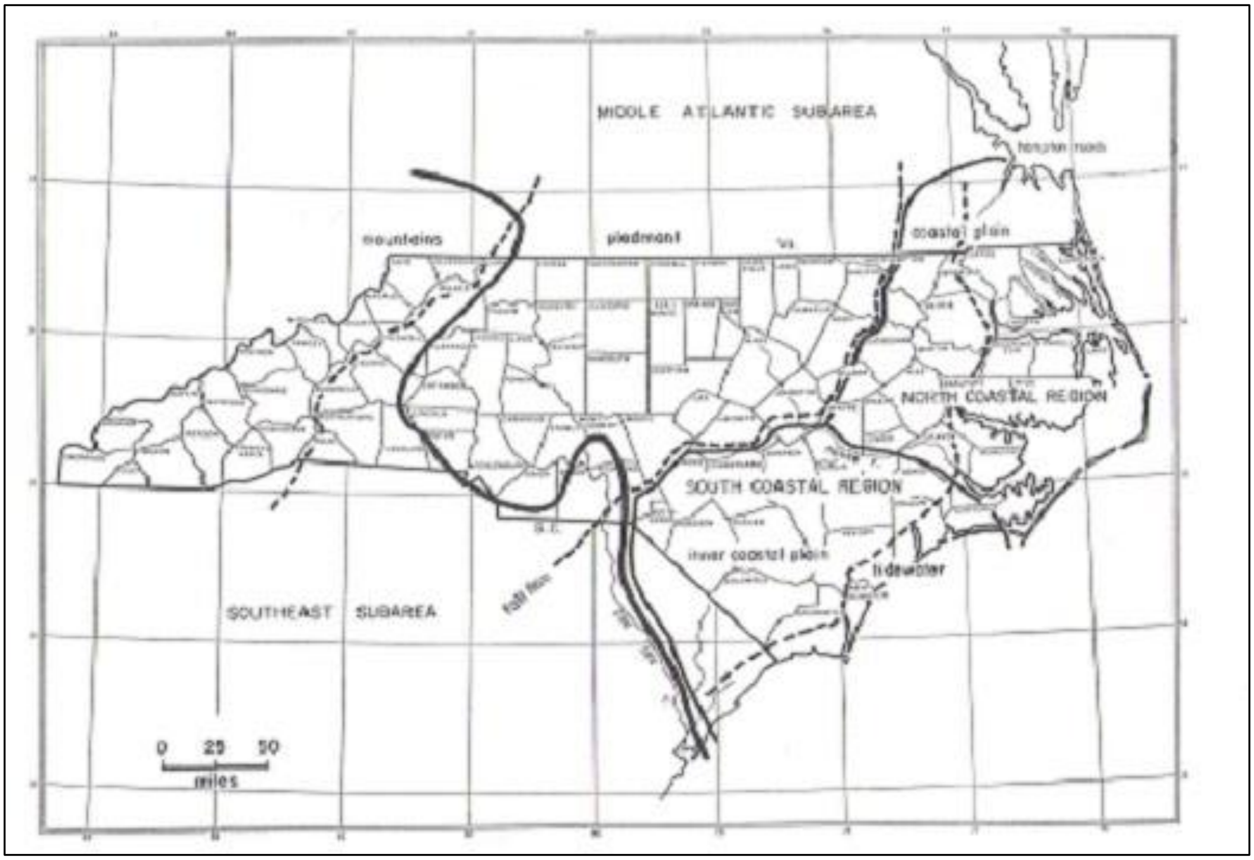


Figure 11: North Carolina Coastal Plain (Phelps 1983).

DATE	CULTURAL PERIOD	COASTAL PLAIN Northern Coast	 Northern Coastal Plain	 Southern Coast	 Southern Coastal Plain
- -	*Historic Tribes*	*Carolina Algonkins*	*Meherrin Tuscarora*	*Cape Fear Indians Waccamaw*	*Lumbee*
- AD 1500 - - - - - AD 1000	Late Woodland	Colington	Cashie	White Oak	?
- - - - - AD 500 - - -	Middle Woodland	Mount Pleasant		Cape Fear	
- - AD 1	Early Woodland	Deep Creek		New River	
- 1,000 BC - 2,000 BC	Late Archaic	Savannah River Thelma?			
- 3,000 BC	Middle Archaic	Guilford Halifax?			
- 4,000 BC		Morrow Mountain Stanly			
- 5,000 BC		Kirk stemmed points			
- 6,000 BC - 7,000 BC - 8,000 BC	Early Archaic	St. Albans Palmer/Kirk Corner-notched points Hardaway side-notched points?			
- 9,000 BC - 10,000 BC	Late Paleoindian Middle Paleoindian Early Paleoindian	Hardaway-Dalton Redstone – Cumberland-Suwannee-Simpson Clovis			

Figure 12: A cultural sequence for the prehistoric North Carolina Coastal Plain (Based on Daniel and Moore 2011; Phelps 1983; Ward and Davis 1999).

Figure 13: A map of the North Carolina Coastal Plain showing the location of Woodland sites (Ward and Davis 1999).

Woodland Period (1000 BC – AD 1600). This period is categorized into three subperiods: Early (1000 BC – 300 BC), Middle (300 BC – AD 800), and Late (AD 800 – AD 1600). Although there is overlap with cultural materials recovered from archaeological sites, this should not be problematic because shifts in cultural technologies are not instantaneous; their peak is what typically signifies a particular cultural period or phase. The onset of the Woodland period is identified by the beginning of the adoption of agriculture and larger, more permanent settlement patterns, more intense social stratification, more elaborate mortuary rituals and burials, development of trade networks with distant societies, and the introduction of distinct pottery types. The Woodland peoples of North Carolina adopted these cultural technologies at significantly varying degrees, depending on their location (Ward and Stephen Davis Jr. 1999).

Canoe 4. The Middle Woodland Period in the North Carolina Coastal Plain is identified by the emergence of Mount Pleasant pottery. This pottery is composed of tempered sand with varying amounts of grit and sand particles, with smooth surfaces or surfaces finished by fabric or net impressed or cordmarking (Phelps 1983; Phelps 1989; Ward and Stephen Davis Jr. 1999). The economy of the people included exploitation of natural resources and some agriculture. Fishing and shellfish were the primary food source, although sites have shown evidence of hunting deer, rabbit, turkey, and turtles as well as charred remains of foods such as hickory nuts. Mortuary practices include burial and cremation, and grave goods have only been found in association with burials found in the northern coastal region (Phelps 1983; Ward and Stephen Davis Jr. 1999).

Canoe 3. The Late Woodland Period in the North Carolina Coastal Plain is identified by the emergence of the Colington Phase shell-tempered pottery that has plain surfaces or fabric impressed, stamped, or incised. This pottery is associated with the Algonquin-speaking people of the region whom are believed to be the descendants of the Late Woodland peoples. This period saw significant changes. Corn as a main crop was introduced and permanent settlements were located near water sources such as estuaries, natural streams, and sounds. People lived in longhouses and populations probably reached near 200 individuals. Mortuary practices changed substantially. While burials and cremation practices continued, burials took the form of mass graves and ossuaries.

The end of the Woodland Period is marked by the beginning of the historical period with the arrival and settlement of European colonists during the early 17th century (Phelps 1983; Ward and Stephen Davis Jr. 1999). Much of what is known is based on early English colonists' ethnographic accounts of Algonquin people and other Indian cultures. Most notably, narratives written in the late 16th century by Thomas Harriot and watercolor drawings by John White, both of England, help to provide an understanding of the lifeways of the Late Woodland peoples (Figure 14).

Engravings by Theodor de Bry in the latter 1500s, from the watercolor drawings of John White provide a visual interpretation of how the canoes might have been made and used, although it should be understood that the drawings of White were not always first-hand accounts of Native American behaviors and customs (Figures 15 and 16). He took some artistic liberties in his portrayal of behaviors and customs, sometimes combining several aspects of a custom within a single drawing. Furthermore, de Bry's engravings are not exact replicas of White's original watercolors and he took artistic liberties as well (Hulton and Quinn 1964).

Native American's were observed using canoes for transportation and fishing. Canoes were built by first cutting down select trees through controlled burning at the trunk, then burning off the bark, leaves, and branches. Once the selected slab was cut and burned to the desired length, it was placed onto a platform made of poles and forked posts. Then the wood slab was hollowed out through a process of controlled burning, then removing the charred pieces with shell or other type of scrapers until it was hollowed out enough for use on the water (Hulton and Quinn 1964). Indeed, charred areas of several canoe fragments are evidence of the burning and hollowing by the early inhabitants.

It should be understood that, while historical records at the time of contact sometimes include creative liberties of settlers' interpretations of Native American customs, they should not be disregarded because they help to fill gaps in the historical and archaeological records. Little is known about the inhabitants of Lake Phelps. Colonists' accounts of Native American customs at the time of contact in addition to archaeological evidence of earlier inhabitants helps to make interpretations of what the people *may* have been like. Future archaeological research will help to identify misinterpretations and refine the working models of cultural chronologies referred to in this section.

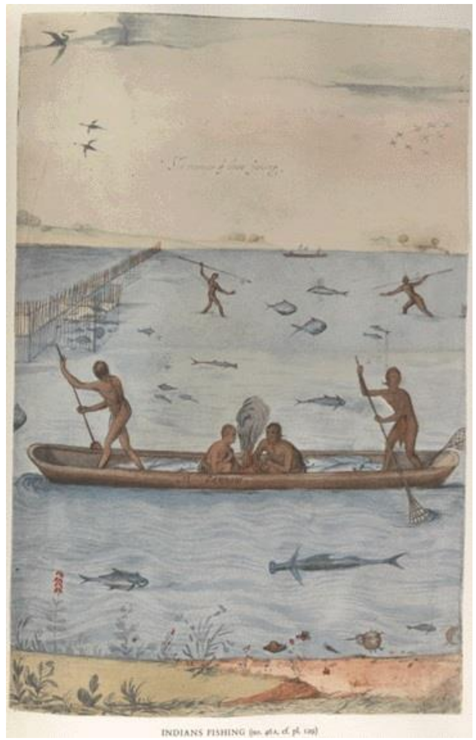


Figure 14: Watercolor drawing "Indians Fishing" by John White (1585-1586) (Hulton and Quinn 1964).

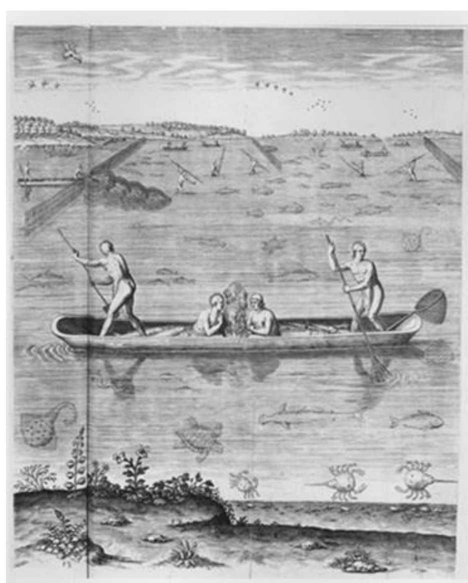


Figure 15: Engraving by Theodor de Bry "Their manner of fishynge in Virginia" (1590) based on John White's watercolor drawing (Hulton and Quinn 1964).

