Wooden Artifacts in Cemeteries: A Reference Manual

by

Anthony & Associates, Inc.
P.O. Box 271400
Fort Collins, Colorado 80527

for

The Historic Preservation Commission
City of Aspen, Colorado

and

The National Center for Technology and Training
645 University Parkway
Natchitoches, Louisiana 71457

NCPTT Grant No. MT-2210-07-NC-04

January 2009

Acknowledgements

Anthony and Associates Inc. would like to thank the many people who were willing to volunteer their time and knowledge for the completion of this project. In particular, we would like to thank Dean Reudrich with Historic North Carolina, Patricia Suggs of the Beaufort Historical Association, Kathy Stockton of the City of Cripple Creek's Historic Preservation and Planning Department, Steve White and Art Tremayne of the Cripple Creek Maintenance Department, Nancy McDonald, a Cripple Creek Historic Preservation Commissioner, and Amy Guthrie and Sara Adams, historic preservation staff for the City of Aspen, Colorado. We also acknowledge the administrative support of the Association for Preservation Technology International and the financial support of the National Center for Technology and Training that made this work possible.

This document was developed under a grant from the National Park Service and the National Center for Preservation Technology and Training. Its contents are solely the responsibility of the authors and do not necessarily represent the official position or policies of the National Park Service or the National Center for Preservation Technology and Training.

Ronald W. Anthony, Wood Scientist, Anthony & Associates, Inc.
Kimberly D. Dugan, Preservation Specialist, Anthony & Associates, Inc.

January 21, 2009

Table of Contents

Acknowledgements ii
Table of Contents iii
Executive Summary v
Introduction: Saving Wooden Artifacts in Cemeteries 1
Intended Audience 1
How to use this Manual 1
Understanding Wood in Cemeteries and Implications for Historic Preservation 2
Wood Characteristics 2
Wooden Markers and Artifacts in the Environment 3
The Secretary of the Interior's Standards for the Treatment of Historic Properties 4
Mechanisms of Wood Deterioration 5
Weathering 5
Moisture 10
Mold and Mildew 10
Lichens and Moss 11
Decay Fungi 15
Insects 20
Identifying Infestations 27
Mechanical Damage 29
Methods for Identifying and Monitoring Problems 33
Visual Inspection 34
Probing 34
Moisture Detection 36
When to Call an Expert 37
Corrective Measures 37
Controlling Water 38
Vegetation Management 39
Coatings to Retard Moisture 40
Ultraviolet Light Blockers 42
Water Repellents and Water Repellant Preservatives 42
Semi-transparent Penetrating Stains 43
Varnishes, Polyurethanes, Lacquer, and Shellac 44
Oil Finishes 44
Borate Rods 46
Epoxy Consolidants 47
Repairs 47
Determining Wood Species 48
Replacement 50
Alternative Materials 50

Considerations for Repair and Treatment 51
Documentation and Planning 52
Soil Conditions and Microclimate 52
Advanced Assessment Methods 52
Repairing Elements with In-Kind Materials 53
Repairing with Alternative Materials 57
The Application of Surface Treatments and Penetrating Finishes 61
Encasement 61
Summary 61
References 63
Appendices 68
Sample Wooden Marker Condition Assessment Form 69
Research Needs for Wooden Artifacts in Cemeteries 79

Executive Summary

In 2008, the City of Aspen, Colorado received a grant from the National Center for Preservation Technology and Training to fund the research and compilation of a comprehensive manual written for cemetery stewards to facilitate the preservation of wooden artifacts in cemeteries. The document is intended to fill the current void – the lack of easily accessible information on the conditions and conservation of wooden artifacts in cemeteries. The goal of the document is to provide a foundation for understanding wooden artifacts in cemeteries and offer realistic preservation options for cemetery stewards who must often act to preserve fragile artifacts with limited financial resources. Additionally, the manual identifies the research priorities necessary to develop state-of-the-art methodologies and technologies for cemetery conservation.

The manual provides information on the mechanisms of deterioration for wooden artifacts, methods of identifying forms of deterioration, and possible treatment options. The first section, Understanding Wood in Cemeteries, discusses some of the physical properties of wood and the reasons why treatments suitable for wood in structures or museum artifacts are not always suitable for wooden artifacts in cemeteries. This section also includes an overview of the Secretary of the Interior's Standards for the Treatment of Historic Properties. The second section, Mechanisms of Wood Deterioration, identifies the various forms of wood deterioration that can occur within wood exposed to the elements. The third section, Methods of Identifying and Monitoring Problems, serves as a how-to guide for cemetery stewards to assess the conditions of the wooden artifacts in their care, while the fourth section, Corrective Measures, offers low-cost, low-maintenance options for extending the life of wooden cemetery artifacts. The final section, Considerations for Repair and Treatment, is provided to emphasize that wood within an environmental context functions as a part of that environment and reiterates the importance of understanding the impact of the environment on repairs and treatments. This section includes examples of failed repair and treatment attempts and also discusses the limitations of current repair and treatment options. Advanced assessment technologies that can help to extend the service life of wooden artifacts in cemeteries are also discussed in this section.

Wooden artifacts in cemeteries are often overlooked as pieces of significant cultural heritage and dismissed as impermanent and/or unsalvageable objects. This manual provides the guidelines for simple, affordable maintenance procedures that can extend the service life of wooden artifacts for years, if not decades, to come.

Introduction: Saving Wooden Artifacts in Cemeteries

Cemeteries are important repositories of local and national history, valued not only for the stories they tell, but also for their emotional and civic connections. Cemeteries in the United States range from large, well-funded and well-maintained historic sacred grounds to forgotten, or nearly forgotten, patches in the rural landscape. In all these locations, monuments and other artifacts are constantly under assault from the forces of sun, wind, rain, snow, ground water, pollution and vandalism. For cemetery stewards, this constant assault creates a tremendous challenge – to forestall the deterioration of irreplaceable civic and personal historic resources.

The wooden grave markers and enclosures created by early pioneers or less affluent families without access to long-lasting monuments are in danger of being lost to the effects of time. We need better means to protect these cultural resources. This document helps to fill the current void – the lack of easily accessible information on the conditions and conservation of wooden artifacts in cemeteries. Additionally, this document identifies the research priorities necessary to develop state-of-the-art methodologies and technologies for cemetery conservation.

Intended Audience

This document is intended to serve as a reference manual for cemetery stewards seeking to conserve the wooden artifacts under their care. Because many cemetery organizations are volunteer and often have limited funds for maintenance and preservation, this manual focuses on low-cost practices and preventive maintenance procedures that can extend the service life of wooden artifacts. Many of these approaches can be conducted by laypersons with minimal technical training. Other preservation options that require higher levels of maintenance and/or a skilled technician are also discussed; however the goal of this document is to provide a foundation for understanding wooden artifacts in cemeteries and offer realistic preservation options for cemetery stewards with limited financial resources.

How to use this Manual

Since wooden cemetery artifacts have unique characteristics and properties that differ from stone and metal monuments, it is important to have a basic understanding of wood and wood deterioration as well as the available treatment options for artifact preservation. Therefore, this manual is divided into five main sections. The first section, Understanding Wood in Cemeteries, discusses some of the physical properties of wood and the reasons why treatments suitable for wood in structures or museum artifacts are not always suitable for wooden artifacts in cemeteries. This section also includes an overview of the Secretary of the Interior's Standards for the Treatment of Historic Properties. The second section, Mechanisms of Wood Deterioration, identifies the various forms of wood deterioration that can

occur within wood exposed to the elements. The next section, Methods of Identifying and Monitoring Problems, serves as a how-to guide for cemetery stewards to assess the conditions of the wooden artifacts in their care, while the fourth section, Corrective Measures, offers low-cost, low-maintenance options for extending the life of wooden cemetery artifacts. *The final section, Considerations for Repair and Treatment, is provided to emphasize that wood within an environmental context functions as a part of that environment and reiterates the importance of understanding the impact of the environment on repairs and treatments.* This section also discusses the limitations of current repair and treatment options, as well as some advanced technologies that can help to extend the service life of wooden artifacts in cemeteries.

Understanding Wood in Cemeteries and Implications for Historic Preservation

It is important to understand that wooden artifacts in cemeteries experience more harsh environmental conditions than wood used in the construction of homes and buildings. Preservation and treatment options for wooden artifacts in cemeteries are limited because of these environmental conditions, as well as by their status as significant historical and cultural relics. Because of this, a brief overview of the physical characteristics of wood and a discussion of the Secretary of the Interior's Standards for the Treatment of Historic Properties have been included in this document.

Wood Characteristics

Because all wood comes from trees, a basic understanding of tree physiology is essential to understanding the properties of milled lumber (and therefore wooden artifacts in cemeteries). Trees have a protective layer of bark, composed of dead wood cells, surrounding their trunks and branches. Just inside the bark is a very thin layer of cells called the cambium, which creates new wood cells. The new cells created on the inside of the cambium are a zone of living cells referred to as sapwood. Sapwood serves to store the nutrients of the tree and transfer sap up from the roots to the leaves. The size of the sapwood zone varies depending on tree species and the size of the tree. At the inner edge of the sapwood there is a transition into the heartwood. Heartwood is not "living" wood in that it is not involved in the transfer of nutrients throughout the tree, but it does contribute to its structural strength. Finally, at the very center of the trunk is the pith. The pith of the tree is a small core of weak cells generated from the first years of growth.

Under a low-powered microscope, a section of wood would resemble a bundle of straws packed tightly together. These "straws" are the tubular sapwood and heartwood cells whose long axes run parallel to the long axis of the tree trunk. The cells are made of cellulose and are bonded together by lignin, a cementing substance. The direction of these tubular cells is referred to as the grain of the wood; grain

direction is very important to understanding how a piece of wood behaves when subjected to various environmental conditions because the properties of wood with parallel grain differ significantly from wood with perpendicular grain. Most trees exhibit a pattern of concentric circles when viewed in cross section; these circles are bands of light and dark wood and represent the growth rings of the tree over the course of its life. The dark rings, called latewood, are denser and thinner than the light-colored rings, as they represent the growth of the tree in the fall and winter. The light-colored rings are generally much wider than the dark rings and represent the faster growth that occurs in spring and summer. This earlywood is typically less dense and weaker in structure than latewood growth.

Most wooden cemetery artifacts currently in existence were created from milled wood. Trees can be milled in a number of ways, and each piece of lumber will have different properties based on the orientation of the grain and how it was cut from the log. Varying grain orientations can cause pieces of lumber to distort differently as the wood dries. Living trees contain significant amounts of water, and after a tree is cut, the water starts to evaporate. These distortions can include cupping, twisting, bowing, checking, and splitting. Wooden cemetery artifacts may have any or all of these distortions, as markers and grave fences were typically hastily constructed and were not allowed to season (dry) before being erected as grave monuments. Additionally, the manner in which a wooden grave artifact was milled will affect its durability when exposed to wood-deteriorating conditions such as ultraviolet light and cyclic moisture and/or freeze-thaw episodes. There are many sources for additional information on the nature of wood; an excellent reference that discusses the fundamentals of wood physiology is *Understanding Wood,* by R. Bruce Hoadley (see References for a full bibliography).

Wooden Markers and Artifacts in the Environment

Wooden artifacts in cemeteries include head and foot markers, crosses, plaques, sculptures, grave curbs, grave fences, grave houses, and plot enclosures, as well as historic perimeter fences. These artifacts function within the environment in which they are placed. Unlike wood used in the construction of a house or building that is typically periodically maintained, smaller wooden cemetery artifacts are continuously exposed to the elements, which hasten wood deterioration. Additionally, most wooden cemetery artifacts are in contact with the ground. Typically, wooden markers and grave fence posts are installed with the end grain buried in the ground; because wood cut perpendicular to the grain cuts across the long tubular cells that once served to pull moisture up from the roots and nutrients down from the leaves in a living tree, a wooden artifact installed with the end grain in contact with the ground is continually wicking moisture from the damp soil. Because of this phenomenon and the continual exposure to ultraviolet light, rain, wind, and freeze/thaw cycles that most wooden artifacts in cemeteries undergo,

conditions are generally too extreme for intermittent or random application of water repellents, water repellent preservatives, penetrating oils, paints, and other protective wood treatments to be effective. However, protective finishes and treatments may extend some benefit with frequent, routine maintenance, and those treatment options are discussed in the Corrective Measures section of this document.

The Secretary of the Interior's Standards for the Treatment of Historic Properties

The majority of cemeteries with wooden grave markers and enclosures are old enough to be considered for eligibility with the National Register of Historic Places, and certainly the preponderance of wooden cemetery artifacts surpasses the 50-year eligibility requirement. Prior to conducting any preservation work, the historic status of a cemetery should be identified, but regardless of any recognized historic status, cemeteries are places of regional, cultural, and personal significance. As such, every effort should be made to adhere to the Secretary of the Interior's Standards for the Treatment of Historic Properties, which require that the historic character of a property be retained and preserved and prohibit the replacement of intact or repairable historic materials. This includes character-defining features of a property, such as the wooden grave markers and enclosures of a cemetery.

All work, including protective coatings, preservative treatments, and repairs, conducted on wooden artifacts within cemeteries should therefore be compatible both physically and visually with the artifact and the cemetery as a whole, as well as documented and identifiable (upon close inspection) for future research and preservation efforts. Distinctive materials, features, finishes, and construction techniques or craftsmanship of the artifacts should also be preserved, which may limit some treatment options. If chemical or physical treatments are necessary, those treatments should be applied using the gentlest methods possible. If repairs to wooden markers, grave enclosures, or other artifacts are necessary, the existing condition should be evaluated to determine the appropriate level of intervention needed. If there are areas of deterioration severe enough to require repair or limited replacement of an element, the deteriorated material should be replaced with the same species and match the original material in composition, design, color, and texture. Additional information on the Secretary of the Interior's Standards for the Treatment of Historic Properties can be found online on the National Park Service website at http://www.nps.gov.

In addition to the Secretary of the Interior's Standards, the American Institute for Conservation of Historic & Artistic Works provides a Code of Ethics that is appropriate when working on wooden artifacts in cemeteries. The key elements of their Code of Ethics are:

1. Do no harm
2. Respect and retain
3. Minimize impact

4. Understand treatments and materials used
5. Be authentic
6. Identify
7. Document
8. Maintain and protect

Additional information on AIC can be found at http://aic.standford.edu.