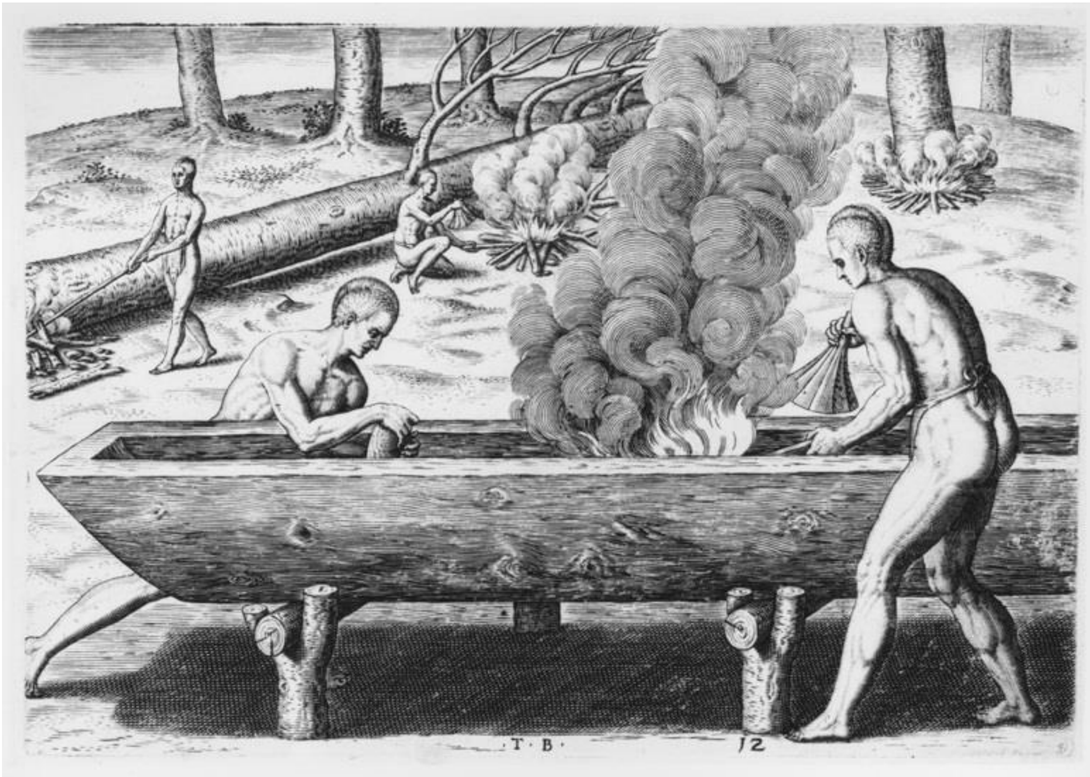


Figure 16: Engraving by Theodor de Bry "The manner of makinge their boates" (1590) from a watercolor drawing by John White, (original drawing is unavailable) (Hulton and Quinn 1964).

CHAPTER 4: THEORETICAL FOUNDATIONS

This thesis is interdisciplinary, utilizing theoretical approaches derived from both conservation and anthropological lenses. The field of archaeological conservation has changed significantly from its early beginnings, and continues to evolve with the development of new approaches and technological innovations. Engaging in any conservation project involving artworks or archaeological materials requires specific knowledge and practices to ensure the integrity of objects being treated is retained. Likewise, the discipline of archaeology requires specific knowledge and practices to protect cultural materials and sites. As Rotroff (2001) argues, archaeologists and conservators must collaborate in the best interests of the proper conservation and curation of archaeological materials. Per the ethical codes of the six archaeological organizations (Archaeological Institute of America (AIA), Society for American Archaeology (SAA), Society for Historical Archaeology (SHA), the Register of Professional Archaeologists (RPA), the American School of Classical Studies at Athens (ASCSA), and the American Schools of Oriental Research (ASOR)) that Rotroff (2001) analyzed, archaeologists are expected to ensure the proper conservation and curation of the artifacts they find. Admittedly, there is perhaps differences of understanding with the "proper" conservation and curation methods between the two disciplines, but this underscores the need for regular, ongoing collaboration between the fields. The process of discovery, excavation, initial conservation, ongoing analyses, and current attempts at conservation retreatment of the canoes presented in this thesis demonstrates past and current approaches that have involved, and continue to involve archaeologists and conservators working together to problem-solve issues these objects present.

The central issue of this research was to identify the *optimal* conservation technique(s) for re-conserving the canoes. It is prudent to clarify here that by *optimal*, the intention is that identified resolutions not only considered aesthetic outcomes, but concern for the stabilization, minimal effects of trial mechanical and chemical cleaning treatments, and proper handling of fragile materials. Another consideration was the reversibility of any chemical applications that might be applied to the objects. Designing the treatment process for the trials included choosing techniques and tests that were in accordance with ethical codes and known practices within conservation (see Chapter 6: Methodology). Preparation included reading documents detailing the history of the archaeology and conservation associated with the canoes, (including recent analyses, experiments, and conservation applications given to any of the fragments).

Cultural anthropologists study culture through ethnography while archaeologists study culture through the material remains left by the people who made them. This includes interpretation and dissemination of the knowledge they have gained through written works and visual mediums, such as museum displays and photographs (Hanare 2003). Oftentimes, the knowledge gained from artifacts is limited; however, the processes associated with re-conservation of the canoes in this thesis has afforded the opportunity to better understand their place within the cultural system that created and used them, adding to the cultural history of the Woodland people who inhabited the Albemarle-Pamlico peninsula in the North Carolina Coastal Plain.

Conservation Science

A relatively brief historical account of the development of conservation provides an understanding of how the field evolved to include the scientific methods as well as the ethical and theoretical premises conservators rely upon. The discipline of archaeological conservation as we know it today has a long history that developed out of non-scientific efforts to clean and restore objects and monuments (Caple 2000; Sease 1996). The earliest account for the concern of the condition of objects is in Pliny the Elder's *Natural History*. While Pliny does not provide detailed information of the restoration processes involved, his writing documents that Romans were aware of the deterioration of objects over time and artists were largely responsible for restoration (Sease 1996). Veneration for ancient artifacts became more prominent during the Renaissance, a time when the aesthetics of objects were the central focus, and restoration was organized toward restoring objects to their original appearance. Artists such as Michelangelo and Cellini mostly restored sculptures. The first documented methods of restoration were written by Cellini (Caple 2000; Sease 1996). During the latter part of the eighteenth century, interest in preserving antiquities grew with archaeological finds such as Pompeii and Herculaneum. Unfortunately, chemical and mechanical techniques for preserving the papyrus scrolls found at Herculaneum were ineffective because the material composition of papyrus was not well understood during that time. A notable development during the early nineteenth century was the invention of a machine used to unroll papyrus scrolls by Genoese monk, Antonio Piaggio (Caple 2000; Sease 1996).

The nineteenth century marks the time where methods and techniques for conserving objects continued to be largely experimental; however, documentation became increasingly meticulous and approaches were becoming more scientific. Archaeologists were documenting conservation procedures as artifacts were excavated. Danish archaeologist, C.J. Thomsen who is credited for developing the Three Age System for classification of prehistoric artifacts, was directly involved in field conservation at excavations. Thomsen collaborated with colleagues such as C.F. Herbst to develop techniques for artifact preservation at excavations. He is credited for developing a process for preserving waterlogged wood (Caple 2000; Sease 1996). During the latter part of the nineteenth and early twentieth centuries, conservation laboratories were becoming established in museums, and published literature grew. One archaeologist of this era, Egyptologist Sir Flanders Petrie, meticulously documented his work, referencing the great amount of time and work required to conserve objects (Sease 1996).

Archaeological conservation was well established in museums in Europe prior to developing as a field in the United States during the early to mid-twentieth century. Conservation training programs were few in Europe and the US where there were even less, and the focus is on conservation of artworks. By the mid-twentieth century, the discipline grew both in number of conservators and internationally. As conservation matured into a more specialized field, groups of conservators founded organizations and established formal codes of ethics and practices that outlined standards of practice (Caple 2000). The International Institute for Conservation of Historic and Artistic Works (IIC) was founded in 1950, and the regional groups, the United Kingdom Institute for Conservation (UKIC) and the American Institute for Conservation of Historic and Artistic Works (AIC) formed soon after. (Caple 2000).

Conservation has continued to grow, both in numbers of practitioners and as a specialized field. With this growth, two premises have become the basis from which professionals conduct their work: minimum intervention and reversibility. (Caple 2000; Cronyn 1992; Viñas 2005). To clarify, these are not the only principles conservators work from, but are at the forefront when considering optimal techniques to use for conserving, preserving, or restoring objects. Certainly, as Cronyn (1992) suggested, collaboration between all interested parties should be the first step in conserving archaeological objects; however, considering minimum intervention strategies and the reversibility of any techniques applied to objects is an imperative part of the collaboration process.

Minimum intervention. Minimum intervention is a broad concept that does not delineate specific interactions with objects; it is not easily defined, and it does not provide a complete statement. Indeed, Caple (2003:65) asks "[t]he minimum intervention to achieve what?" Certainly, any technique used to conserve an object could be defined as applying minimum intervention and depends upon the context of the object needing conservation. If an object is quite fragile, and only enough strategies are used that would ensure the immediate or long-term stabilization of an object, this might be considered as minimum intervention. Conversely, a more stable object in need of significant repair might require a greater degree of mechanical or chemical applications. These examples bring about two issues that would need to be defined by those undertaking the conservation of an object.

First, what does "long-term" mean? How should it be defined? Next week? Ten years from now? Forever? The canoes discussed in this thesis were treated with a sucrose solution treatment and displayed for a number of years before deterioration was evident. Although, to be fair, the relationship of the environment, wood, and sucrose solution were not well understood at that time. Regardless, it could be said that the canoes received the minimal intervention necessary for their long-term storage. When we look back at the methods used at that time and conclude those methods were not conducive to the long-term storage and display of the objects we have the benefit of hindsight. As is the case with defining minimal intervention, it depends on the context of the object(s) being conserved. In this case, it seems adequate to define "long-term" as stabilizing the wooden objects until they begin to degrade further or the crystallization of the sugars reappear on their surface.

Second, what determines the need for "significant repair?" Again, it depends on the context. If the object in question is, say, an historic building in need of restoration because it presents safety issues aside from aesthetics, then conservation methods will be more substantial than those of a much smaller object. This is not to say small artifacts do not require major repairs, but they do not typically present the issues of buildings and structures in need of conservation.

Clearly, as Caple (2000) suggested, the application of minimal intervention indicates a relativist approach. Furthermore, the context and purpose of minimum intervention should be identified during the collaboration process and those strategies can vary greatly from one project to the next. In can include no conservation, leaving the object(s) in their current state to thoroughly cleaning and repairing them (Viñas 2005). In essence, minimum intervention could be defined as the application of conservation techniques using the least intrusive procedures necessary for the immediate or more permanent stabilization of objects, and considers their contextual basis.

Concerning the canoes (see Chapter 6: Methodology), collaboration occurred throughout the retreatment process and minimum intervention was identified as being that which would include their stabilization and treatments that would minimize or eliminate the appearance of the surface deposits that have formed. In addition, the concept of reversibility was a central consideration when identifying techniques for trials.

Reversibility. The concept of reversibility within conservation developed because during the twentieth century, conservators were faced with re-conserving antiquities that had been previously conserved with chemicals that were found to be harmful to the objects, such as "cement, plaster of Paris and shellac" that had become permanent additions to the objects (Caple 2000:63). This changed how conservators approached conserving objects; they became focused on preserving objects for the future as much as they were preserving the past. Additionally, some degree of risk is required when conserving objects, especially when utilizing newer, untested techniques, causing conservators to move toward using reversible treatments (Caple 2000; Viñas 2005). Reversibility is defined as being able to return an object to its state prior to the conservation treatment; the goal is to be able to undo conservation so that an object can be re-treated in the future if and when better approaches are identified and developed (Caple 2000; Viñas 2005).

Although reversibility is a primary consideration and goal of conservators, it has limitations. For example, cleaning techniques are not reversible. Once an object is cleaned, it cannot be returned to its previous state. In fact, any contact with an object has technically changed it at the molecular level. Some polymers used as consolidants are not reversible. The structure of objects and their relationship with the chemicals they are treated with varies over time; therefore, conservators cannot guarantee they will remain in their same state over time (Caple 2000; Viñas 2005). Caple (2000:64) suggests reversibility is a valid concept if it is considered to mean "retreatable" or able to "undo" previous applications. Likewise, Viñas (2005) is also critical of the concept due to its limitations and notes true reversibility is a misguided notion. In spite of his criticisms, he acknowledges reversibility to be a valid goal for conservators so long as they understand its limitations and that it is not a requirement in all cases.

Material Culture Theory

Artifacts are the material culture of a specific community or society of a particular time. Material culture is the objects created by the people of a particular time and is the tangible evidence that is studied to learn about the socio-cultural characteristics of the people who made or built them. The "values, ideas, attitudes, and assumptions" of a culture of a specific time can be learned through the study of material culture. Material culture can include objects such as pottery sherds, lithic objects modified into tools by people, landscapes modified by people, buildings or other kinds of structures (Prown 1982:1). Certainly, material culture includes the dugout log canoes that are the focus of this thesis. As Hodder (1994a) infers, all objects are cultural. The kind and amount of information gleaned from objects varies and embodies many of the cultural aspects of a society, but does not usually provide clear, precise information about said culture. Specific environmental processes determine the long-term survival of an artifact. In fact, most objects do not survive intact for long periods of time, and those that are found, typically embody a specific part of a culture not the entirety of that culture. (Grassby 2005).

The canoes in this thesis offers an example of the kind of information that can be learned about the Woodland (1000 BC – AD 1600) Period cultures, specifically, people that once inhabited the Lake Phelps area. Two canoes from different Woodland periods are presented, Canoe 3 from the Late Woodland Period (AD 800 – AD 1600) and Canoe 4 (300 BC – AD 800) from the Middle Woodland Period. Neither is an intact representation of an entire dugout log canoe, but they are in several wooden fragments. Canoe 3 is in four pieces and Canoe 4 is in eleven pieces. When the pieces are put into context with one another, it can be seen they make up dugout log canoes. Additionally, charred portions on fragments infer burning was a part of the process when they were built. As discussed in Chapter 3, specific cultural characteristics such as ritual burials or agricultural practices varied amongst communities of the Woodland period, indicating processes for building canoes may also vary, but are probably quite similar. Furthermore, historical narratives and drawings by European colonists at the time of contact with the Algonquin peoples suggest their ancestors, presumably Woodland peoples, likely used similar, if not the same methods for constructing canoes, and used canoes for the same reasons, transportation to access food. The point here being that the canoes provide material evidence for that a community of people inhabited the Lake Phelps area at least seasonally, prior to its discovery by 16th century colonists. What can be learned about those cultures cannot be understood solely through the analysis of the canoes, but through the compilation of additional archaeological and historical investigation. As Prown (2005) suggests, artifacts cannot provide the core beliefs of a culture without additional data. Artifacts alone cannot inform us of the intent of their creation, or other hidden meanings.

Hodder (1994a) offers that the analysis of objects can be categorized into three general types as a way to provide an interpretation of their meaning: functional, symbolic, and historical. The functional meaning of an object is its basic use within a community and can be interpreted based upon its material composition and design. An interpretation can be made as to how it was used and how it affected an individual or the society. To interpret the symbolic meaning of an object suggests the maker of that object either intentionally or unintentionally added some form of aesthetic to the object when he or she was making it. In other words, although an object might be constructed in the same manner as all other objects like it, the maker of that object expresses some symbolic value of the culture into the object he or she makes. A particular color, size, or design of an object can be the symbolic value of a community or individual and is expressed through the maker's techniques. Every object has historic meaning. Objects are the material evidence for a society at a given place and time, and add to the cultural and historical timelines of human existence. In addition, objects can be classified into a typology, thus providing a reference for dating them, helping archaeologists to put them into context to construct and interpret the socio-cultural characteristics of a past society (Caple 2000).

It is important to note that Hodder (1994a) states that the three types of meaning are always working together and inseparable. He is critical of, and cautions against using functionalist only views of material culture because they do not consider cultures as dynamic processes, but as assume a natural state of "homeostatic equilibrium" (p. 49). There are too many characteristics within any culture to analyze through normative methods. Alternatively, Clarke (1994) argues in favor of functionalist views of material culture through his systems analysis approach. A sociocultural system is a single system and subsystems of that system are arbitrary categories that are technically just "different aspects of the same system" that cannot be sufficiently defined because they are too complex to be treated independently and intersecting at the same time. Subsystems can be categorized into, as few or as many as one chooses to generate, therefore any subsystem is just a part of the social continuity of a specified culture (Clark 1994:44). Tilley (1994) argues that functionalism is limited to deterministic generalizations that explain how an object is used, but not why. Objects should be studied as expressions of their connections to other objects or culture they represent. Every instance of the manufacture of an object by humans is an expression of social behavior where cultural forms can be found in the design of objects or the relationships between different spaces within a society.

Clearly, conveying meaning of objects is problematic because there is not a single unified theory of culture, which is evident by the differing views discussed here. In any case, a process of evaluating objects can be defined. Prown (1982) proposed that material culture analysis must go through three phases, sequentially, from description, to deduction, to speculation. Description involves only what can be observed of the objects themselves. This includes thorough documentation of the objects including their size, shape, condition, specific measurements and weights, and photographs. The next phase involve deduction where the investigator working with the objects consider what it would be like to use the objects in their time and place of original construction and use. He or she handles the objects, as appropriate, depending upon their scale of fragility or size, and imagines how they might have been used, and infers their relationship within the culture they represent. The investigator responds with some degree of emotion, whether with excitement, surprise, curiosity, indifference, or wonderment. The interaction between the investigator with his or her history and the objects with theirs, are what form this stage of deduction. The final stage of the analysis is speculation. The investigator takes into account of the information gained up to this stage and develops hypotheses about the cultural significance of the objects, then develops a plan for, and executes research through external scholarly sources to test the previously developed hypotheses. The investigator continues to work with the objects while engaging in research activities aside from the objects themselves.

A discussion of the theoretical frameworks considered in this thesis provides a framework for understanding the various processes involved in the re-conservation of the canoes that are the focus of this study. The discipline of conservation has evolved from cleaning and restoration projects that were acceptable long ago into a specialized field where modern methods require conservators to adhere to specific ethical standards and approaches when conserving objects. Collaboration, reversibility, and minimum intervention are the premises from which conservators work to ensure ethical treatment of the objects they work with. Material culture theory considers how different professionals approach the study of objects in order to place them into a specific place and time within the particular culture they symbolize. This sets the stage for the discussion of the applied work with the artifacts presented in this thesis.

CHAPTER 5: RETREATMENT OF THE DUGOUT LOG CANOES

When conserving objects, it is important to understand their material composition and the conditions that precipitate their need for treatment. The material composition of the canoes is wood, an organic material, which is the remains of a once living organism, that decays over time. The situation that brought about the need to re-conserve the canoes in this thesis is varying amounts of a brownish and white, crystallized and caked substance had formed on the surface of all of the wooden fragments. It had become apparent that these artifacts were at risk for further deterioration and needed to be stabilized. In order prevent further formation of surface deposits or potential degradation, they were relocated to ECU's West Research campus until they could be re-conserved (Watkins-Kenney 2008).

Before re-conservation could begin, a research plan was created which included locating and reading reports and previous analyses. This helped to understand the circumstances that led to the current condition of the canoes and provide a basis from which to design the trials in order to determine optimal treatment strategies. After this, a design was constructed which included a series of mechanical and chemical cleaning techniques and scanning electron microscope (SEM) analysis of selected samples from samples that had previously been taken from Canoe 3 and Canoe 4 when they were relocated (Gilman 2014). After the trials were complete, a decision was made to conduct further trials due to the varying conditions of the wooden fragments. It was at this time, through collaboration with the NCDCR UAB conservation staff, that it was decided to test the validity of a form of "misting." This is a conservation technique conventionally used for restoring paper, and not wooden objects.

The following sections include a discussion of the components of wood, the species of wood the canoes are made of, and using sucrose in conserving waterlogged wooden objects. Although the canoes are no longer waterlogged, it is important to understand the specific conditions conservators face when working with waterlogged wooden objects in order to understand the circumstances that have contributed to the current condition of the canoes.

Next, a discussion of sucrose will be presented. The canoes were conserved with a sucrose solution nearly thirty years ago. Over time, crystallized and caked surface deposits developed on the fragments. Although concerns focus on the aesthetic quality of the fragments, there were also concerns about the structural stability of the artifacts. It is important to understand the relationship of the wood, sucrose solution, and environmental factors that led to the canoes' current condition.

Finally, this chapter concludes with the methodology used in this study to discover optimal conservation techniques that will ultimately allow the canoes to be relocated back to Pettigrew State Park where they can be displayed for public viewing and education.