Mechanisms of Wood Deterioration

Weathering

Weathering of wood is the result of the action of cyclic wetting and drying, exposure to ultraviolet (UV) light and erosion of the wood through wind-blown debris (a process similar to sand blasting). Weathering is a long-term process and is a significant factor in the deterioration of wooden-artifact components, often resulting in the loss of lettering on grave markers. The weathering process changes the appearance of wood and gradually erodes the wood fibers, but the process is slow enough that collapse of a wood member due to decay or insect attack generally occurs long before weathering becomes a major factor in the wood failure. We typically think of weathered wood as aesthetically pleasing because it adds an air of authenticity to historic sites, and, unlike decay or insect attack, it seldom damages the wood enough to require replacement (Figures 1 and 2).

Figure 1. A grave marker with the gray wood typical from UV exposure and weathering-caused cracks and checks that allow moisture penetration

Weathering is often the primary mode of deterioration of wooden artifacts in cemeteries because wood in cemeteries is typically exposed to precipitation and direct ultraviolet light. Weathering is readily apparent from the grey and brown surfaces of the wood and the small splits that develop during the weathering process.

As noted above, the weathering process consists of cyclic moisture and associated shrinkage and swelling of the wood, coupled with exposure to high ultraviolet light and erosion of the wood by wind-blown debris. Initially, the wood grays or darkens and small seasoning checks and splits begin to develop on the wood surface that allow for moisture penetration (Figures 1 and 2). These turn into longer splits due to cyclic wetting and drying of the wood or freeze-thaw action. As moisture is absorbed into the wood, the wood expands, generating more splits and establishing a favorable environment for active wood decay.

Figure 2. The top of a grave enclosure corner post showing splits developing from cyclic moisture or freeze/thaw episodes.

In addition to the graying from UV exposure and swelling, shrinking, checking and splitting due to moisture intrusion, wind-blown debris facilitates the weathering process by continually eroding fibers on the exposed wood surface. Wind-blown debris can also collect in crevices, inhibit moisture evaporation, and serve as a growth medium for wind-blown plant spores and seeds (Figure 3). As the weathering process continues, individual wood fibers on the surface begin to slough off the artifact. The lighter-colored earlywood in the growth rings erodes faster than the darker, denser latewood bands, resulting in a rough surface texture.

In addition to individual fibers sloughing off, small wood chips are lost as the checks and splits meet. The exfoliation of small pieces of weathered wood exposes fresh surfaces which are then exposed to the weathering process. This process is slow and varies by wood species and the amount of environmental exposure. In general, however, wooden artifacts lose up to a quarter inch of thickness per century of exposure, depending on the wood species. In addition to exposure, the weathering rate is greatly influenced by wood density, climate, and soil conditions (see Figure 4 for examples of varying degrees of weathering).

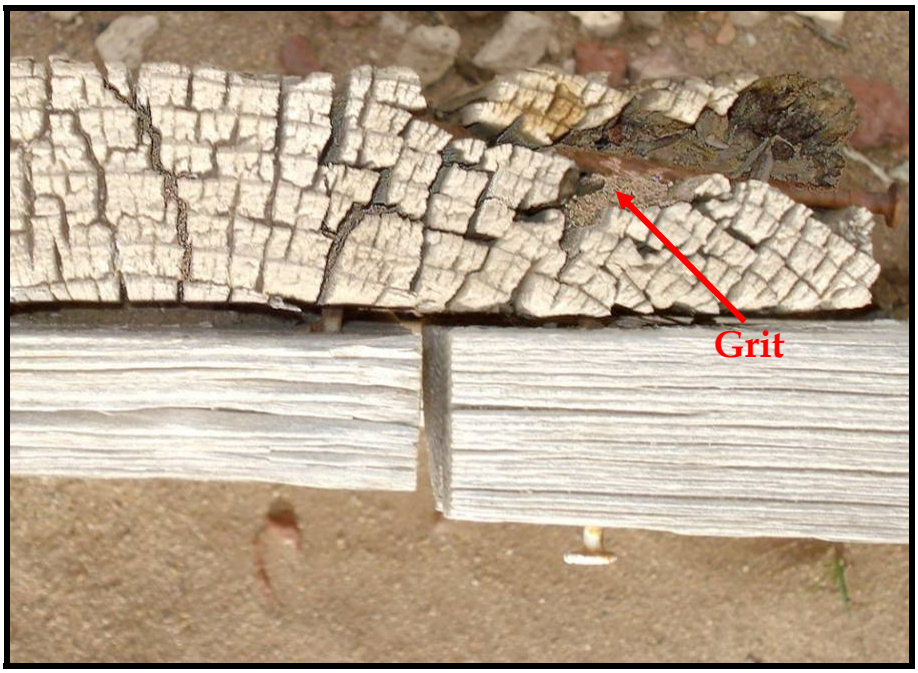


Figure 3. Detail of a grave enclosure post with weathering, showing sand and grit accumulating within the crevices.

Where moisture can penetrate the wood, shrink-swell and freeze-thaw cycles can loosen the connections between wood fibers to the point where gaps develop. As the gaps increase in size with cyclic moisture effects, more wood surface is exposed to ultraviolet light and contact with moisture, thereby accelerating the rate of deterioration. Decay fungi will eventually find their way into the exposed wood. Weathering of the wood over time (decades) will make it possible for decay fungi to enter the wood through the many checks and splits (Figures 5 and 6). Eventually, the decay process, which is much more rapid than weathering, will become the dominant means of deterioration.

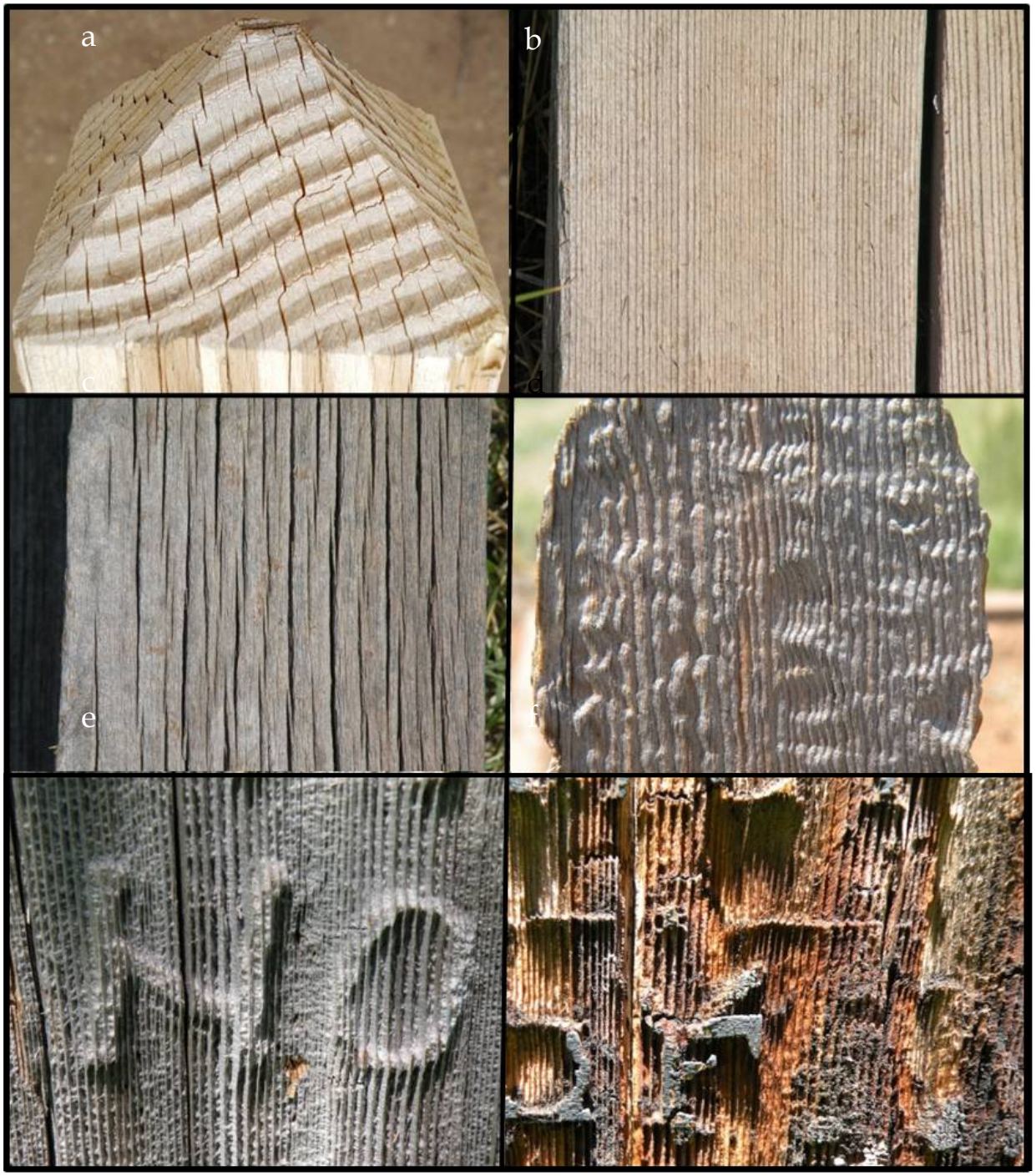


Figure 4. Examples of weathering ranging from some surface checking and slight discoloration (a through c) to extensive erosion of the softer earlywood (d through f).

Figure 5. A small, almost unrecognizable, key-shaped foot marker with organic debris collecting within heavily weathered and insect-damaged crevices.

Figure 6. A grave enclosure corner post with debris collecting in a deteriorated area. This is an example of weathering that can lead to cavities susceptible to decay.

Moisture

Moisture is not so much a mechanism of deterioration as it is the means for forms of deterioration to develop and progress. Moisture serves as a catalyst for many forms of deterioration and is an integral component of weathering (including freeze-thaw action), decay and insect attack. Moisture stains are not an indication of damage to the wood but a record of the wood being exposed to water either repeatedly throughout its life or for an extended period of time. Moisture can cause nails and screws to rust, which can cause additional staining of the wood (Figure 7). As previously mentioned, moisture aids in the weathering process by causing wood to swell or shrink, thus generating checks and splits as the wood fibers expand or contract. Wood that is not exposed to environmental weathering or in contact with a source of moisture can remain stable for decades or centuries. Wood that reaches a moisture content of 20 percent or more is at risk for decay fungi and insect attack. Wood with a moisture content higher than 30 percent has a high probability of decay and insect infestation.

Figure 7. Stains on a grave enclosure caused by the combination of moisture and a chemical reaction between extractives in the wood and the metal fasteners.

Mold and Mildew

Molds and mildews are types of fungi that do not deteriorate wood but can cause surface discoloration (Figure 8). Most molds and mildews are green, orange, or black and are powdery in appearance (Levy 1979). Sapstain or bluestain fungi can penetrate deep into the wood and stain it blue, black, or gray, but similar to surface-staining molds, they do not weaken the wood. If spores are present, they can grow very quickly on moist wood or wood in very humid conditions. Since the conditions

that are favorable for growth of molds and mildews are the same as for more destructive decay fungi, the wood discoloring organisms should be considered as warning signs of potential problems.

Figure 8. The back of a painted wooden grave marker with what is likely green mold growth.

Lichens and Moss

Lichens are unique organisms that can grow on wood but typically do not harm the wood fibers (Figure 9). Although it is recommended that lichens be removed from stone artifacts based on physical evidence, such evidence is lacking for wood, and experts do not agree on whether to remove or leave lichens on wooden artifacts. Lichens are actually two, and sometimes three, types of organisms living in a symbiotic relationship. Lichen fungi generally pair with various types of algae and/or cyanobacteria to create what appears to the naked eye to be a single organism. Lichens typically follow three growth patterns (see Figures 10 and 11). Crustose lichens have a hard, crunchy exterior and are so tightly attached to what they grow on that they can't be removed without damaging the underlying material. Foliose lichens, which are much more loosely attached to their substrate, are lobed and may appear somewhat leaf-like. Fructicose lichens are usually branched and often look like small plants growing upward or they can hang down from their locations in long strands (Desbenoit, Galin and Akkouche 2004).

Figure 9. Lichens growing on a grave enclosure corner post.

Figure 10. Crustose lichens (orange and gold) and foliose lichens (green and purple) growing on the top rail of a grave enclosure.

Lichens grow from spores and tend to grow very slowly. They need an undisturbed surface, indirect sunlight and moisture to develop. Thus, they often grow on porous surfaces such as wood and many types of stone. The fungal components of the lichen do not parasitize living plant cells, break down wood cells or provide gateways for other pathogens to enter wood fibers (Goerig and Chatfield 2004). Because most

lichens are extremely firmly embedded in their substrates, forcible removal of lichens can cause significant surface damage to wooden artifacts and is not recommended. Based on research and physical evidence, lichens on wooden artifacts, therefore, should be left in place and should not be considered as harmful to the long-term preservation of the artifact.

Figure 11. Fructicose lichens and green mold growing on grave enclosure pickets.

Mosses are non-vascular plants that can thrive on a variety of porous, moisture retentive surfaces such as brick and wood (Figures 12 and 13). Mosses grow from spores that are distributed by air currents and are generally found in damp, low-light conditions. Most mosses require near-constant moisture levels to survive. Mosses do not damage wood fibers; however, the presence of moss is an indication of a continuous high moisture environment, and the sponge-like composition of the moss plant traps moisture at the wood surface. If mosses are present on grave markers or enclosures, moisture levels are likely to be very high and decay fungi are probable. Moss can be easily removed from cemetery artifacts with natural bristle brushes and careful cleaning, but mechanical removal will spread rhizomes and spores, so unless underlying conditions are altered, the moss will likely return. While biocides are effective for killing mosses, chemical applications can cause staining of the artifact or nearby monuments, plant and animal injury, and can pollute the ground and contaminate nearby water resources (Davidson and Byther 1999). Additionally, chemical treatments do not alter the conditions that make it favorable for moss (and

wood decay fungi) growth. Mosses can more effectively be controlled by improving the underlying conditions that lead to moss growth (high moisture content and low-light conditions). Alterations made to improve ground drainage and irrigation system modifications can reduce the amount of moisture contributing to moss growth and trimming trees and vegetation that shade wooden artifacts can increase the amount of direct sunlight to help deter moss growth.

Figure 12. Moss on a grave curb. Pencil is for scale.

Figure 13. A variety of lichens and mosses growing on a log stump, indicating high levels of moisture and low levels of sun exposure.

Decay Fungi

All wood is subject to a variety of deterioration mechanisms, the most prominent of which is wood-decay fungi. Wood-decay fungi excrete enzymes that break down wood fibers, which can ultimately lead to the inability of the wood to perform its intended function. Most wood-decay fungi are only able to grow on wood with a moisture content greater than 20 percent and are unable to damage adjacent dry wood (Levy 1979). However, there are two types of fungi that are able to destroy dry wood by pulling water through several feet of root-like strands (called rhizomorphs) to moisten the wood enough to allow for decay processes to occur. Fortunately, these destructive dry-rot fungi are rare and found in limited geographic areas of the northeastern U.S. (Old House Web [OHW] 2008).

Figure 14. Cottony white fungal fruiting body found on a marker.

Wood with nondestructive white mold or mildew on the surface remains firm and sound. Wood that has been attacked by decay fungi at or just below the surface loses this firmness and is easily penetrated with a blunt awl or a similar implement with a blunt tip (more on the appropriate use of an awl as a condition assessment tool can be found in the Methods for Identifying and Monitoring Problems section of this manual). Caution: Avoid using an ice pick, a sharp awl (which is a leather awl) or a sharp screw driver as they can damage even sound wood. **Use of an awl or blunt implement to probe wooden artifacts should be done with extreme care to avoid damaging the artifact.** Typically, one or two gentle probes will reveal whether the wood has deteriorated or not. Probing the wood more than once or twice is not recommended.

More common white-rot, soft-rot, and brown-rot fungi are the typical causes of wood deterioration. Both white-rot and brown-rot fungi can produce a cottony white growth on the surface of the wood that should not be confused with non-destructive white mold or mildew (Figure 14). Wood that has white or brown-rot decay fungi will tend to be soft, friable, and easily penetrated by an awl (Figure 15). Brown-rot fungi will cause wood to darken and appear brittle and cracked. Wood affected by brown-rot fungi will ultimately shrink, twist and become dry and powdery. White rot fungi leads to fibrous, spongy wood that appears bleached or drained of color. Wood affected by white-rot begins to shrink only after advanced decay has occurred (OHW, 2008). Soft-rot fungi generally occur in wood with high water and nitrogen contents and are commonly found in fence posts and other wooden artifacts that are in contact with the ground and can "recruit" nitrogen from the soil. Soft-rot acts as its name implies and destroys the structural integrity of wood by degrading the cellulose and hemicelluloses, the materials in wood that form the wood "skeleton".

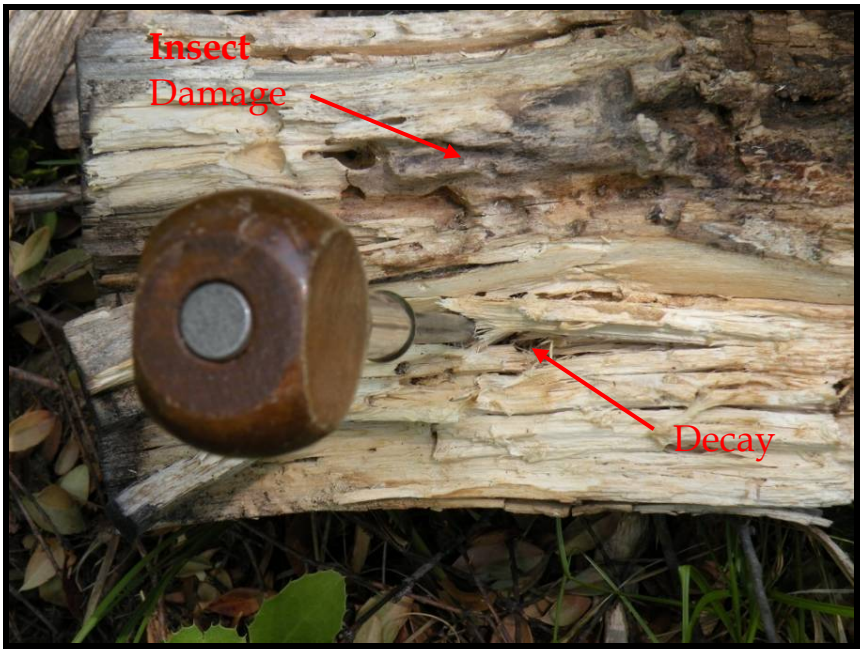


Figure 15. Example of decay (bottom half) and minor insect damage (top half) on the face of a marker at ground level. Penetration of the awl with very little applied pressure at a single location exposed the severely decayed wood.

Larger wood members, like corner posts of grave enclosures, depending on wood species, will frequently rot on the interior with no externally visible sign of deterioration. Moisture absorption though the buried end of the post, seasoning checks, or drilled holes provides a highly favorable environment for decay fungi to attack the interior of the wood member (Figure 17). Deterioration through decay is a particular concern where the wood is in contact with the ground or other materials, such as porous stone, that may facilitate moisture absorption into the wood. The decay visible in Figure 17 following the removal of the artifact from the ground could

have been detected before removal with one or two probes with an awl at the ground level.

Figure 16. Fruiting body found in association with a decaying wooden marker. The 1 ½–inch diameter awl handle is shown for scale.

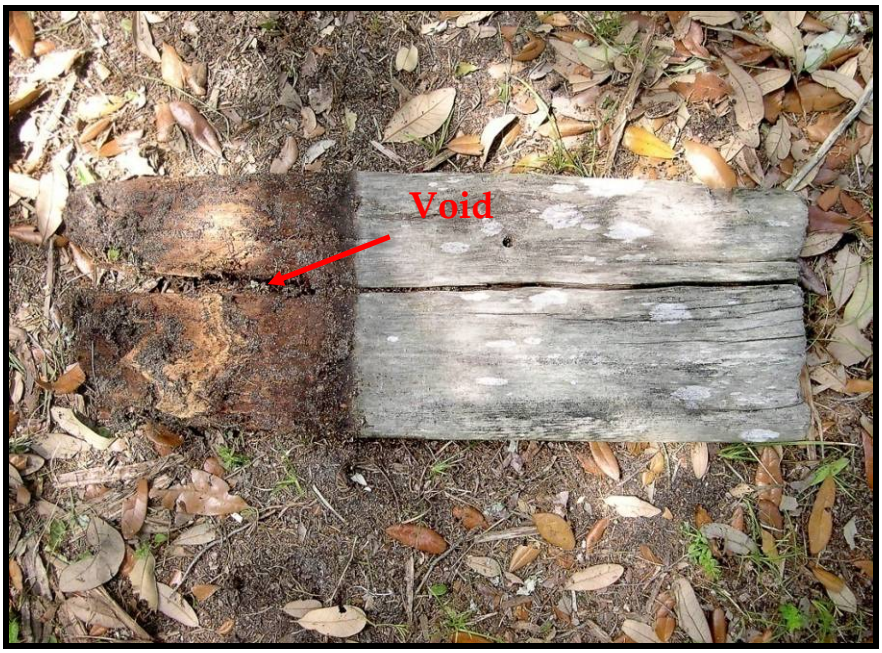


Figure 17. An example of moisture wicking along the grain of a grave marker that has allowed the growth of decay fungi and ultimately resulted in a void below ground as the decay progressed. Note: this marker was removed from the ground for research purposes. Removing artifacts from the ground for assessment is not recommended.

Decay fungi break down wood components over time. The early stage of decay (incipient decay) is characterized by discoloration and an initial loss of integrity of the wood. No voids are present. At this stage of decay, probing with an awl or blunt implement may reveal the wood to be soft or punky (sharp implements such as an ice pick or screwdriver may easily penetrate even sound wood and damage fragile, historically and culturally significant artifacts). Punky wood is spongy wood that has experienced a loss of strength and structural integrity due to the decomposition of connective fibers (Figure 18). As the decay progresses the cellular integrity of the wood deteriorates until small voids develop. These small voids continue to extend primarily along the wood grain (where it is easier for moisture to move through the wood) but can also progress across the grain.

Figure 18. Evidence of advanced decay – the below-ground portion of this marker is punky and easily breaks apart.

As wood weathers, the exposed end grain continues to swell and shrink through wetting and drying cycles, opening larger and larger gaps for moisture, and subsequently decay fungi, to penetrate the wood. Over time, individual boards may succumb to decay. This process will continue until the artifact, such as a grave enclosure, eventually collapses from loss of integrity (Figure 19).

Larger voids can develop where the decay started and the boundaries of the incipient decay will continue to extend, reducing the integrity of the wood and, potentially, compromising the ability of the wood to provide the structural support required (Figure 19). Advanced decay, the ultimate result of moisture absorbed into the wood

through either ground contact or small cracks and drying checks on the wood above ground, is a severe threat to the long-term viability of wooden artifacts (Figure 20).

Figure 19. A grave enclosure in partial collapse due, in part, to decay of the corner posts at ground level.

Figure 20. A grave enclosure corner post with signs of advanced internal decay and failure of a cross-member.

Insects

Insect attack is generally a minor contributing factor to the deterioration of wood, as most insects seek out wood that has already been compromised by high moisture content levels. Based on field observation, approximately 90 percent of wood deterioration in North America is due to wood decay. The remaining 10 percent is primarily due to insect attack. However, there are a number of wood-boring insect species that can cause significant damage to wooden artifacts and are likely to be of concern to cemetery stewards in areas where wood-damaging insects are present. In the southeastern U.S. and other humid coastal regions, in particular, insects are more likely to be an issue for wooden artifacts in cemeteries than in other parts of the country. The diversity of insect species that can damage wood is quite broad, so only the most common and most damaging of these insect pests are discussed here.

Insect attack by termites or other wood borers will reduce the cross section of a wood member by either digesting or tunneling through the wood. With decay, there is usually a gradual transition from sound wood to punky wood to a total loss of wood fiber (a void). Unlike decay, insect damage tends to have an abrupt transition between affected and unaffected areas of the wood. The mechanism of deterioration is different for insect attack but as with decay fungi, moisture is generally required and the result is a loss of integrity of the wood.

As termites are the primary cause of wood failure due to insect attack, special attention should be paid to monitor and identify potential infestations by closely examining wooden artifacts for bore holes, frass (wood substance removed by the boring action of the insect), mud tubes, and/or live insects or other evidence of wood-boring activity. A number of termite species can damage standing or fallen trees and shrubs and wooden artifacts in cemeteries. These species include subterranean termites, Formosan termites, drywood termites, and dampwood termites. While termite species found in the U.S. can be difficult to distinguish from one another, especially when swarming, each species does have specific identifying characteristics. Any suspected termite infestation within a cemetery should be handled by a professional exterminator, preferably one with experience in historic preservation.

The subterranean termite is the most common termite that attacks wood in the United States, and is found in every state except Alaska. These termites require moist wood to survive and typically damage the interior core of wood members first, so an infestation often goes unnoticed until the damage has become severe. Subterranean termites tend to eat softer earlywood first, leaving latewood in ridges around their galleries (Figure 22). These termites often enter wood members through wood in contact with the soil, but they can survive in wood with no soil contact provided the wood remains moist. A common visual indicator of subterranean termites is the presence of mud tubes on the surface of a wooden artifact (Figure 21)

or heavily channeled wood compacted with mud (Figure 22). Prolonged infestation can lead to a significant loss of wood and integrity in wooden artifacts (Figures 23 and 24).

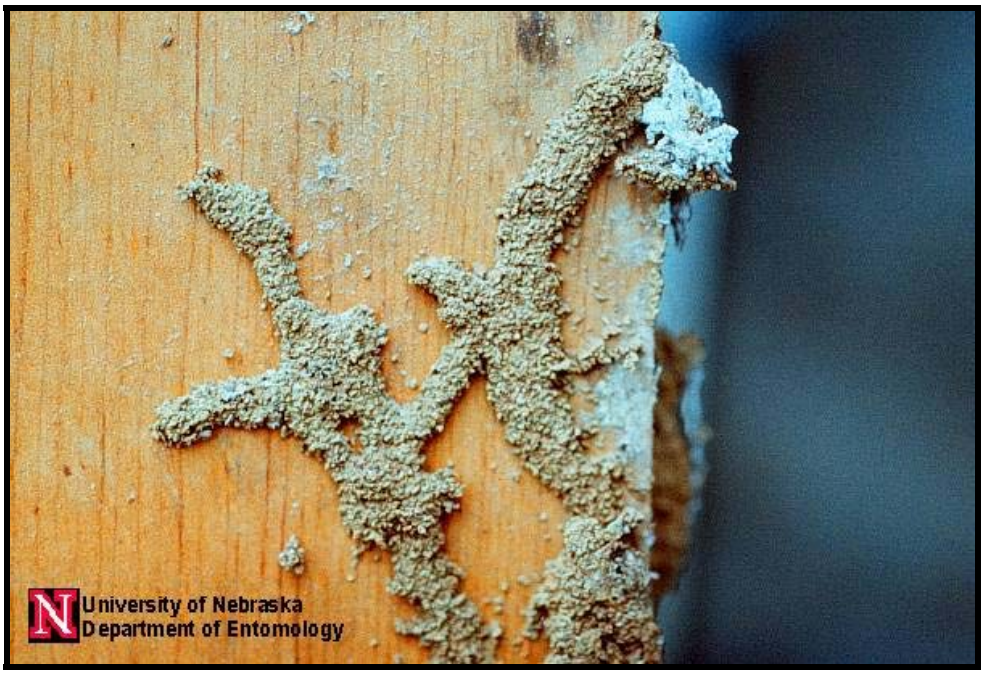


Figure 21. Subterranean termite mud tubes on lumber (Keith, 2000).