Material Composition of the Dugout Log Canoes (Bald Cypress)

Archaeological wood is an organic material derived from woody plants such as trees and shrubs that have been modified by people in some way, and is found in either dry or waterlogged conditions (Rodgers 2004; A. Unger et al. 2001). In order to discuss the re-conservation methodology of the canoes it is important to understand the characteristics of the material they are made of, trees. There are two general categories of trees, hardwoods (broad-leafed) and softwood (conifers). The structure of wood consists of a protective outer layer of bark and an inner thin layer of cambrium that produces the sapwood (also new wood) where water is moved vertically through a tree. As the cells of the sapwood die off, the heartwood is produced. Rays radiate from the center of the tree, where the pith is located, and distribute nutrients horizontally (Cronyn 1990; Hamilton 1996; Hamilton 2010; Rodgers 2004; A. Unger et al. 2001). Figure 17 illustrates the structure of a tree trunk. There are three principle surfaces, or planes of wood: the transverse (horizontal cross-section), tangential, and radial planes; the tangential surface is perpendicular to the transverse and radial planes, whereas the radial plane lies along the rays and is perpendicular to the annual growth rings (Figure 18) (Hamilton 1996; Hamilton 2010; Rodgers 2004; A. Unger et al. 2001). Microscopically, the category of wood can be identified by the presence of fiber, tracheids, or vessels (Figure 19 and Figure 20). Hardwoods are composed of fiber that provides structural support, and tracheids and vessels that serve as channels for distributing liquids. In softwoods, only tracheids are present and serve as both channels for distributing liquids and structural support. Pits are the openings within the cell walls where liquids are transferred between cell walls (A. Unger et al. 2001).

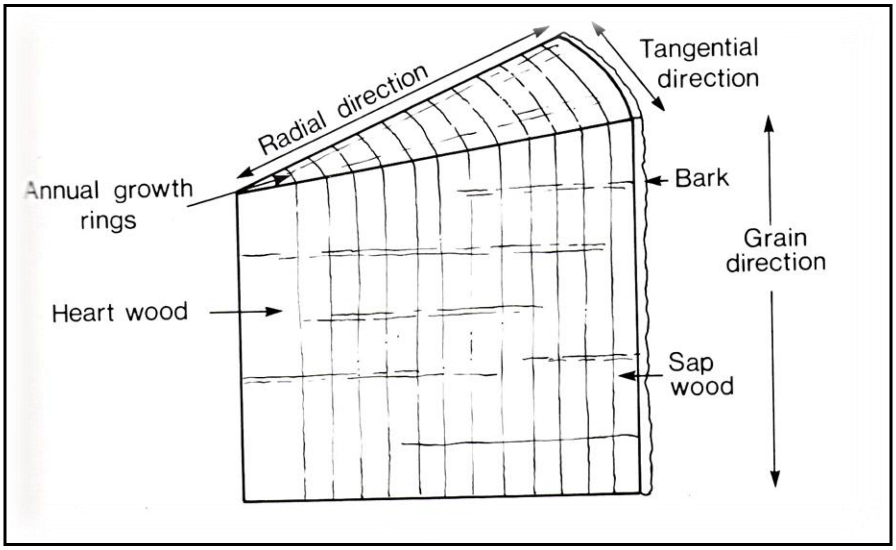


Figure 17: Diagram of the structure of a tree trunk (Cronyn 1990).

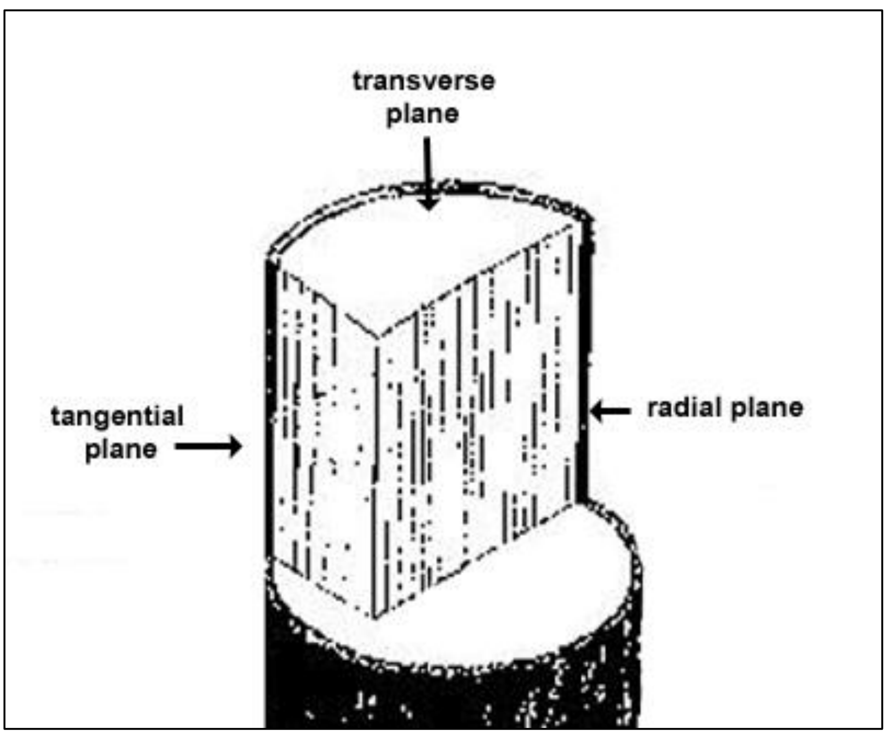


Figure 18: Diagram illustrating the primary planes of wood (Hamilton 2010).

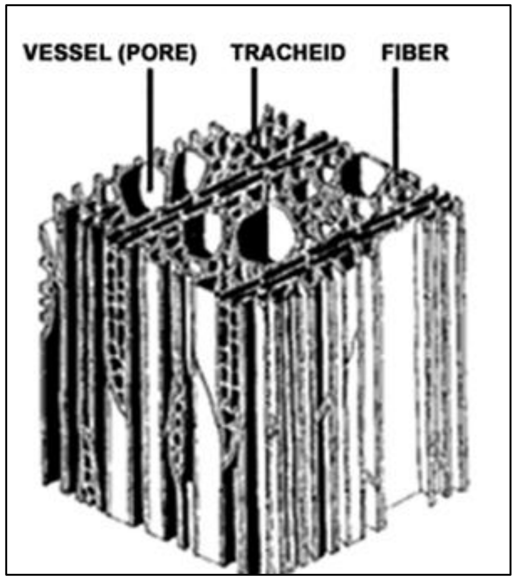


Figure 19: Diagram of hardwood cell walls illustrating the vessels, tracheids, and fiber (Hamilton 2010).

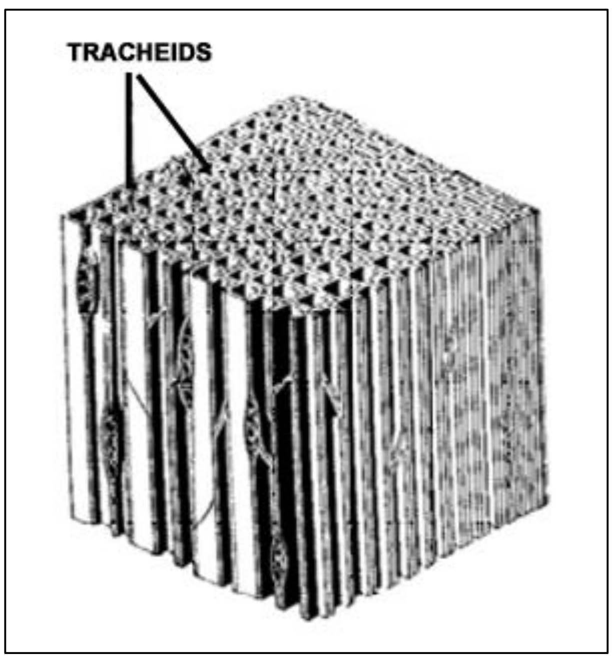


Figure 20: Diagram of softwood cell walls illustrating the tracheids (Hamilton 2010).

Samples from the Lake Phelps canoes were sent for microscopic analysis for speciation and results concluded that they are made of bald cypress (*Taxodium distichum*) (Bright 1986). Bald cypress is a softwood tree found throughout the southeastern region of the United States, from "Delaware to southern Florida, westward through the gulf coast region to southeastern Texas, and up the Mississippi Valley to southeastern Illinois and southwestern Indiana" (Kennedy Jr. 1972:1). Most bald cypress is found in swampy environments although it grows best in wet sites with good drainage. This species grows very slowly, reaching prime harvest potential at around 200 years. Trees aged to 800 years reached six feet in diameter and 120 feet in height, although trees found today are much younger and smaller. The heartwood in bald cypress is naturally resistant to decay and is well suited for use in building materials that require strength and will endure for some time (Kennedy Jr. 1972). The moderate natural resistance of this wood likely contributed to the survival of the canoes in relatively good condition for so many centuries.

Archaeological wood is subject to a variety of factors that can cause its degradation including weather, climate, rodents, insects, and microscopic organisms such as bacteria and mold (Rodgers 2004). Waterlogged wood may be found in aerobic or anaerobic environments. In aerobic environments, wood is subject to biodeterioration throughout its structure (often from mold or wood-boring organisms), while anaeorobic environments degradation is typically limited to the outer portion of its structure, leaving the inner portion structurally sound (A. Unger et al. 2001). Wood is a hygroscopic material where its moisture content (MC) can increase or decrease; when its temperature and relative humidity (RH) remain constant, the wood will reach a stable MC. When temperatures and RH vary in extremes, the wood will hydrolyze, causing it to swell or shrink, leading to further damage (A. Unger et al. 2001). In circumstances of waterlogged wooden objects, water has filled the cellular walls; as these objects are dried and water leaves the cells, the wood is subject to cracking, warping, and shrinkage resulting from the collapse of the cell walls (Hamilton 1996; Rodgers 2004; A. Unger et al. 2001).

Waterlogged wooden materials should not be dried immediately upon discovery; they should be kept wet in appropriately constructed containers until a plan for conservation has been determined. Two methods are used for conserving waterlogged wooden materials, impregnation and bulking. Impregnation involves using agents that fill the cell lumen to prevent distortion and collapse, and are used when the cell walls are severely damaged. Bulking involves using agents that fill the cell walls only to prevent shrinking and warping (Rodgers 2004). Canoe 3 and Canoe 4 were bulked with a sucrose solution. Over time, surface deposits developed in varying amounts on each of the wooden fragments that make up each canoe.