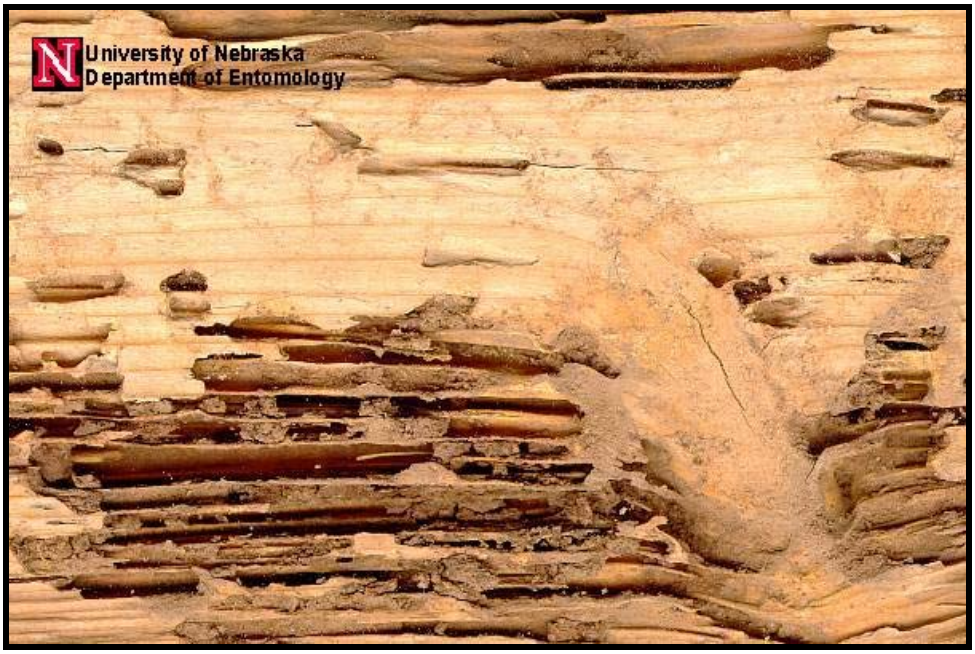


Figure 22. Subterranean termite damage in pine. Note the mud packed within the galleries (Kalisch 2000).

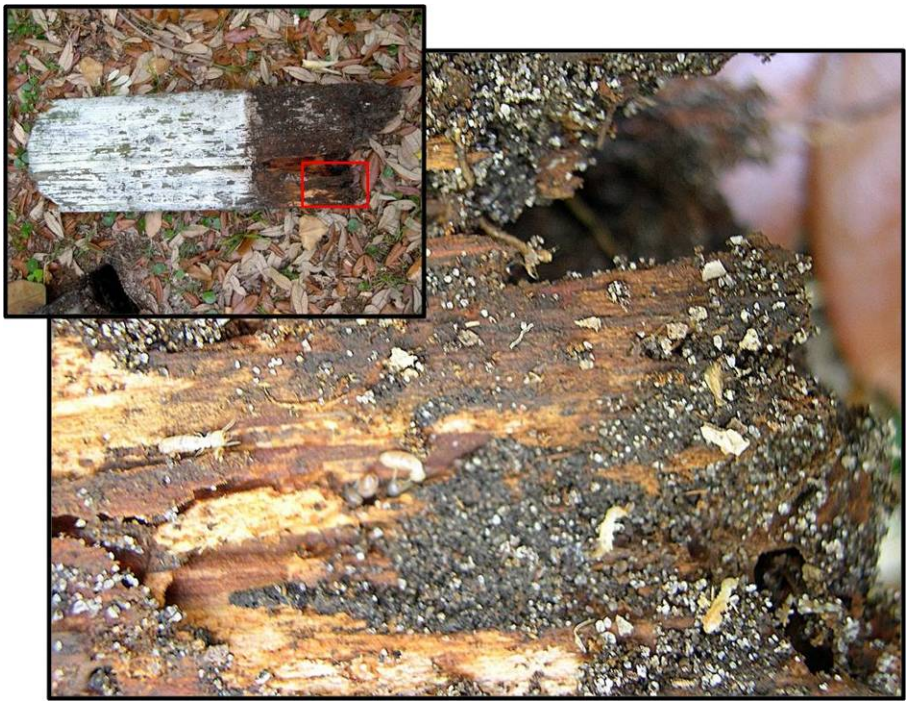


Figure 23. Subterranean termites found on the in-ground portion of a wooden grave marker.

Figure 24. Loss of wood in the underground portion of a grave marker by subterranean termites.

The Formosan subterranean termite is an invasive termite species larger and more aggressive than native North American subterranean termites. Native to southern China, Taiwan, and Japan, Formosan termite populations were established in South Africa, Hawaii and in the continental United States by the mid-1900s. A highly destructive insect species, Formosan termites live in extremely large colonies that can

contain up to several million termites with a foraging range up to 300 feet in soil. Because of its population size and foraging range, the presence of Formosan termites

Figure 25. Aggressive Formosan subterranean termites (magnified 400 percent) found in Hawaii and many southern regions of the United States (Bauer 2003).

poses serious threats to wooden artifacts in cemeteries and surrounding wooden structures, particularly along the Gulf Coast, southern California and Hawaii. There may be little to no external evidence of infestation, so wooden markers and artifacts in states known to have active Formosan termite populations should periodically be closely inspected to identify potential termite activity on an annual or more frequent basis, to prevent loss of the artifact.

It has been reported that Formosan termites are resistant to many of the commonly-used contact chemicals designed to control termite infestation (Southern Pine Council 2008). However, there is a promising new treatment that exposes termites to spores of a fungus *Paecilomyces fumosoroseus*, which kills the host termite within a few days (Agricultural Resource Service 2007). An exterminator skilled in Formosan termite extermination and with familiarity with historic preservation requirements should be called in cases where Formosan termites are suspected. Formosan termites have been reported in Alabama, Arizona, California, Florida, Georgia, Hawaii, Louisiana, Mississippi, New Mexico, North Carolina, South Carolina, Tennessee, Texas, and Virginia.

Drywood termite infestations have been recorded in Alabama, Arizona, California, Georgia, Florida, Louisiana, Mississippi, New Mexico, North Carolina, South

Carolina, Texas, and Utah. Drywood termites do not require contact with the soil or sources of moisture within the wood. Colonies can reside in non-decayed wood with

Figure 26. Typical drywood termite galleries discovered after breaking through a thin shell of sound-looking wood. Note the collection of fecal pellets. Awl handle in foreground is shown for scale.

low moisture contents. Drywood termites live in small social colonies with as few as 50 insects to over 3,000 insects for a mature colony. They remain entirely above ground and do not connect their nests to the ground with mud tubes or galleries. Typically, the first sign of a drywood termite infestation is fecal pellets collecting at or near the base of wood members. The fecal pellets are hard, angular, less than 1 mm in length and vary in color from light gray or tan to very dark brown (Figure 26). Interior galleries tend to be broad pockets or chambers connected by smaller tunnels that cut across latewood. Irreparable damage to wooden elements can be caused by drywood termites in 2-4 years, depending on the size of the element and the size of the infestation.

Dampwood termites, most commonly found along the Pacific Coast, have been identified in Washington, California, Nevada, Oregon and Montana. Some less destructive dampwood termite species also live in Florida. Although typically not as destructive as subterranean termites, with ideal conditions they can cause significant damage to wooden artifacts in cemeteries. Dampwood termites are larger than subterranean termites, and unlike subterranean termites usually build their colonies in wood that is already in the early stages of decay. As long as the wood has a high moisture content, the colony will not require contact with the ground. In relatively

sound wood, the galleries will tend to follow the softer earlywood, however, if decay is more advanced, the galleries tend to become larger and cut through harder latewood. Fecal pellets tend to be the same color as the wood being eaten and, in very damp wood, stick to the sides of the galleries in amorphous clumps (Figure 27).

Figure 27. Dampwood termites (magnified 150 percent). Note the amorphous clumps of fecal pellets, left (Scheffrahn and Su 2000).

Another wood-boring insect species, the carpenter ant, can cause damage to wooden artifacts (Figure 28). Unlike termites, however, carpenter ants do not feed on wood but rather burrow into wood to make nests. Carpenter ant infestation is most

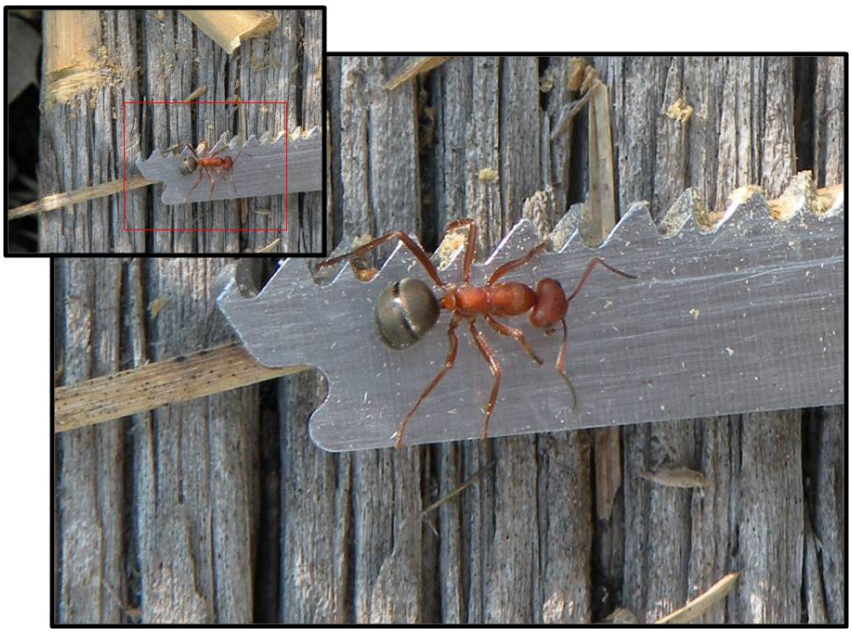


Figure 28. Detail of a carpenter ant. Saw blade is for scale.

typically identified by the presence of large (¼-inch to ½-inch long) ants that can range in color (depending on species) from dull black with reddish legs and golden hairs covering the abdomen to a combination of red and black or completely red, black, or brown. Damage to the wood is typically in the interior, but there may be piles of fibrous, sawdust-like frass in or around checks and splits. Galleries within the wood generally follow the grain.

Figure 29. A wood truss with severe carpenter ant damage (Fritsche 2005).

Carpenter bees can also damage wooden artifacts. Carpenter bees have a world-wide geographic range and vary in size and shape from small, ¼-inch long bees to large, hairy bees that resemble non-wood-boring bumblebees. There are approximately 500 species of carpenter bees, many of which build their nests in dead wood, bamboo, or structural timbers. In the U.S., 21 species of small carpenter bees can be found across the country, as well as 7 species of large carpenter bees that range across the southern states from Arizona to Florida and along the east coast as far north as Virginia (Grissell, Sanford and Fasulo 1999). Typically, only the larger species of carpenter bees create nesting galleries in solid wood and pose a risk to wooden artifacts in cemeteries. These large carpenter bee species are, on average, ½-inch or longer in length and can range in color from yellow to black and resemble non-wood-boring bumblebees (Figure 30). In several species, the females live in tunnels alongside their offspring in loose social groups. Carpenter bees typically create shallow tunnels that do not cause significant structural damage for wooden buildings or structures. Smaller wooden artifacts, however, may lose significant cross-section.

Figure 30. Carpenter bees. Image (a) is of a male carpenter bee (Witsch 2006), image (b) shows a female carpenter bee within her nest (Zinkova 2007), and image (c) shows the frass generated by the bees' wood-boring activity (PixOnTrax 2007).

Identifying Infestations

In general, wood that has been damaged by wood-destroying insects will have noticeable exit and entry holes. These holes tend to be round or oval and vary in size from $^{1}/_{50^{th}}$ of an inch to ½-inch, depending on the insect species. Wooden artifacts should be closely inspected, particularly near ground-line for evidence of insect activity. Often, frass (wood substance) and fecal pellets can be seen near or within the holes. Table 1 provides introductory information on how to identify insects based on the entry and exit holes and frass left behind. However, proper species identification and mitigation options may be difficult to determine and may be a task for skilled entomologists and/or exterminators familiar with cultural resource management and historic preservation requirements.

Table 1. Identification of Common Bees, Beetles and Wasps that Attack Wood
(Table adapted from Levy 1979)

Shape and Size of Exit/Entry Hole	Wood Type	Age of Wood Attacked*	Appearance of Frass in Tunnels	Insect Type	Is Re-infestation a Concern?
Round 1/50″ – 1/8″	Softwood and Hardwood	New	None Present	Ambrosia beetles	No
Round 1/32″ – 1/16″	Hardwood	New and Old	Fine, flour-like, loosely packed	Lyctid beetles	No
Round 1/16″ – 3/32″	Bark/sapwood interface	New	Fine to coarse, bark-colored, tightly packed	Bark beetles	No
Round 1/16″ – 1/8″	Softwood and Hardwood	New and Old	Fine powder and pellets, loosely packed; pellets may be absent and frass tightly packed in some hardwoods	Anobiid beetles	Yes
Round 3/32″ – 9/32″	Softwood and hardwood (bamboo)	New	Fine to coarse powder, tightly packed	Bostrichid beetles	Rarely
Round ½″	Softwood	New and Old	None present	Carpenter bee	Yes
Round 1/6″ – ¼″	Softwood	New	Coarse, tightly packed	Horntail or woodwasp	No
Round-oval 1/8″ – 3/8″	Softwood and Hardwood	New	Coarse to fibrous, mostly absent	Round-headed borer	No
Oval 1/8″ – 1/2″	Softwood and Hardwood	New	Sawdust-like, tightly packed	Flat-headed borer	No
Oval ¼″ – 3/8″	Softwood	New and Old	Very fine powder and tiny pellets, tight	Old house borer	Yes

*New wood is defined as unseasoned wood or lumber. Old wood is seasoned or dried lumber.

Mechanical Damage

In addition to wood deterioration through decay fungi, weathering, and insect attack, wooden artifacts in cemeteries frequently get damaged by people, animals, tree roots, falling trees, ground maintenance equipment, and fire. People can inadvertently knock over or move grave markers, or intentionally steal or vandalize them. Animals can knock markers down, scratch the surfaces, or even chew on surfaces and in-ground portions (Figure 37). Tree roots and ornamental plantings that are no longer maintained can damage markers by dislodging them or growing into or through them (Figure 34). In cemeteries within wooded areas, falling trees can crush or break wooden markers and grave enclosures (Figure 31). Grass trimmers and lawnmowers can nick the sides of fragile wooden markers and fences (Figures 35 and 36). Additionally, fires, either controlled burns or wildfires, can damage or destroy wooden markers and grave enclosures (Figures 32 and 33).

As inherently fragile resources, wooden artifacts should be protected from mechanical damage through careful vegetation management, public education, and proper landscape maintenance. Fences may inhibit vandalism and damage by some animals, and careful hand-trimming of vegetation around wooden markers can reduce incidences of accidental human, fire, and mechanical damage.

Figure 31. A fallen tree grazed this marker on the way down, damaging the top of the marker and pushing it partially out of the ground.

Figure 32. A cemetery fence post damaged by fire.

Figure 33. A grave enclosure corner post damaged by fire.

Figure 34. A grave enclosure damaged by overgrowth of an invasive shrub in combination with decay of the corner posts.

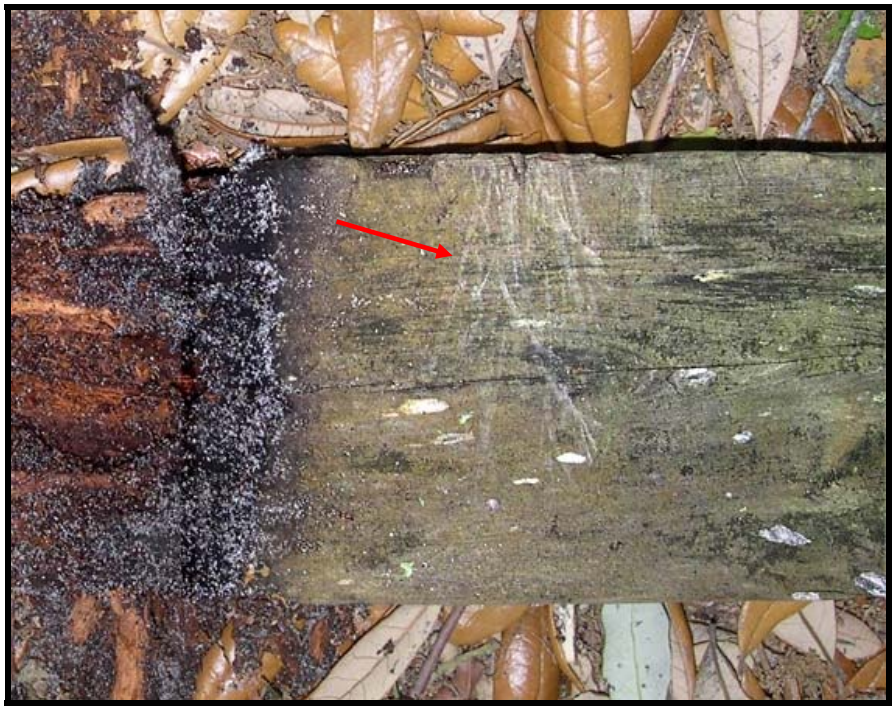


Figure 35. A grave marker showing damage from a weed trimmer. This marker was removed from the ground during research. Removing artifacts from the ground is not recommended.

Figure 36. Damage on the edge of a wooden marker caused by a weed trimmer.

Figure 37. A wooden plaque marking a grave with the surface chewed off by animals.

Methods for Identifying and Monitoring Problems

Effectively identifying and monitoring problems involves several key components. One essential component is good documentation. A sample wooden marker condition assessment form is provided in the Appendix; however, it may be useful to develop a form specific to your needs. At a minimum, the assessment form should include the following:

- a description of the marker, including general shape and dimensions
- the location of the marker relative to other artifacts such as stone markers with clear inscriptions
- some description of the condition of the artifact that includes any identified decay, loose connections or failures, insect damage, excessive vegetation, mechanical damage, etc.
- a brief description of the soil and drainage conditions

Another key component of an effective identification and monitoring program is to utilize an approach that applies the gentlest means possible to assess conditions and minimizes the use of invasive techniques. Several of the techniques described here, such as probing with an awl, can cause damage to fragile wooden artifacts if utilized in an overzealous or casual manner. Additionally, the removal of artifacts from the ground is not recommended, as removal may damage the in-ground portion and de-stabilize formerly well-anchored artifacts. Additionally, re-insertion into the ground can be difficult and makes artifacts more susceptible to damage, theft, leaning, and collapse. Artifacts photographed in this document were removed from the ground in order to illustrate various wood conditions, however, it is not necessary to remove artifacts to identify potential problems.

To identify potential problems, wooden artifacts should undergo a condition assessment survey. A simple, but thorough, condition assessment of wooden markers should include a visual inspection, probing in likely problem areas, and moisture content readings. Many of the visual inspection and probing techniques can be learned and taught to cemetery stewards to help monitor the condition of wooden artifacts. Experts should be called following visual inspections that determine there may be a problem with no easily identifiable solution. Visual inspection, probing, and moisture content readings are sufficient for a preliminary condition assessment. The tools necessary for a condition assessment survey, other than visual acuity and tactile senses, include a blunt awl and a moisture meter. Awls and moisture meters are inexpensive, easy to use, and exceptionally useful for identifying potential problems. Assessment findings should be recorded on an appropriate condition survey form (see the Appendix for a sample form). More advanced methods of assessment are addressed in this report in the section, Considerations for Repair and Treatment

Visual Inspection

Visual inspection provides a rapid means of identifying areas that may need further investigation and should be the first step in assessing wood conditions. Visual examination of the wooden artifacts within cemeteries allows for identifying components that are missing, broken, under insect attack, or in an advanced state of deterioration. Missing components are those which have been removed or have fallen away due to damage (mechanical, human, insect, or animal damage) or to extensive deterioration. Components that have fallen away due to damage can frequently be found nearby; broken or separated elements should be collected and placed near the source artifact until repairs can be made. If missing components were intended to provide structural support, such as corner posts for a grave enclosure, their replacement may be essential to prevent long-term damage to the structure. Missing or broken elements should be recorded on a condition survey form.

Visual inspection also allows for the detection of current moisture problems above ground, as evidenced by wood that appears wet or feels moist to the touch. Through visual inspection, external wood decay fungi can be identified by the presence of decay fruiting bodies such as mushrooms or other advanced fungal growth, such as white, cottony fungal bodies. The presence of moss should also be noted, as moss is an indication of high moisture content in the wood and environmental conditions suitable for wood decay fungi. Insect activity can also be identified through the presence of insects, insect bore holes, or wood substance (frass) removed by wood-destroying insects.

Probing

Although introduced in the Mechanisms of Wood Deterioration section of the manual, it is worth reiterating that probing the wood with a blunt awl enables rapid detection of voids just below the surface in wood that may not be detectable by a visual inspection. A sharp object, such as an ice pick, may easily penetrate even completely sound wood, so it is important to ensure the tip of the probing instrument is rounded and blunt. Internal decay or insect damage is often hidden by sound-looking wood surfaces but it can be detected when an awl is able to pierce what visually appears to be sound wood. Probing can also detect advanced decay, especially in cases where large internal voids are present near the surface. Even for early-stage decay, termed incipient decay, probing is beneficial. Probing can often reveal areas of incipient decay in wood markers or members, which have experienced sufficient deterioration due to decay fungi to allow for easy entry of a probe although no void is yet present. Wood without incipient decay has much more resistance to probing due to the higher density and intact internal wood structure of sound wood. Probing should be conducted judiciously and only in suspect areas at ground level and within or near wood joints and connections (Figures 38 and 39).

Sound wood will feel firm and be difficult to penetrate. Unsound wood or wood with internal voids may sound hollow or dull when tapped on with the awl handle, and wood with significant insect damage or decay below the surface will be easily penetrated.

Figure 38. Probing at the base of a marker with an awl to check for deterioration.

Figure 39. An awl at the base of a grave marker. Based on the length of penetration, this marker has approximately ½-inch of punky wood below the ground surface.

Moisture Detection

Prolonged exposure to moisture can produce undesirable conditions and long-term maintenance issues for wooden artifacts. Excessive shrinkage or swelling, checking, loose connections and decay are typical problems. Moisture content measurements can be taken using a resistance-type moisture meter at locations where decay typically manifests, such as near or just above the ground-line. Additional readings can be taken near the top of the element to determine whether the moisture is uniformly distributed or concentrated at or near the ground-line (Figure 40). Resistance-type moisture meters use pins that may be insulated or un-insulated; insulated pins provide a moisture content reading at the depth the pins are inserted, while un-insulated pins will record the highest moisture content throughout the depth of penetration (which may be at the surface if measured after precipitation). Resistance meters that use insulated pins must be inserted into the wood parallel to the grain to provide an accurate moisture content reading below the wood surface.

Figure 40. Taking moisture readings on a grave marker using a resistance-type meter. Image (a) shows a reading being taken at the base of the marker; (b) shows the digital readout of 10 percent; (c) shows another reading being taken at the top of the marker (where the moisture content reads 6 percent).

Dielectric or capacitance meters do not have pins and may be used to attain moisture content readings where punctures of the wooden element by pin probes may be undesirable. However, dielectric meters provide an average moisture content of the zone penetrated by an electric field. The effective depth of the measuring field ranges from ½ inch to 1 inch, depending on the model. Thus, dielectric meters are best suited for utilization on thinner elements as the electric field cannot penetrate deeply enough to provide accurate moisture content readings on larger elements.

Moisture content measurements identify wood with favorable moisture levels for the growth of wood-decay fungi. Generally, if the moisture content is less than 20 percent, wood-decay fungi are unable to grow. While fungi may be present at lower moisture contents, they are unable to continue to deteriorate the wood without additional moisture. Moisture contents from 20 to 30 percent indicate areas of concern where moisture is sufficient for fungi to grow but not sufficient to indicate advanced decay. Moisture contents above 30 percent are often an indication of advanced decay with internal voids and/or surface deterioration. When taking moisture content readings, the user should be aware of recent precipitation or watering that may affect the reading. Since the internal moisture content is of interest for determining whether conditions are favorable for decay, artificially high moisture content readings due to liquid water on the wood surface can prevent determining the true internal moisture content.

When to Call an Expert

Wooden markers and enclosures have historical and cultural significance and every reasonable effort should be made to preserve these artifacts. Expert advice should be sought if there are moisture problems where the source of moisture cannot be identified or mitigated, insect infestation, other indications that there may be decay problems, and situations where advanced decay has damaged or destroyed elements. Experts, through the use of advanced assessment methods can help to define the scope of the damage and provide guidance on appropriate levels of intervention. State Historic Preservation Offices and online resources are good places to start when looking for a wood expert with cultural resource expertise.

Corrective Measures

To aid cemetery stewards, whether paid or volunteer, numerous references on the weathering and maintenance of stone and metal artifacts exist (e.g. Winkler, 1986; Matero, Curtis, Hinchman and Peters, 2002). However, wooden artifacts, such as grave markers and enclosures, present a particularly dire problem. Not only do they deteriorate more rapidly than stone or metal artifacts, there is very little information available to aid the cemetery steward or conservator in making informed treatment decisions. Further, these wooden artifacts are often found in the smaller, rural

cemeteries that are cared for by volunteer stewards with little technical training. Even when under the care of a conservator, deteriorated wood is often simply replaced with new wood (Paine, 1983).

The two most cost-effective measures for extending the life of wooden cemetery artifacts are controlling water and vegetation management. These measures can greatly improve the micro-environment around the artifact.
If organic debris and vegetation are cleared from around the bases of wooden markers, enclosures, and other artifacts, and if the artifacts' exposure to moisture is minimized, the rate of deterioration due to decay fungi will typically be slowed. Controlling water and vegetation management are two corrective measures which should always be considered and are highly recommended.

There are a number of other means that have been used on wooden cemetery artifacts to try to extend their service lives. Most measures require regular maintenance, but some approaches require a minimal investment in time and money. These measures include the application of a film-forming coating or whitewash (when known to be historically appropriate) and the use of ultraviolet light blockers, water repellents and water-repellent preservatives, varnishes and polyurethanes, consolidants, and oil finishes. As part of the assessment, it may be desirable to remove historic paint remnants from an artifact for analysis for documentation purposes as well as consideration of corrective measures. The conservation of wooden artifacts has been extensively researched but many of the potential solutions are simply not viable for preservation of wooden artifacts in cemeteries because of the cost or complexity of implementing the solutions that have been tried in other wood applications (Unger, et.al. 2001). The most common treatments that are applied to wooden artifacts are discussed below, not because they are recommended, but because cemetery stewards frequently use them, even though the treatment may be detrimental to the long-term survival of the artifact.

Controlling Water

As previously discussed, moisture is the primary means through which weathering, decay fungi and insect infestation cause wood deterioration. The key to preserving and extending the life of wooden artifacts in cemeteries is to control moisture levels as much as possible. This means inspecting irrigation systems for leaks and noting the location of water spigots and sprinkler heads. Spigots that are located near wooden markers or grave enclosures should be moved or at the very least, carefully monitored when in use (Figure 41). The direction of spray from water sprinklers should be carefully assessed and alterations to the direction and intensity of flow made if necessary to prevent water saturation of the ground near wooden artifacts and to prevent wooden markers, fences and other artifacts from getting wet. If the water table is just below the ground surface or if the ground surrounding the wooden artifact(s) is low-lying and/or consistently damp, it may be possible to

excavate carefully around the artifact and replace the soil with pea-gravel or another quick-draining material, which will help to prevent water from pooling around the base of the artifact. Altering the slope or drainage must be done with care to minimize the overall impact to the historic landscape. Prior to altering the ground profile, the SHPO should be contacted for advice and regulations regarding removing soil from the base of the artifact.

Figure 41. A water sprinkler located directly next to a wooden marker that is showing signs of decay at the base.