Surface Deposits

The chemical changes of the sucrose the canoes were treated with reveals the relationship of the wood and relative humidity (RH). Sugar (sucrose) is a commonly used bulking agent within the field of conservation used to treat waterlogged wood. Although previous studies revealed sugar solutions were used to stabilize waterlogged wooden artifacts prior to the conservation of the canoes, it was not a commonly used technique at that time and relatively little was understood about how environmental factors would affect treated wooden objects (Parrent 1985). Parrent's (1985) study included experiments of waterlogged wood in various states of deterioration. Results revealed that sucrose, due to its low molecular weight, will penetrate all areas of a wooden object; hardwoods and regions on wooden objects where better preservation tend to be resistant to agents with high molecular weight. Furthermore, the hygroscopicity in wood changes when treated with sucrose. The results of this test revealed that as sucrose content increases, the hygroscopicity of wood decreases. The results of Parrent's (1985) study ultimately showed refined white sugar to be a viable bulking agent for conserving waterlogged wooden objects, and provided specific recommendations for successful conservation treatment. Sugar solutions should begin with a low sugar content and increase in incremental percentages of 1% to 5%, and eventually 10% until "the wood has reached an equilibrium at 50%" (Parrent 1985:71). In addition, a biocide should be added, and if needed, an insecticide. During the drying process, wood should be dried slowly with a high RH, decreasing both slowly. Storage conditions should be limited to under 70% and the wood should not be in conditions where the RH reaches over 80% where condensation and the leaching of the sugar could occur.

While Parrent's (1985) study was instrumental in the field of conservation, information that is more recent has been gathered since that time regarding the use of sucrose to treat waterlogged wood. The use of sucrose solutions in treating waterlogged wooden objects has several advantages: they are inexpensive compared to the traditionally used Polyethelyne glycol (PEG), easy to use, non-toxic, non-corrosive, do not generally discolor the wood, and provide stabilization (Hoffman 1996). In light of these advantages, research suggests there are some limitations that should be considered. Shrinkage and warping pose considerable risks, especially for unique, elaborate objects, sucrose may be the only realistic option for less elaborate projects (Hoffman 1994, 1996). Others have conducted trials to find alternatives to PEG and sucrose methods within warm, humid environments and found that lacitol, and mannitol + sucrose mixtures are effective conservation agents (Imazu and Morgós 1997; Morgós and Imazu 1994). Clearly, sucrose is not the "cure all" it was perceived to be, but it is an effective conservation agent in some circumstances. Furthermore, the way sucrose and wood respond in warm, humid environments is essential to understanding the conditions that necessitated the retreatment of the canoes presented in this thesis.

Sugar is a hygroscopic material and is more so than wood. While wood can be stored at the higher RH percentages recommended by Parrent (1985), sugar cannot. An ideal storage environment for sucrose was found the RH to range 55 to 65% (Hutchings and Spriggs 2004). In remembering that wood decreases in hygroscopicity with higher sucrose content, it becomes clear that lower a RH would enhance the stability of the wood. The problem that arises when sucrose is exposed to high RH environments is that, it hydrolyzes into fructose and glucose, which are both higher in hygroscopicity (Daniels and Lohneis 1997). What this means is, once sucrose hydrolyzes into fructose and glucose, instability of the sugars occurs at lower RH levels, and, depending upon the fluctuation of the environmental temperature and RH, a cycle could develop where further development of crystallized surface sugars and deterioration of the wood continues. The results of this instability are that the sucrose, fructose, and glucose can leach from the conserved wooden artifact, creating crystalized, caked, deposits on the surface. In addition, these sugars can liquefy into a syrupy substance (Daniels and Lohneis 1997; Hutchings and Spriggs 2004).

Over time, while stored and displayed in an uncontrolled environment, surface deposits developed on each of the wooden fragments of both canoes. These deposits presented mostly in the form of a brownish and white crystallized, caked substance that appeared in varying degrees. A syrupy substance formed in some areas. Chemical testing revealed the composition of the surface deposits to be 20 to 30% reducing sugars (glucose and fructose) (O'Cain, Kennedy, Watkins-Kenney, and Kenney 2010). The hydrolysis of the sugars was a result of the combination of fluctuation in room temperatures and humidity typical of the North Carolina climate, and the hygroscopicity of the sugars and the wood. As stated previously, wood is hygroscopic and its hygroscopicity decreases when treated with sugar. Although its hygroscopicity decreases, it remains hygroscopic. Fluctuations in temperature and humidity can cause shrinking and swelling. Hydrolysis of sucrose to fructose and glucose contributes to an increased retention of moisture in the wood and sugars, potentially causing further degradation of the wood over time.

Methodology

The canoes have not received any conservation treatments in their entirety since their original treatment with a sucrose solution and water; however, there have been two documented attempts to determine how to best proceed in the re-conservation of the canoes (Gilman 2014; Hauk 2011; NCDCR UAB 2014: QAR DB). In 2011, a research project conducted by graduate student Chelsea Hauck involved a series of trials to test the reaction of sucrose to different solvents, focusing on potential cleaning treatments for the canoes discussed in this thesis (Gilman 2014; Hauck 2011). This study included several treatments and immersion experiments on wood samples that were controls and not samples from the canoes themselves. In addition, this study illustrated the usefulness of solvent solutions (water, alcohol, and acetone) in the removal of sucrose from wooden objects. A conclusion from the study suggested alcohol and acetone solvents to be promising in removing sugar from wood, but did not provide specific suggestions geared towards proceeding in re-treating the canoes themselves (Hauck 2011).

In 2012, graduate assistant Hannah Smith used a 50 percent solution of ethanol (etoh) and reverse osmosis (RO) water and cotton swabs to clean sections of canoe fragment PHL0003.002 (Gilman 2014; NCDCR UAB 2014: QAR DB). Analysis in 2014 without the aid of magnification revealed the sections of this fragment that had been cleaned using this technique appeared to be a viable method for retreating the canoes; however, retreating all of the canoe fragments using this method would be an ineffective use of resources (Figure 21). It should be noted that this procedure did not result in an official report and documentation was retrieved from the NCDCR UAB QAR database.

In 2014, updated analyses were conducted to determine the current condition of the wooden fragments. The results of these analyses were that no further surface deposits have formed and the fragments appear to be stable within their current controlled environment where temperature is kept within the range of 20 – 22°C (68-77 °F) and RH at a range of 45 – 55%, keeping the environment as constant as possible. No significant changes in size or weight were observed and any variations in documented measurements were determined to be differences in measuring techniques. In addition, experimental trials were designed with a goal to determine ideal methods for re-conserving the canoes in their entirety.

Although there is extensive literature in conservation science for archaeological materials, literature for retreatment of objects such as the canoes presented in this thesis is limited. Initially, the research plan was to conduct experimental trials to determine the best option(s) to re-conserve Canoe 3; however, because the fragments of both canoes represent a wide variance of surface deposits in the form of crystallized sugars, it was decided to include a fragment from each canoe and samples from both. Initial trials included tests of chemical and mechanical cleaning treatments, immersion experiments, and scanning electron microscopy (SEM) (Gilman 2014). During the experimental trials, testing ultrasonic misting was considered. Due to the limitations of tools on hand, a technique of using a spray bottle with a high concentration of a solvent solution to dissolve the sugars into the wood was developed. These trials are the focus of the remainder of this chapter.

Figure 21: Canoe 3 (PHL0003.002) fragment showing the location of previous cleaning near the center, with a 50% (aq) etoh solution.

Mechanical and chemical conservation techniques. A series of mechanical and chemical cleaning methods were conducted on a single fragment from each canoe. The cleaning methods were chosen based upon conventional methods in the field of conservation, and the results of the previously discussed research. The fragments selected were representative of the conditions of the canoes. Canoe fragments PHL0003.004 and PHL0004.003 were selected based upon their comparable sizes and the samples could be divided relatively evenly. After the completion of each trial, results were observed macroscopically, then microscopically at 10x magnification.

Wooden objects are not evenly structured and there is some variance between sample sizes, but this was not problematic for this study. Fragment PHL0004.003 was visibly in worse condition than PHL0003.004; these fragments were representative of the differences in condition between the two canoes (Figures 22 and 23). In order to keep samples separate throughout this study, a stencil was made of each fragment (Figure 24). Initially the stencil worked, but there was no way to secure the mylar while the objects were stored away in between experiments without possibly causing further damage to the objects. A technique was developed to cut pieces of string and lay them onto the fragments according to the predetermined sample sections (Figure 25). This method proved to be viable and non-destructive (Gilman 2014).

Figure 22: Canoe fragment PHL0003.004 before treatment with the trial samples.

Figure 23: Canoe fragment PHL0004.003 before treatment with the trial samples.

A series of eight trials on each fragment were conducted using mechanical and chemical surface cleaning techniques known in the conservation field. In addition, two sample trials involving immersion were conducted. In all cases, ethanol (ethoh) was the chemical solvent selected because of previous success in cleaning sections of PHL0003.002. Furthermore, although a 50% etoh solution in RO water was previously shown to be effective, 100% etoh was selected to learn how it would affect the sugars and wooden objects. Once the sections for the experimental trials were determined, tests began. The eight samples were:

1. Control: no treatment applied.
2. 100% reverse osmosis (RO) water: applied using cotton swabs and cotton balls, using a "dabbing and rolling" technique going along the wood grain in even steps to pull out the sugar.
3. Mechanical cleaning: a variety of hand tools including toothpicks, a dental pick, and a scalpel were used to remove the macroscopically visible surface deposits.
4. 100% ethanol (etoh) solution: applied using cotton swabs and cotton balls, using a "dabbing and rolling" technique going along the wood grain in even steps to pull out the sugar.
5. Dry brushing: dry brushing with medium and stiff bristled brushes, using light-pressured, even strokes with the wood grain was used to remove the surface deposits.
6. Soot sponge: a soot sponge was used by gently pressing and "rolling" the sponge along with the wood grain to try to remove the surface deposits.
7. Poultice using Kimwipes tissue and 100% etoh solution: Kimwipes tissues were soaked in a 100% etoh solution then applied to the predetermined sample area and allowed to dry.

8. Poultice using Laponite gel and a 100% etoh solution: a poultice was created by mixing 30 grams of Laponite powder with 50 ml of 100% etoh solution.

A concern with using a poultice technique was that it might attach itself to the wood, resulting in further damage to the object. A series of tests were conducted using tongue depressors and red food coloring to test each poultice method. The results revealed the poultice removed from wood easily and absorbed the food coloring. During these tests, it became apparent that evaporation of the etoh solution would be an issue. To resolve this problem, plastic wrap was wrapped around each tongue depressor where a poultice mixture was applied and showed to resolve the problem of the etoh solution evaporating too quickly. The results of the tongue depressor tests indicated that the poultice trials should proceed.