Vegetation Management

Often, wooden markers get lost in the volunteer trees, shrubs, and grasses that spring up following their placement, or get covered over by untended ornamental plants (Figure 42). This overgrowth creates a moist microclimate conducive to decay fungi through a combination of denser shade, reduced air flow around the marker, and increased nitrogen production. Denser shade reduces surface temperatures of markers and other artifacts and allows water vapor released from transpiration to condense more rapidly on the markers. Concentrations of leafy vegetation also can reduce air flow around the wooden objects, which decreases rates of evaporation. Dense clusters of vegetation drop leaves that release nitrogen as they decompose and attract decay fungi. Dense vegetation also poses other risks to wooden artifacts. Markers and other artifacts obscured by vegetation may be inadvertently damaged by cemetery visitors or maintenance crews unaware of their locations. Increased vegetative cover also often attracts insects, rodents, and larger animals that can damage wooden artifacts. Dense vegetation also increases the risk of fire.

A vegetation management plan should be established to routinely inspect the cemetery grounds for overgrowth and trees that need pruning. Hand tools should be used to carefully prune plants and trees s if they pose a risk to nearby markers or artifacts.

Figure 42. The vegetation in this cemetery is so dense that a rake must be used to search the ground for markers.

Coatings to Retard Moisture

Ultraviolet light, wind-blown debris, moisture and extreme temperature variations all contribute to the weathering process and subsequent fungal decay and/or insect attack of wooden artifacts in cemeteries. Some artifacts were originally coated with a protective coating such as paint or a lime-based whitewash, which may have been intended to mitigate the deteriorating effects of the environment. For previously coated artifacts, proper application of opaque coatings such as lime-based white-wash and latex-based or oil-based paints can dramatically reduce environmental weathering impacts (Figure 43). Opaque coatings, provided they can be applied for full coverage, block 100 percent of sunlight's damaging UV rays and prevent the exfoliation process from occurring. Opaque coatings also serve to seal small cracks and crevices, thus preventing debris build-up and subsequent moisture penetration and retention. Paints also provide a water-resistant barrier and seal exposed end grain surfaces, reducing the total amount of moisture that may wick into a marker, grave enclosure, or other artifact. Treatment with a paint or lime-based whitewash should only be considered for artifacts that exhibit evidence of a past coating. Also, it is important to note that before applying any coating, the artifact must be dry. Then

all exposed, previously coated surfaces, must be coated. One adverse effect of applying a coating that serves as a moisture barrier is that moisture absorbed below ground can accelerate the decay process because that moisture is prevented from evaporating from the wood by the coating above ground.

Figure 43. A freshly painted grave enclosure. Note the deformed pickets due to the tree root growth.

Oil-based or alkyd paints are the most resistant to water penetration; however, oil-based paints require turpentine clean-up and tend to get brittle with age. Latex paints are water soluble and create more flexible polymers that, while less resistant to water penetration, are better able to accommodate dimensional changes in wood. However, latex paints will block the evaporation of moisture that is absorbed from the ground and lead to internal decay. Oil and latex paints will likely need to be reapplied every three to seven years depending upon environmental conditions.

Lime-based whitewashes have long been used on adobe and masonry surfaces and were often historically applied to both masonry and wooden artifacts in cemeteries. However, while some research has been conducted on the effects of lime-bashed washes on masonry, very little is known about the effects of lime-based washes on wood. Whitewash is moisture permeable; on masonry, whitewash serves to harden the substrate and allows the underlying material to breathe (Chicora Foundation Inc. 2000). Lime-based washes are alkaline and therefore somewhat biocidal, and the qualities of lime do not promote fungal and bacterial growth (Swearingen 2004). Lime-based whitewash also reduces the surface temperature of wood exposed to direct sunlight by 20° F over untreated wood and nearly 6° F less than wood coated

with latex paint (Watts 2007), but the extent of any wood-protecting qualities is unknown. Whitewash is known to be considerably less durable than oil or latex paints; however, it may be a historically accurate finish and therefore a more appropriate coating. Whitewash may need to be reapplied every year.

Although paints may provide a high level of protection to wooden artifacts, the application of such products has significant drawbacks. Paint in and of itself cannot prevent decay fungi if conditions are favorable for growth. Visitors may object to the look of freshly painted markers or fences. Also, painting a marker may not be historically accurate and is a process that is not easily reversible. Additionally, painting markers requires regular maintenance that some cemeteries with small budgets or those that operate on a volunteer basis may not be able to perform.

Ultraviolet Light Blockers

Ultraviolet (UV) light blockers may provide an alternative to dramatically changing the look of wooden artifacts by painting or applying an opaque coating. UV light blockers are available in transparent finishes that minimize changes in the wood's appearance. UV light blocking finishes generally contain iron oxide pigments that help to deflect harmful UV rays and minimize damage to the wood by solar radiation. UV light blockers do not inhibit decay fungi growth, nor do they prevent moisture penetration.

While UV light blockers do not change the appearance of wooden artifacts as dramatically as opaque finishes, such products still impact the visual appearance of the artifacts. Finishes tend to be glossy and/or deepen the color of the wood. Also, UV finishes do not adhere well to weathered wood and may require sanding and/or frequent (biannual) applications. Sanding of wooden artifacts is not recommended as it removes historic fabric. As alterations to the physical appearance of grave markers are typically undesirable, and as UV light blockers do not provide protection against other forms of wood deterioration or moisture penetration, the use of UV light blockers is not recommended unless used in conjunction with a wood preservative. Such treatments require regular maintenance to be effective and are, therefore, not recommended.

Water Repellents and Water Repellant Preservatives

Water repellents and water repellent preservatives are not, generally, recommended for application on cemetery artifacts for a number of reasons. The primary reason is that most wood in cemeteries deteriorates either when in ground contact or at joints (e.g. rails in an enclosure). Water repellents and water repellent preservatives are surface treatments. Since deterioration takes place within the wood where the treatment cannot reach, these treatments are largely ineffective. Additionally, these treatments can trap water in artifacts in ground contact that have poor drainage,

which will accelerate deterioration. Treatments may last as little as six months and therefore require frequent re-application. However, water repellent preservatives do offer some protection to fragile wooden artifacts and horizontal members *if regularly applied* and could be considered if vegetation and moisture management are not effective in slowing deterioration rates. It should be noted that remedial wood preservatives may darken the wood or cause it to look wet, altering the appearance of culturally and/or historically significant objects.

Water repellents are penetrating wood finishes (as opposed to film-forming wood finishes such as paint) that can increase the durability of wood by decreasing its ability to absorb moisture. Waxes, oils, or similar water-repelling substances are used to inhibit moisture absorption, which in turn can minimize the growth of decay fungi. Water repellents also decrease swelling and shrinking cycles that can lead to cracking and warping (Williams and Feist 1999). Water repellents offer no protection from harmful UV light exposure and do not contain products that inhibit mold, mildew, or other fungal growth (mildewcides or fungicides). Because water repellents only penetrate the first few cellular layers of the wood, applications typically do not last long (less than six months). They are, in general, recommended for cemetery artifacts only when a regular maintenance plan can facilitate frequent applications on artifacts with excellent drainage or other means of controlling water. Table 2 provides some basic guidelines for estimating the time between repeat applications for various wood treatments.

Water repellant preservatives are similar in formulation to water repellents. Typical preservatives contain a fungicide, a wax or other water-repellent, a resin and a solvent. Water repellant preservatives can be applied by brush or by dipping. Such application methods do not allow for deep penetration of the preservative, however they can provide some protection against decay in elements that are exposed above ground, particularly when applied to the end-grain and between joints. Reapplication does not require sanding or extensive surface preparation, and the treatment becomes more long-lasting with continual use. These finishes offer effective, short-term above-ground protection against decay and slow the weathering effects of moisture and UV light. Because preservative treatments can only penetrate a thin layer of outer wood on lateral surfaces, preservative-treated members that are below ground or in contact with water will not last long and application in such situations is not recommended (Williams, Knaebe, and Feist 1996; Williams and Feist 1999b).

Semi-transparent Penetrating Stains

Semi-transparent penetrating stains have several drawbacks for application on wooden cemetery artifacts. These finishes will not protect wood that is below ground or in contact with a constant source of moisture, and will change the appearance of the wood, even with "natural" formulations. It is also difficult to

avoid the development of a glossy finish on particularly dense wood and with repeated applications. Given these issues, the application of semi-transparent stains on wooden artifacts is generally not recommended and should be carefully considered prior to application. Application of these types of finishes is only recommended under excellent drainage conditions and if minimal color changes are acceptable.

Semi-transparent penetrating stains are generally composed of a water-repellent preservative solution and pigments. While it is not recommended to apply a treatment that changes the look or appearance of wooden artifacts, the addition of pigments greatly increases the durability of the stain by protecting the wood surface from ultraviolet light (Williams and Feist 1999b) and many newer formulations include "natural" finishes that minimize appearance changes. Semi-transparent penetrating stains do not form a film and are easy to reapply without extensive surface preparation. While initial applications may last two to three years, subsequent applications may last as long as ten years on above-ground portions of elements depending upon orientation (vertical or horizontal) and environmental conditions (Williams and Feist 1999b).

Varnishes, Polyurethanes, Lacquer, and Shellac

Transparent film-forming finishes such as varnishes, polyurethanes, lacquer and shellac and are generally not recommended for exterior wood because ultraviolet light readily penetrates the finish and degrades the wood underneath (Feist 1990). While varnishes and polyurethanes may last as long as two years in exterior conditions, the finish will eventually become brittle, crack and peel as a result of UV exposure (Figure 44). Lacquer and shellac have very little to no moisture resistance and are extremely brittle, making them unsuitable for long-term protection of wood in exterior conditions (Williams et al. 1996). These finishes require intensive maintenance.

Oil Finishes

Oil finishes have a long history of use for both interior and exterior applications, and oils do provide some protection for wood exposed to the environment (Williams et al. 1996). The most common drying oils used for wood are linseed oil and tung oil. A drying oil is an oil that hardens to a tough, solid film after a period of exposure to air. The term "drying" is somewhat misleading as these oils do not harden through water evaporation or the evaporation of other solvents, but through a chemical reaction in which oxygen is absorbed from the environment (autoxidation) and the fatty acid chains link with each other to form an extremely large cross-linked polymer (wikipedia.com 2008a). Drying oils are a key component of oil paint and many varnishes. Under optimal environmental conditions, oil finishes can have a lifetime similar to water-repellent preservatives (Williams et al. 1996).

Figure 44. Failure of a transparent, film-forming finish, likely varnish or polyurethane.

Linseed oil, also known as flax seed oil or simply flax oil, is a clear to yellowish drying oil derived from the dried ripe seeds of the flax plant. When applied to wood, linseed oil provides a moderately water-resistant finish that will darken the wood as it ages. Tung oil, also referred to as China wood oil, is derived from the pressed seed of the tung tree. Tung oil provides a slightly more durable, water-resistant finish that does not darken the wood noticeably with age (Wikipedia.com 2008b). Both linseed oil and tung oils penetrate wood well through multiple brushed coats or through dipping; properly thinned, the oils can penetrate an inch or more of wood.

Application of natural oils, such as linseed and tung, help to slow the weathering process by reducing moisture absorption. However, natural oils are a food source for mildew and can encourage mildew growth if used without a mildewcide. Mildewcides interfere with the polymerization process required for these oils to cure properly. Linseed oil and tung oil also do not offer any protection against ultraviolet light degradation or insect attack. Additionally, these oils are typically thinned with turpentine for application, increasing health and fire hazards. Because of these characteristics, it is not recommended to treat wooden artifacts with natural drying oils.

Table 2. Application and Maintenance of Finishes for Exterior Wood (not in ground contact).

(Table adapted from Williams et al. 1996)

Finish	Initial Application		Appearance of Wood	Maintenance		
	Process	Cost		Process	Cost	Timing
Water Repellent Preservative	Brushing	Low	Grain visible, wood brown to black, fades slightly with age	Brush to remove surface dirt	Low	6 months to 3 years
Oils	Multiple brush coats; preferably dip application	Low	Grain and natural color visible, becoming darker and rougher textured with age	Clean and reapply	Low to medium	6 months to 3 years
Semi-transparent Stains	One or two brush coats	Low to medium	Grain visible, deepened natural color for natural finishes	Clean and reapply	Low to medium	2 to 6 years
Clear Varnish	Three coats (minimum)	High	Grain and natural color unchanged if adequately maintained	Clean, sand, and stain bleach areas; apply two more coats	High	2 years or when break-down begins
Paints and solid-color stains	Brushing, water repellent, prime, and two top coats	Medium	Grain and natural color obscured	Clean and apply top coat, or remove and repeat initial treatment if damaged	Medium	4 to 10 years for paint, 3-7 years for solid-color stains
Lime-based Whitewash	Brushing, up to 10 coats	Medium	Grain and natural color obscured	Clean and reapply; coat as necessary	Low	1 year
Epoxy Consolidants	Brushing and injection	High	Glossy; grain and natural color visible	Clean, sand, and reapply	High	4 to 10 years

Borate Rods

For additional protection, borate rods can be inserted into holes drilled into the wood where deterioration is likely. Borates are low-level toxicity preservatives that are used to improve the durability of both new and in-service wood products. Borates are not an alternative to pressure-treated wood that will be in ground contact. They require moisture to migrate through the wood so they are placed in the wood where

moisture is likely, such as near the exposed end grain, near the bottom face of elements close to ground contact and at exposed, wood-wood connections where members meet, including repair and replacement splices. Borates also effectively control termites, carpenter ants, a variety of beetles, and other wood boring insects. Topical borate treatments (liquids) applied to the surface offer no protection to the more vulnerable interior of wooden artifacts and are not recommended.

Borate-rod installation is not complicated and can be completed by anyone with basic carpentry skills and appropriate tools. To install borate rods, holes are drilled on the bottom or below-grade lateral face of markers or enclosure posts, the rods are inserted and the holes are filled with either a pressure-treated wood plug or a plastic threaded plug (to aid in inserting additional rods during future inspection cycles). These rods are typically effective for three to ten years depending on environmental conditions, but they should be regularly inspected and used as part of a cyclic, long-term maintenance program.

Epoxy Consolidants

Certain epoxy formulations have been used to seal and strengthen wood, particularly in marine applications. There are also products currently available that are designed to consolidate rotted or punky wood that contain epoxy resins. While these systems may be useful for consolidating historic wood in structures such as window components, molding and siding, they are not designed to consolidate or preserve uncoated wood in unprotected exterior conditions and in ground contact. Wood repaired with an epoxy consolidant is resistant to attack by fungi, insects and bacteria, and does not have increased combustibility (Unger et al. 2001), however, most epoxy formulations have little UV resistance and will yellow and chalk when exposed to direct sunlight, moisture, and/or excessive heat (Soller 2005). Cured epoxy resins darken the wood, cause considerable gloss formation, and are fixed irreversibly in the wood (Unger et al. 2001). Because of these limitations and the lack of product testing for wood exposed to the environment and in ground contact, epoxy consolidants are not recommended for use on wooden artifacts in cemeteries.

Repairs

It is important to remember that wooden artifacts in cemeteries, regardless of their condition, are valuable cultural and historic artifacts and that every effort should be made to preserve such artifacts without altering the original materials. However, in situations where repairs need to be made in order to protect the artifact, such as when a wooden grave marker can no longer stand upright due to complete failure of the in-ground portion or in the case of a grave enclosure where the structure has collapsed due to failure of some or all of the corner posts, repairs to the original artifact will be necessary in order to preserve the artifact from further deterioration. As noted earlier, extended contact with the ground will hasten wood deterioration due to increased moisture absorption and greater likelihood of insect attack.

Additionally, wooden artifacts that are no longer upright are more likely to be accidently damaged or moved by landscape maintenance workers and visitors.

In general, if damage due to decay or insect attack is severe enough to affect the structural integrity of a wooden artifact (meaning it has collapsed or partially collapsed), repair or replacement of elements or portions of elements should be considered. The choice to replace an original artifact or portions of an original artifact should always be made judiciously. It is recommended that a professional carpenter or conservator be used to make any repairs to the wood. Prior to any repair work, however, the conditions that led to the artifact's failure should be mitigated to prevent repeat failure or further damage. When repairing a deteriorated marker, fence, enclosure, or other artifact, efforts should be made to retain as much original material as possible.

There are a variety of possible repairs for wooden markers and other wooden artifacts, but typically, the wood that is below ground on a grave marker or enclosure fence-post will degrade long before the rest of the element. In some cases, it may be desirable to repair the marker or post by removing the damaged portion and attaching a new below-grade piece. The repair should not impair the aesthetic effect of the original artifact and the replacement wood should be reclaimed material of the same species, density and type of cut.

Determining Wood Species

To determine the appropriate species for repairs, a sample of the original artifact must be removed and sent for analysis. Samples can be sent to a number of private consultants for a fee or to a public or government institution such as the U.S. Forest Products Laboratory Center for Wood Anatomy Research that can provide species analysis free of charge.

Samples should be taken from sound wood and should measure a minimum of ¼-inch wide x ¼-inch deep x ½-inch long (Figure 46). The soundness of the wood sample can be determined by rolling it between the fingers; if the wood breaks apart, it should not be submitted and a new sample will need to be taken. To extract a sample, use a sharp knife, craft saw blade, and/or a chisel to make two cuts across the grain of the element. These two cuts should be a minimum of $^{3}/_{16}$-inch deep and ½-inch apart. A specimen can be split out by prying up at one of the incised points with a knife, or if a chisel is used, the edge of the chisel can be placed in one of the cuts and then angled down the grain towards the other cut. A sharp tap with a small hammer or rock should provide enough force to remove a good specimen from the host element. All samples should be taken from an inconspicuous spot such as the underside of a bottom rail or the inside of a corner post near ground level (Figure 45).

Figure 45. Cutting a sample from a grave enclosure rail.

For markers, try to remove a sample from the area that is being repaired. Each sample should be recorded, labeled and bagged separately prior to shipment for analysis.

Figure 46. The sample after removal from the enclosure rail. Ant and saw blade are for scale.

Repairs may be spliced to remaining sound wood using a variety of wood joints and/or wooden dowels. An epoxy resin can be used to insure adhesion between the pieces; however, epoxies tend to inhibit moisture flow through the member and may cause the repair to fail at a much faster rate than if no adhesive is applied. Additional research needs to be conducted to determine alternatives to epoxies for this type of application.

Replacement

There may be occasions when it is not possible to repair an artifact, such as a grave enclosure with a fence post too badly deteriorated to repair or missing entirely. With artifacts of considerable historical or cultural significance, the choice may be made to place the wooden artifact in a museum or curation facility and install a modern replacement. A second example of when replacement may be chosen over repair is when a grave marker is missing due to vandalism. Regardless of the reason, the choice to replace an original artifact or portions of an original artifact should always be made judiciously.

When creating a replacement, the wood utilized should be reclaimed material of the same species that matches as closely as possible the original wood's density and type of cut. Dimensions and detailing should match the original dimensions and the profile and should not be altered. The replacement member should be dated in an inconspicuous spot to aid future preservationists in determining historic fabric. Borate rods may be inserted into the end grain or in a lateral face that will be below the ground surface following installation to extend the service life of the replacement artifact, using the techniques and inspection cycle described above.

Alternative Materials

Because wood exposed to moisture is not exceedingly durable, it often seems illogical to replace deteriorated wood with wood of the same species, or even wood at all. Often, the desire to replace wooden artifacts with a more durable material seems the most economical and logical approach. According to the Secretary of the Interior's Standards for preservation, "the preferred treatment is always replacement in kind, that is, with the same material" (Myers and Hume 1984). Because this approach is not always possible, the use of a compatible substitute material may be considered if the "form, detailing, and overall appearance of the substitute material convey the visual appearance of the historic material, and the application of the substitute material does not damage, destroy or obscure historic features" (Myers and Hume 1984).

Figure 47. Historic wrought iron and wooden grave enclosures flanking an out-of-place grave enclosure made out of vinyl.

However, the use of a substitute material, such as replacing a wooden grave enclosure with one made out of vinyl, changes the character-defining features of a cemetery, alters the "historic visual relationship" between the grave markers and the cemetery and damages the historic character of the cemetery (Figure 46). Wooden markers, grave enclosures, fences, and other wooden cemetery artifacts are historically significant because "the materials and craftsmanship reflected in their construction are tangible and irreplaceable evidence of our cultural heritage. To the degree that substitute materials destroy and/or conceal the historic fabric, they will always subtract from the basic integrity of historically" significant artifacts (Myers and Hume 1984). The use of alternative materials is not recommended, therefore, for complete replacement of fragile wooden artifacts. However, there may be situations where the use of alternative materials as replacements for select artifactual elements with limited visual impact is the best option for the long-term preservation of the artifact as a whole. Such an approach is described in the following section.

Considerations for Repair and Treatment

There has been very little research conducted on the long-term success of repairs made to wooden markers and other cemetery artifacts. For a variety of reasons, repairs may fail at a much faster rate than the failure of the original artifact: wood used for repairs may have a greater percentage of softer earlywood than original artifacts and may therefore be more susceptible to weathering. Adhesives used in the

repair process may interfere with natural wicking and evaporative processes within a member and may prevent moisture from escaping below the repair, or joints that are not properly crafted may allow moisture penetration and the development of decay fungi. For these reasons, any repairs will need regular inspection and maintenance to monitor conditions for signs of problems or failures. Additionally, repairs to cemetery artifacts need careful planning and extensive documentation, along with a number of other factors that need to be considered. These factors are discussed below.

Documentation and Planning

First and foremost, cemetery stewards should have a maintenance plan and budget in place so that repairs can be monitored over the long term and supplementary repairs or alterations to the repairs can be made in a timely manner. Any repair effort should be conducted in a systematic way with full documentation of the process after a complete conditions assessment has been performed. The documentation should include maps of the locations of repaired artifacts, drawings, photographs of the artifacts before, during, and after the repair process, and a written report detailing the scope of work.

Soil Conditions and Microclimate

Environmental factors are also a concern when deciding upon the appropriate repair methodology. Additionally, the microclimate around individual artifacts can vary significantly. Be familiar with moisture distribution patterns, nearby plant, shrub, and tree growth patterns, typical temperature and humidity conditions and the slope or grade surrounding the artifact prior to conducting any repair work. If possible, cut back overgrown vegetation and improve poorly graded soil to increase ventilation and drainage. The addition of gravel to improve drainage, so long as it does not significantly alter the historic landscape, is an excellent means of altering the microenvironment around the artifact. However, any excavations within cemeteries may disturb culturally significant artifacts, and any excavations within a publicly-owned cemetery need to be approved by the appropriate SHPO.

Advanced Assessment Methods

In some situations, wood condition assessments conducted by individuals with little technical training may not provide enough information to determine an appropriate level of intervention and/or repair methodology. Wood technologists or wood conservators can be contracted to provide a greater level of detail on wood conditions that can help with repair and preservation efforts. Wood technologists can use a method of detection called resistance drilling to assess wood condition. Resistance drilling is a quasi-nondestructive technique for determining the relative density of wood (Figure 48). It is best suited for determining internal problems in timber or large members that do not show obvious signs of deterioration or surface

decay. Any internal void or early stage of decay at the location drilled can be detected by determining the relative density of the wood. The relative density is printed on a strip of paper as a small diameter needle penetrates the wood. The technique is very reliable for quantifying the extent of voids when used in combination with other techniques to rapidly locate areas of probable deterioration.

Figure 48. Resistance drilling a corner post of a wooden grave enclosure.

Experts, whether they be wood technologists or scientists, preservationists, or conservators cannot only facilitate in the identification of any problem areas, they can also help to quantify the extent of the damage and offer potential options for maintenance, repair, and when necessary, replacement.

Repairing Elements with In-Kind Materials

The long-term success of repairing cemetery artifacts by removing the decayed, below-ground portion and attaching a new wooden base has not been documented through any scientific study and the failure rate for this type of repair is not known. However, the following photos represent a collection of grave markers that were treated with a linseed oil and turpentine bath and repaired with new wooden bases, dowels, and epoxy adhesive between 1992 and 2000; a return visit in 2008 demonstrated that the majority of the repairs, if not all of them, had failed (Figures 49-54).

It is important to note that these repairs did not involve the use of borate rods, which can improve the service life of wood in contact with the ground. While the success of

borate rods within a cemetery application is not known, the known benefits of borate rods indicate considerable potential in historic preservation efforts in cemeteries.

Figure 49. A previously repaired grave marker that has failed and is no longer in situ.

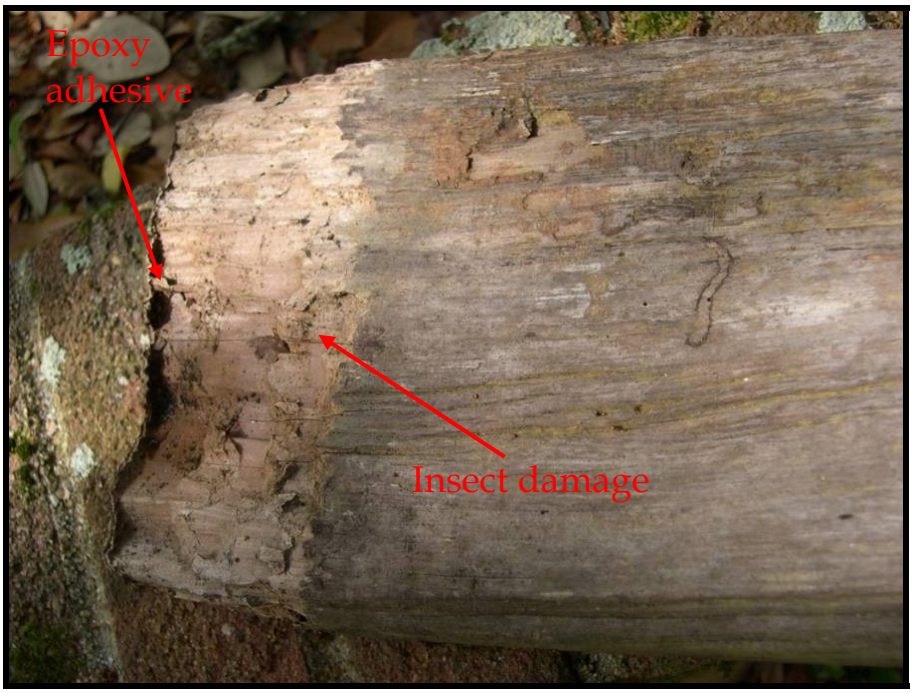


Figure 50. A detail of the repaired end of the marker in Figure 49; the epoxy remains even though the below ground portion of the marker has deteriorated.

Figure 51. The back side of the same grave marker from Figures 49 and 50. This side was in ground contact and is significantly deteriorated after an unknown length of time on the ground.

Figure 52. The repaired end of the marker (from Figures 49, 50, and 51) shows that the epoxy remains but the wooden dowels have rotted away.

Figure 53. Another grave marker with a repair that has failed and is no longer in situ.

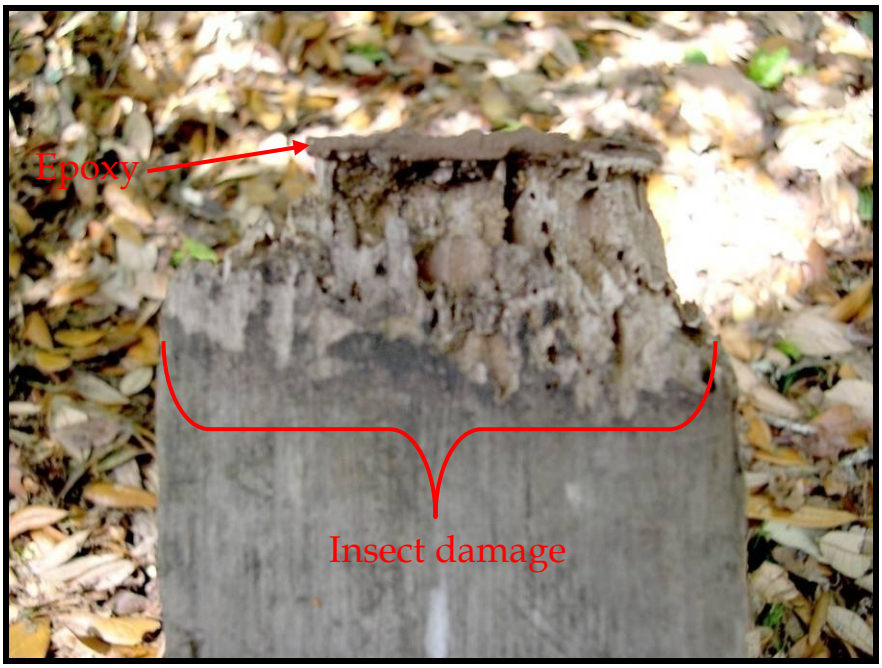


Figure 54. The repaired end of the marker from Figure 53 shows evidence of subterranean termites and epoxy that remains despite the degradation.