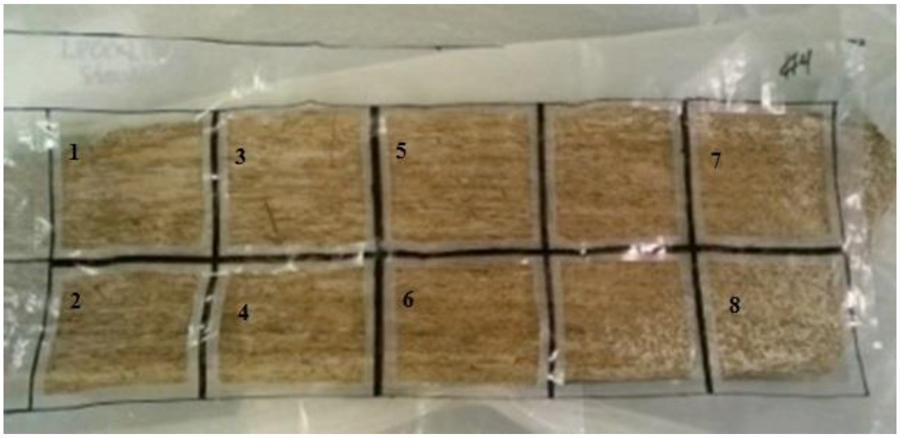


Figure 24: Canoe fragment PHL0004.003 example illustrating the use of a Mylar stencil and location of specific samples; 1 – Control sample; 2 – 100% RO water with cotton swabs; 3 – Hand tools; 4 – 100% etoh solution with cotton swabs; 5 – Dry brushing; 6 – Soot sponge; 7 – Kimwipes tissue poultice with a 100% etoh solution; 8 – Laponite gel poultice with a 100% etoh solution.

Figure 25: Canoe fragment PHL0003.004 demonstrating the string technique in use.

Although the results of the mechanical and chemical surface cleaning techniques are not macroscopically visible, differences can be viewed with the aid of magnification. While each technique used did remove some of the surface deposits, the determination of which was more successful than other techniques used was based on the context and scale of re-conserving all of the canoe fragments. For example, the use of hand tools was interpreted to be an unsuccessful technique because it would be an inefficient technique to re-conserve all of the fragments, considering the size of some fragments and the rough, uneven texture, and condition of Canoe 4 (see Gilman, 2014). The most successful trials were samples 4, 7, and 8, where a 100% etoh solution was used. In addition, these trials were more successful when applied to the Canoe 3 fragment than the Canoe 4 fragment where there are "caked" surface deposits. In any case, results indicated further experiments should be conducted before re-conservation of the canoes could begin (Figures 26 and 27).

Figure 26: Canoe fragment PHL0003.004 showing after treatment results of the experimental trials.

Figure 27: Canoe fragment PHL0004.003 showing after treatment results of the experimental trials.

Immersion. Trials were conducted to test the viability of using immersion techniques for the smaller wooden fragments from Canoe 4 to remove the crystallized sugars. Wooden samples had previously been cut from fragments from Canoe 3 and Canoe 4; however, no documentation exists indicating which fragments they were taken from. Samples for the immersion tests were taken from the Canoe 4 samples that were labeled LP4.0.1 and LP4.0.2. Both samples were immersed into a 100% etoh solution for two weeks, then air dried for one week. The sample taken from LP4.0.1 measured 2" x 1" x 1" and weighed 4.903 grams before treatment began; after treatment the sample measured 1.75" x 1" x .75" and weighed 4.090 grams. The sample taken from LP4.0.2 measured 1.5" x 1.25" x 1" and weighed 5.27 grams before treatment began; after treatment the sample measured 1.25" x 1.125" x .75" and weighed 4.195 grams. Observable changes were documented during the experiment. After one week in the immersion solution, sugar crystals had been removed or disintegrated and tiny, unmeasurable pieces of wood from each sample had broken away.

Table 4. Before and after immersion treatment measurements and weights of the canoe samples

Sample	Before treatment measurement (inches)	Before treatment weight (grams)	After treatment measurement (inches)	After treatment weight (grams)
LP4.0.1	2 x 1 x 1	4.903	1.75 x 1 x .75	4.090
LP4.0.2	1.5 x 1.25 x 1	5.27	1.25 x 1.125 x .75	4.195

The results of these trials indicated that at least some shrinking was likely and further structural damage could occur if this method was selected for re-conservation of any of the wooden canoe fragments. What these trials did reveal is that immersion could be a possible conservation method for treating the smaller canoe fragments, but a less pure solvent such as a 25% or 50% (aq) etoh solution would likely be a better option. In addition, the shrinkage of the samples here indicates immersion should be carefully considered when used in conservation.

Scanning electron microscope (SEM) analysis. The fragility and conditions of the canoe fragments can be observed without the aid of magnification; however, viewing samples with a scanning electron microscope (SEM) allowed the damage to be viewed at a microscopic scale, and learn whether sugar crystals were present within the wood. Wood samples were cut into less than 1 cm squared samples from larger samples previously taken from both canoes. Each sample was cut with a sterile scalpel and placed onto a platform designed for SEM analysis. Samples were cut from the Canoe 3 sample that had been previously cut and labeled 3/1.1. There have not been any treatments applied to this sample. Other samples were taken from the LP4.0.1 sample that had not received immersion treatment, and from the sample cut from the LP4.0.1 sample that had received immersion treatment. SEM analysis provided a microscopic view of the surface and internal portions of the wooden samples. The SEM images revealed that the wood structure was badly damaged; the tracheids and rays were visibly degraded and no crystallized sugar deposits were visible (Figures 28 through 31).

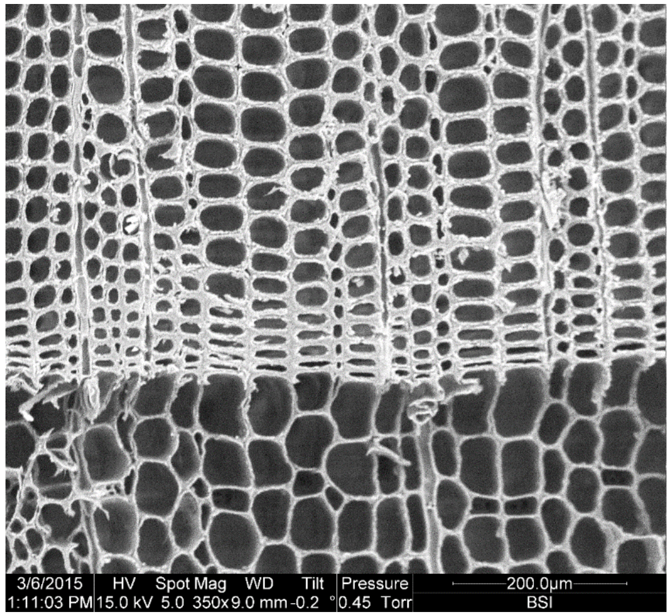


Figure 28: A transverse view of a wood sample from LP3/1.1 at 350x magnification.

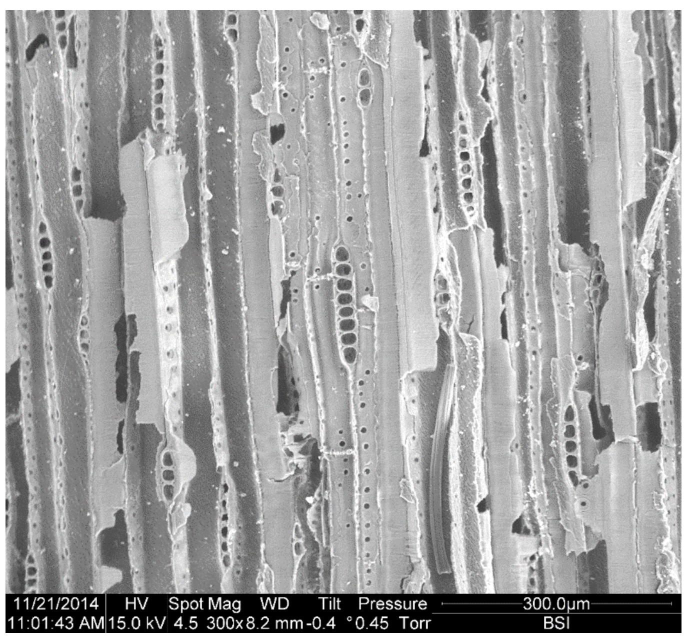


Figure 29: A tangential view of a wood sample from LP3/1.1 at 300x magnification.

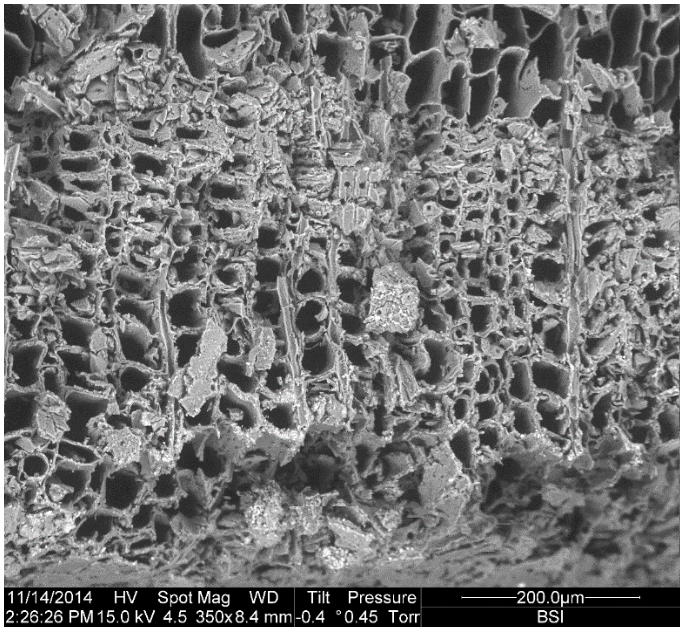


Figure 30: A transverse view of a wood sample from LP4.0.1 at 350x magnification that had undergone the immersion experiment illustrating the poor condition of Canoe 4. The brighter areas within this image are dust particles reflecting light during SEM analysis and not crystallized sugars.

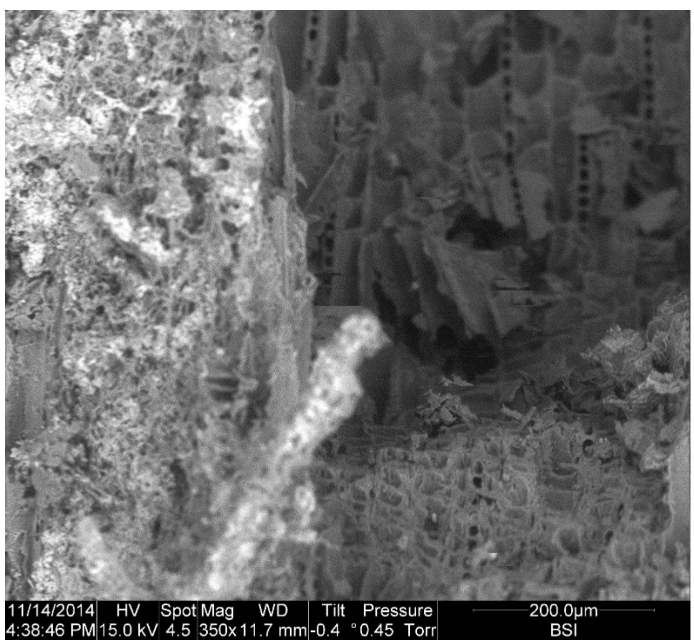


Figure 31: A radial view of a wood sample from LP4.0.1 at 350x magnification that had not undergone the immersion treatment. Notice the severity of the damage to the wood structure.

Ultrasonic misting. After the initial experimental trials were completed, collaboration with NCDCR UAB conservators located at the QAR lab resulted in testing an additional technique, ultra-sonic misting. While the trials discussed in this chapter showed potential in re-conserving the canoes, there were concerns whether they were viable on a larger scale than the samples used in the trials. Furthermore, the concept of dissolving the crystallized sugars into the wood and not removing them from the surface was introduced.

Ultrasonic misting is a conservation method that has been used to consolidate artworks and other historical artifacts where paint has been applied, but not as a technique to conserve objects such as the canoes presented in this thesis (Dignard et al. 1997; Michalski and Dignard 1997; Michalski et al. 1998). This technique was developed and first demonstrated by Stephan Michalski at the Canadian Conservation Institute (CCI) in 1989 as a way to consolidate unstable (flaking and curling) pigments in artworks; it has since been used on other kinds of artifacts where pigment is present (Dignard et al. 1997; Michalski et al. 1998). Ultrasonic misting allows the conservator to apply consolidants in a slow, controlled manner that prevents loss of evaporation of the solvent(s). Michalski and Dignard (1997) noted some of the problems with using the ultrasonic method are the method is time consuming and only non-viscous chemical solutions can be misted and not all solvents work well. Solvents such as water and ethanol have been found to work well but solvents such as acetone evaporate too quickly.

An experimental design was developed based on the concept of the ultrasonic method. Before trials could begin, there were several concepts that had to be contemplated. First, wood samples needed to be selected. The wooden fragments used in the mechanical and chemical conservation technique trials (PHL0003.004 and PHL0004.003) were selected for the reasons they were originally used; they are of similar size, are representative samples of Canoe 3 and Canoe 4 respectively, and they are easily transported within the laboratory. Second, a solvent solution was selected. Ethanol was used in the trials and results showed this to be a viable solvent; however, a comparable solvent needed to be selected based upon the inventory available at the laboratory. Reagent Alcohol was readily available in sufficient quantities and is a comparable solvent to ethanol. Third, the purity and amount of solution to be applied to the test fragments had to be carefully contemplated to be effective, but not oversaturate the wood. Through collaboration with NCDCR UAB conservators, a 75% reagent alcohol solution in RO water was chosen; the concept was that by using a solvent at a high purity level, evaporation would occur, but not too quick to dissolve the crystallized sugars back into the wood. Fourth, in the absence of an ultrasonic mister or the supplies, time, and funds to build one, an alternative device needed to be identified in order to proceed with testing. Michalski et al (1998) provides specific instructions for building an ultrasonic mister and Michalski and Dignard (1997:110) cite Arnold (1996) who has identified alternatives of ready-made devices. It was necessary to ensure the device selected was appropriate for containing solvents to prevent deterioration of the container and contamination of the solution. A *Thomas 3345 Polypropylene 240mL Adjustable Spray Wash Bottle with Polypropylene Sprayer* was identified and selected as the device to apply the 75% (aq) reagent alcohol solution to the wooden fragments for these trials. This allows for a fine spray application and contains the solvent without incurring the problems previously noted. Finally, a location for the trials to be conducted had to be identified. Initially, trials were conducted within a room where ventilation seemed adequate; however, after several applications, the location was moved to a better-ventilated space where larger fragments would be re-conserved in a larger space within the laboratory. This was outfitted with a large fan providing adequate ventilation. Smaller items could be treated under a fume hood.

The purpose of these experimental trials was to determine the viability of "spray misting" in dissolving the crystallized sugars into the wood and not re-crystallize after re-conservation. The wooden fragments would be treated with the 75% (aq) reagent solution then transferred back to their location where they are stored in an environmentally controlled area where the RH and temperature are kept as constant as possible (RH is generally kept in the range of 45 – 55% and temperature in the range of 20 – 22°C (68-77 °F)). After five treatments, both samples would be examined for evidence of sugar re-crystallization on their surfaces. It should be noted that applications of the solution involved using the "fine mist" setting on the spray bottle and a slow, even-patterned process of application with the wood grain. The solution mist was applied until the surface was damp, but not oversaturated.

The results of these trials after five applications proved to be the most successful of the trials conducted in this study; no reappearance of surface deposits developed. Observations after five treatments revealed nearly all of the crystallized sugar deposits on the PHL0003.004 fragment were dissolved; only microscopic sugar crystals remain predominantly within the cracks of the wood (Figures 32, 33, and 34). Although caked sugars remain on the PHL0004.003 fragment from Canoe 4, its condition was significantly improved (Figures 35, 36, and 37). Once the trials were completed and the conditions of the fragments supported that misting application of a 75% (aq) reagent alcohol solution is a viable and efficient conservation method, re-conservation of Canoe 3 began and continues to be in process. In addition, five treatments were slated to be applied to the Canoe 4 fragments. Further collaboration and research should occur regarding how to best proceed with re-conserving the wooden fragments from this canoe beyond the five re-conservation treatments.

Figure 32: Before misting treatment experiment photo of PHL0003.004.

Figure 33: During misting treatment experiment photo of PHL0003.004.

Figure 34: After misting treatment experiment of PHL0003.004, after five treatments.

Figure 35: Before misting treatment experiment photo of PHL0004.003.

Figure 36: During misting treatment experiment photo of PHL0004.003.

Figure 37: After misting treatment experiment of PHL0004.003, after five treatments.

CHAPTER 6: RESULTS

Several methods commonly used in conservation were tested to determine ideal techniques for re-conservation of the Lake Phelps Canoes 3 and 4. Mechanical and chemical surface cleaning techniques consisted of eight different trials on each canoe fragment from Canoe 3 (PHL0003.004) and Canoe 4 (PHL0004.003). Of these trials, three were determined to have the greatest potential for re-conserving the artifacts. Two immersion tests were conducted to learn whether this method would be viable for re-conserving the smaller wooden fragments of Canoe 4. SEM analysis was conducted on wooden samples taken from larger samples previously cut from each canoe. A technique of "misting" was developed based on the method more commonly used in consolidating artworks, ultrasonic misting. In addition, problems were identified with each technique that was observed to have the greatest potential in re-conserving the canoes. It is noteworthy to say that collaboration was vital throughout this study.

The mechanical and chemical surface cleaning techniques tested were composed of eight trials on PHL0003.004 and replicated on PHL0004.003. As stated previously, the results of each technique removed at least some of the crystallized sugars; three of these techniques had the most promising results. The remaining mechanical and cleaning techniques were not selected because they would not be an efficient use of resources, considering the scale of this re-conservation project. Each of the samples that produced the most optimal results included a 100% etoh solution. The purity of this solution was selected and tested because previous cleaning applications with a 50% (aq) etoh solution were shown to be effective on a fragment from Canoe 3 where no caked crystallized sugars were present on the surface. Several of the fragments from Canoe 4 are nearly entirely covered in surface deposits and a more pure etoh solution was tested to learn whether this technique would, more readily clean the surface deposits from the objects without damaging the wood. Sample 4 consisted of using cotton swabs and cotton balls saturated in a 100% etoh solution and "dabbing and rolling" along the wood grain. The crystallized sugars were easily cleaned from the surfaces of both canoe fragments; however, when viewed microscopically at 10x magnification, more crystallized sugars remained on PHL0004.003, especially within the wood grain sections and areas where organisms damaged the surface when Canoe 4 was temporarily stored in a pond after it was first discovered. This would prove to be the case in each of the three trials discussed in this section.

Samples 7 and 8 were variations using poultice techniques. Sample 7 consisted of using Kimwipes soaked in a 100% etoh solution while sample 8 consisted of mixing mixing 30 grams of Laponite powder with 50 ml of 100% etoh solution. A concern with testing the poultice trials was whether either poultice would adhere to the wood and not remove easily, thus potentially further damaging the objects. Experiments using tongue depressors and red food coloring were used. Once the poultice applications dried, they removed easily from the tongue depressors. Another problem was identified where the solution was evaporating too quickly. Plastic wrap was wrapped around the samples to deter this problem. Observations of the completed tongue depressor trials revealed the poultice techniques could be successfully applied to PHL0003.004 and PHL0004.003; however, the differing textures of the surfaces between these objects was not accounted for. The poultices removed the sugars more easily from PHL0003.004 than PHL0004.003.

In each of the three trials where results were the most optimal, problems were identified that suggested further trials of these techniques should be conducted before selecting any one, or all for retreatment of the wooden objects. The results of the trials with sample 4 revealed that the crystallized sugars removed easily, but additional applications may be required in the case of the areas on the Canoe 4 fragments where caked surface deposits are located. A recurring theme emerged with the completion of each trial where, although a technique was shown to remove the crystallized sugars on the small samples, using these methods on a larger scale on all of the fragments of both canoes would be an expensive use of resources, both in materials and person-hours. The technique of using a 100% etoh solution and cotton swabs and cotton balls to remove the crystallized sugars would need to be modified to a 50% (aq) etoh solution because this was already shown to work and would be more cost efficient than using a more pure etoh solution. Using a more pure solution did not dissolve the caked surface deposits, thus indicating additional trials should be conducted, focusing on the fragments from Canoe 4. Furthermore, additional trials with the poultice techniques would need to be conducted before either can be selected as a re-conservation technique to retreat the canoes. These could include additional kinds of materials similar to the Kimwipes used here could be tested. In addition, less pure solvent solutions should be tested, such as 25% and 50% (aq) etoh solutions to observe evaporation rates when combined with poultice materials such as Kimwipes and Laponite gel. A final observation concerning the poultice trials lies with the Laponite gel and 100% etoh solution mixture.

Specific "recipes" documenting exact amounts to use of Laponite gel and how it should be applied to objects are virtually non-existent. The following directions document how to mix and apply Laponite gel when conserving ceramics.

> Laponite RD is a synthetic, inorganic fine clay which, when mixed with water (5% by weight), will gradually thicken after 2 hours to form a transparent gel. The gel is then applied to the object to a thickness of 5 mm. Evaporation of the solvent can be controlled by covering the object with polythene. The Laponite RD should be removed before it becomes too hard otherwise it may cause damage. This tendency of Laponite to adhere to the ceramic surface may be reduced by applying a layer of Japanese tissue between the ceramic by misting it with Arbocel to modify the absorbency of the poultice [Oakley and Jain 2002:51-52].

This experience underscores the necessity for archaeologists and conservators to document clear and specific instructions associated with the excavation, analysis, curation, and conservation processes of the artifacts they work with. Additionally, this experience emphasizes the interdisciplinary nature of both fields; pertinent information is often located beyond the scope of the primary research topic. In any case, the results of the poultice trials discussed here reveal that additional experiments need to be tested before using either of these techniques to conserve wooden objects.

The results of the immersion trials indicated that at least some shrinking was likely and possibly further structural damage could occur if this method was selected for re-conservation of any of the wooden canoe fragments. What these trials did reveal is that immersion could be a possible conservation method for treating the smaller canoe fragments, but a less pure solvent such as a 25% or 50% (aq) etoh solution would likely be a better option. In addition, the shrinkage of the samples here indicates immersion should be carefully considered when used in conservation. Likewise, because this technique removed the crystallized sugars on the surface and presumably any sugars within the wood, re-bulking the wooden fragments would need to be carefully considered.

The SEM analyses of wooden samples from Canoe 3 and Canoe 4 fragments allowed for a comparison to be made regarding the structural condition of the canoes; this demonstrated the fact that Canoe 4 is in significantly worse condition, thus more fragile than Canoe 3. Additionally, these analyses disclosed the crystallized sugars are located on the surfaces of the wooden objects. Although it should be noted that these samples are not representative of the smaller, more fragile wooden fragments from Canoe 4, where some surfaces are entirely covered with surface deposits (Figure 36).

The strategy of the misting technique was different from the previous techniques tested in this study. Instead of removing the crystallized sugars, the concept was to dissolve the sugars into the wood, then immediately place the wooden object back into its storage space within the controlled environment where the RH is kept in the range of 45 – 55% and temperature in the range of 20 – 22°C (68-77 °F). Five treatments were applied to fragments PHL0003.004 and PHL0004.003 where macroscopic observations revealed the crystallized sugars dissolved and did not reappear. The results of these trials indicated this technique to be the optimal method to use to re-conserve the canoes, although, as in previous trials, the caked sugars did not dissolve as readily from PHL0004.003 as they did from PHL0003.004. Once these trials were completed and after collaboration with NCDCR UAB conservators, the decision to proceed with re-conserving the canoes was made. The re-conservation of both canoes is currently in progression. After each of the wooden fragments from both canoes has received five treatments, analysis of their condition will be made in collaboration with the NCDCR UAB conservators, specifically concerning Canoe 4. Currently, the smaller fragments from Canoe 4 have received five treatments and shown improvement (Figures 38 41 to be added). It is possible that the fragments from Canoe 4 will simply need more conservation treatments than the Canoe 3 fragments. Further research regarding the use or construction of similar misting devices would help to identify additional approaches in conserving archaeological materials such as the canoes that are the focus of this thesis.

Figure 38: Image of the smaller wooden fragments from Canoe 4 illustrating the varied amounts of crystallized sugars on the surfaces before misting treatments.

Figure 39: Image of the smaller wooden fragments from Canoe 4 showing improvement after five misting treatments.

CHAPTER 7: CONCLUSION

Four canoes were retrieved from Lake Phelps and subsequently conserved with sucrose solution treatments in the latter part of the 1980s. Canoe 3 and Canoe 4 are two of those canoes. Updated analyses of the other canoe fragments may indicate re-conservation is necessary in the future. The remaining 26 canoes have been documented and left *in situ*. Circumstances such as those that led to the recovery of the four canoes could occur in the future and necessitate the recovery of additional canoes. This thesis will provide a foundation for conservation treatments of any canoes retrieved in the future.

The artifacts presented in this thesis are the remains of two canoes recovered from Lake Phelps in 1986 and conserved with sucrose solution treatments to stabilize and prevent their further degradation. Prior to receiving sucrose solution treatments, both canoes were analyzed for speciation where results confirmed they are made of bald cypress (*Taxodium distichum*) (Bright 1986). Furthermore, Canoe 3 was carbon dated to c. AD 1400 and Canoe 4 dated to c. AD 340 (Beta Analytic 1987; Beta Analytic 1988; Eastman 1994; Phelps 1989; Shomette 1993; Watkins-Kenney 2008). After receiving conservation treatments, both canoes were put on display at the Information Center at Pettigrew State Park. Over time, the sugar leached out from the wood in response to the uncontrolled environmental conditions where the temperature and RH varied substantially.

The relationship of the hygroscopic nature of the wood and sucrose, and uncontrolled environmental conditions caused some of the sucrose to hydrolyze into fructose and glucose, which are more hygroscopic sugars (O'Cain, Kennedy, Watkins-Kenny, and Kenney 2012). In 2011, the canoes were relocated to the East Carolina University West Research Campus and stored in a controlled environment, keeping conditions as consistent as possible with the RH in the range of 45 – 55% and temperature in the range of 20 – 22°C (68-77 °F) (NCDCR UAB 2014: QAR DB; Watkins-Kenny 2008). The purpose of this study was to identify optimal conservation techniques to re-conserve the canoes in their entirety so they can be returned to Pettigrew State Park where they will be displayed for public viewing and education. Re-conservation of the canoes focused on their aesthetic and structural quality for long-term storage and public display, and the causal factors that led to the development of the surface deposits.

Before conservation of any object can commence, several concepts must be carefully considered. Before conservators proceed with an undertaking, advantages and limitations should be carefully contemplated and collaboration should occur whenever circumstances require it because it is a vital part of conservation projects and helps to limit mistakes (Cronyn 1990). As demonstrated in this project, collaboration can also help to identify problems as well as lead to the development of new techniques. The concepts of minimum intervention and reversibility are the basis from which conservators approach conserving objects.

Minimum intervention is not easily defined and the context in which a particular object is to be conserved must be carefully considered before proceeding with treatment(s). For example, the intent concerning the retreatment of the canoes in this thesis is they can be stored "long-term." In this case, long-term has been defined as being until they begin to degrade further or crystallized sugar deposits reappear on their surface. Another concept that was considered was the degree of "repair" to be conducted. The concept of minimum intervention is more easily defined as using the least intrusive conservation techniques required to stabilize an object while considering the contextual basis of the object being conserved.

Reversibility is generally defined as using methods that can undo conservation treatments so that an object can be re-treated in the future if and when better approaches are identified and developed (Caple 2000; Viñas 2005). The techniques used in the trials for this thesis were selected because they would not cause further damage to the wooden objects and are not permanent applications; however, as Caple (2000) and Viñas (2005) have pointed out, technically, any conservation applied to an object changes it at the molecular level. Therefore, as Caple (2000) inferred, conservation of objects should be approached with the idea that applications can be undone in the future.

The canoes presented in this thesis have implications in both archaeology and conservation. Concerning archaeology, the focus does not, nor should it end once artifacts are excavated and curated; they should be made available for the interested public's enjoyment and education. This being said, other considerations must be evaluated. For example, Canoe 3 was made by people from the Middle Woodland Period and Canoe 4 by people from the Late Woodland Period, people who no longer exist. As discussed in Chapter 3, the Woodland peoples are believed to be the ancestors of the Algonquin people early colonists first met; the way in which these artifacts are interpreted and publicly displayed are essential concerning the relationships between archaeologists and Native American peoples today.

As Watkins (2013:261) points out, "archaeology cannot and does not" answer the questions we construct about past peoples. We are influenced by our own cultural biases when making interpretations about the past and it is important we consider how we construct our interpretations, especially how we portray the ancestors of descendant and other cultural groups. A central feature of public archaeology as Watkins (2013) suggests is collaboration, including building relationships with other cultural groups. As stated previously, a comprehensive archaeological study has yet to be done of the Lake Phelps region (Curci 2006). Should a comprehensive study be conducted in the future, it may attract interest from descendant groups who may provide useful insights about any artifacts found during said study. This is not to say that we, as archaeologists are disinterested in scientific evidence, indeed, we are, but non-western narratives are as important as our own because they can help to limit the biases of our interpretations. In addition to archaeological concepts, the re-conservation of the Lake Phelps canoes presented in this study offers a framework for future conservation projects of this nature.

Several experimental trials were developed using commonly used techniques within the conservation field to determine optimal methods for re-conserving the canoes in their entirety. Initially, three techniques were identified as being the most viable to retreat the wooden fragments, although initial results indicated further tests needed to be developed and completed before re-conservation could begin. While collaborating on developing further tests, an alternate technique was presented; instead of cleaning the sugars from the wooden surfaces, the focus was to dissolve the sugars into the wood. This additional trial was developed, based on ultrasonic misting, a method used in consolidating artworks and other artifacts with unstable (curled, cracked, peeling) pigments. A 75% (aq) solution of reagent alcohol was selected as the chemical agent to dissolve the sugars. Using a solution of this purity would dissolve the sugars and the moisture would evaporate from the wood without oversaturation. The device selected in which to administer the solution was a polypropylene spray bottle with a polypropylene sprayer, and a light mist spray function. This technique has shown to be the most viable technique in which to re-conserve the canoes. Although treatments have been successful, further collaboration and testing should occur concerning re-conserving Canoe 4 due to the caked surface sugars present on most of the surfaces of the fragments. The process of re-conserving the canoes, with the focus of retreating Canoe 3 first is still in process at the writing of this thesis.

In addition to constructing an experimental design to learn which conservation methods would be ideal for re-conserving the canoes, research had to be conducted to understand the factors that caused the crystallized sugars to form on the surface of the wooden fragments. Once the canoes have been re-conserved, they will be relocated back to Pettigrew State Park for long-term storage and public display. Before they can be returned, an environmentally controlled space must be identified and constructed where the temperature (20 – 22°C (68-77 °F)) and RH (45 – 55%) are maintained within constant ranges to maintain the stability of the canoes. Maintaining a controlled environment is a primary factor in stabilizing the artifacts as evidenced by Canoe 3 and Canoe 4 being stored in their current controlled environment since 2011 and no observable changes in their condition have been made. A stable, controlled environment is an essential factor, but not the only one that must be understood.

Both wood and sugar are hygroscopic materials, meaning they have a maximum point at which they can maintain moisture within certain temperature and humidity ranges. When wood is treated with sucrose, its hygroscopicity decreases. Wood can be safely stored with the RH reaching 80% (Parrent 1985). Although wood decreases in hygroscopicity when treated with sucrose, sucrose is higher in hygroscopicity and will hydrolyze at lower RH levels. An ideal RH range in which to store sucrose was found to be 55 – 65% (Hutchings and Spriggs 2004). When sucrose is exposed to high RH environments, it hydrolyzes into fructose and glucose, sugars higher in hygroscopicity. These sugars will hydrolyze within lower RH ranges, creating a syrupy material and caked sugar deposits (Daniels and Lohneis 1997). Within unstable, uncontrolled environments, the instability of the sugars and shrinking and swelling of the wood will, over time, cause further degradation of the wood.

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