Repairing with Alternative Materials

In many cases, the portion of the artifact that is in contact with the ground has been completely destroyed by decay or insects and repairing the artifact with the same materials simply is not a feasible solution. While this approach is not the preferred method when attempting to adhere to the Secretary of the Interior's Standards for the Treatment of Historic Properties, it may be worthwhile to consider alternatives for objects that simply cannot be repaired with in-kind material. Consider a popular grave marker in Beaufort, North Carolina. The story of a little girl's death at sea, her father's promise to bring the girl back to her mother, and the subsequent placement and burial of her body in a rum keg is one that piques considerable interest and draws a number of visitors to this small coastal cemetery. However, the below-grade portion of the little girl's grave marker has deteriorated. In order to keep the grave marker on display, an alternative base was built utilizing copper rods or tubes.

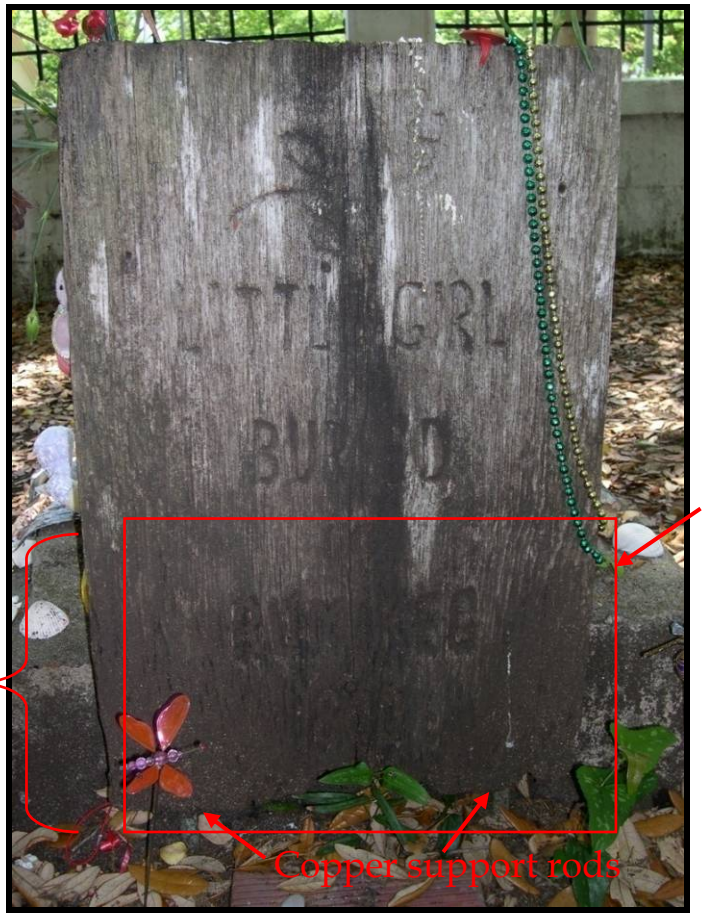


Figure 55. The grave marker of the little girl buried in a rum keg. Note the copper support rods.

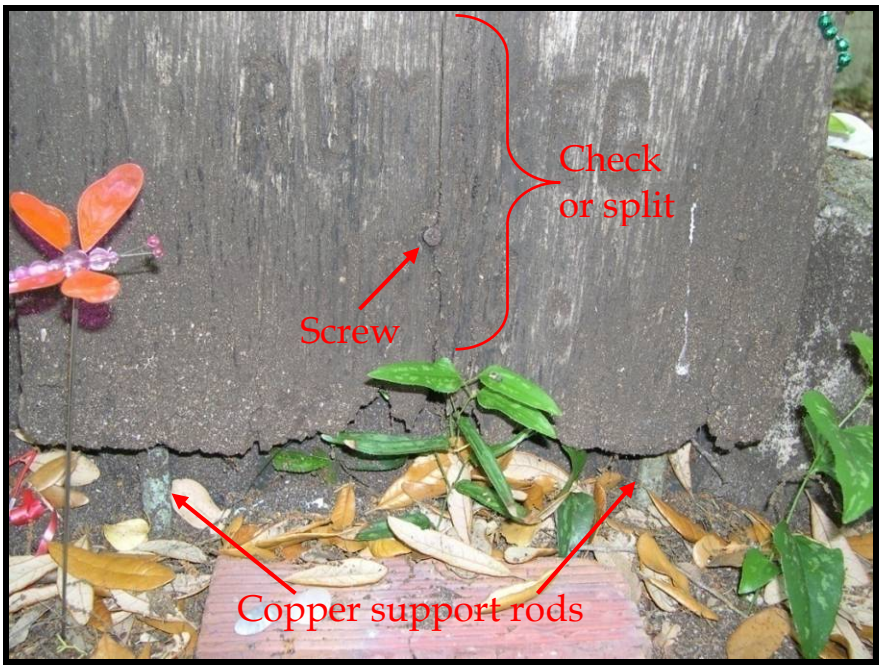


Figure 56. A close-up of the base of the marker showing two copper supports. The wooden marker is no longer in contact with the ground. Note the screw on the face used to hold the historic marker in place and the check likely caused by its installation.

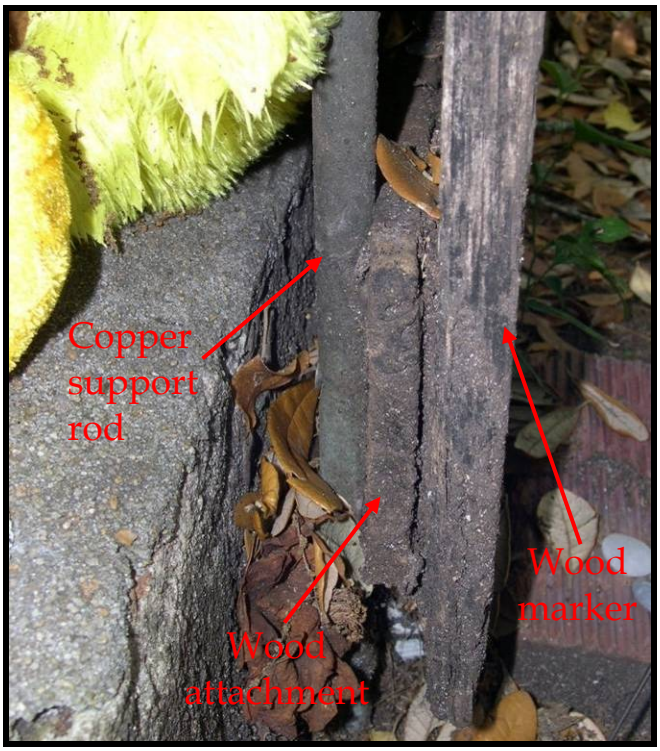


Figure 57. A close-up of the side view of the repair showing the wood the marker has been sandwiched to and the copper pipe, along with organic debris.

The unfortunate consequence of this repair is that the marker can only be viewed from one direction; the repairs cover a portion of the other side. Additionally, the screws used to hold the marker in place were placed on the front face of the marker and are easily visible and may have contributed to a check that runs along the face. If such a repair is necessary, every effort should be made to place fasteners judiciously so as to have the least visual and physical impact on the artifact. Simply installing the screw from the other side would have kept the face of this marker in more pristine condition. Despite these drawbacks, however, the marker remains on display and is somewhat protected from further degradation because it is no longer in contact with the ground.

Similar types of repairs have been made at other cemeteries. At Mount Pisgah Cemetery in Cripple Creek, Colorado, a maintenance plan has been in place for the past several years that includes painting and repairing wooden markers and enclosures. Bases of grave enclosure corner posts that are deteriorated below ground are typically replaced with channeled steel rods. Alternatively or in addition to repairs with steel rods, bases of natural rock are placed under the deteriorated posts to prevent structure collapse and moisture absorption into the failed element (Figure 58). The maintenance and repair program at Mount Pisgah has kept the vast majority of wooden artifacts from extensive deterioration. Minor adjustments to their maintenance procedures, such as boring insertion holes for the metal rods into the end grain of the corner posts rather than attaching the rods to the exterior and leaving stones used as supports unpainted, can help to reduce the visual impact of the repairs and improve the historic character of the cemetery.

Figure 58. The deteriorated base of a grave enclosure corner post has been replaced by a channeled metal rod and natural stones, painted white.

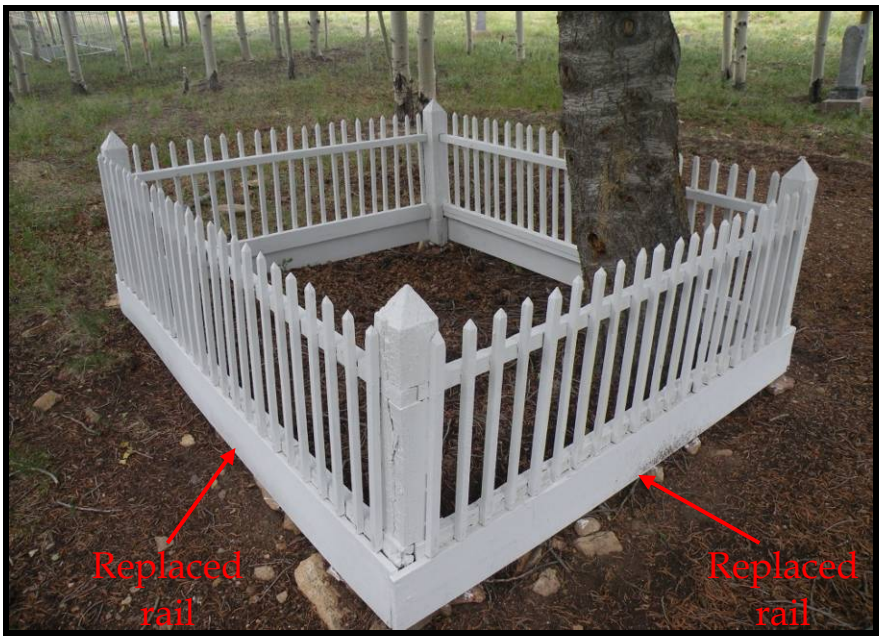


Figure 59. This grave enclosure has had its base rail replaced and the degraded corner posts now sit on stone piers.

Figure 60. The top photograph shows a grave marker and grave curb. The original wooden marker was replaced with one of plywood, a material not suited for exterior conditions. The bottom photograph is a close-up of the top of the marker; through the paint the effects of weathering and the beginning of de-lamination are evident.

The Application of Surface Treatments and Penetrating Finishes

Currently, there is no wood treatment or finish that can protect wooden artifacts in cemeteries from all aspects of wood deterioration. However, some surface treatments, such as paint (on previously painted artifacts only), and penetrating finish formulations, such as water repellent preservatives, can extend the service life of wooden artifacts with regular inspection, maintenance and reapplication. The artifact should be thoroughly cleaned by brushing with a natural bristle brush to remove as much dirt and debris as possible without damaging friable surfaces. The artifact must be dry prior to applying a coating. Moisture readings can be taken with a hand-held meter to determine the moisture content, which should be below 20 percent.

Encasement

An additional alternative, given the high rate of deterioration that can occur in wooden artifacts due to extreme environmental conditions, is to consider encasing fragile or extremely weathered markers in glass or acrylic to maintain the integrity of the inscription and protect the wood from further abrasion. Although this is not typically done in cemeteries, this method can be used to protect fragile wood exposed outdoors and may be an option in situations where it is desired for fragile markers to remain on display. However, encasement can lead to the development of micro-climates that can negatively impact the long-term preservation of the artifact. Artifacts that have been encased in glass or acrylic will need to be carefully monitored for changes in condition.

Summary

Wooden artifacts in cemeteries are disappearing from our cultural landscapes. The methods of deterioration are well-known and have been described in this manual. The methods for identifying and monitoring problems exist for both cemetery stewards and preservation professionals. What are lacking are long term corrective measures. This manual describes several possible corrective measures. They should not be taken simply as a list of things to do or not do. The benefits and consequences of each corrective measure have been discussed and it is important that cemetery stewards understand the issues before selecting a particular corrective measure or treatment option.

It can be discouraging to learn that nothing is currently available to entirely stop the weathering and decay processes on cemetery artifacts. Over time, they will succumb to the elements. However, through regular maintenance and routine inspections and assessments, the decay of wooden artifacts can be slowed substantially and their service lives can be extended. More importantly, the unique history and cultural

significance of wooden markers, grave enclosures, and other artifacts can be preserved for future generations to experience.

References

Agricultural Research Service (2007). Fungal Foam Seeks and Destroys Termites. *Agricultural Research*. U.S. Department of Agriculture. Vol. 55: No. 8.

American Society of Civil Engineers (1982). *Evaluation, Maintenance and Upgrading of Wood Structures: A Guide and Commentary*. New York: American Society of Civil Engineers.

Avarami, E. C. (1993). *Preserving Wood Features In Historic Buildings, An Annotated Bibliography,* U. S. Dept. of the Interior, National Park Service, Washington D. C.

Bauer, Scott (2003). *Invasive and Exotic Species*; Image: Formosan Subterranean Termite. Electronic image, http://www.invasive.org/browse/detail.cfm?imgnum=1324066, accessed November 23, 2008.

Center for Wood Anatomy Research, Forest Products Laboratory, USDA Forest Service (Date Unknown). *Wood Identification Procedures*. Madison, Wisconsin. Electronic document, http://www2.fpl.fs.fed.us/WoodID/idfact.html, accessed July 24, 2008.

Chicora Foundation, Inc. (2008). *Whitewash*. Electronic document, http://www.chicora.org/whitewash.pdf, accessed July 24, 2008.

Davison, A. D. and R. S. Byther. 1999. Algae, Lichens and on Plants. Pacific Northwest Plant Disease Control Handbook. p. 39.

Desbenoit, Brett, Eric Galin and Samir Akkouche (2004). Simulating and Modeling Lichen Growth. *Eurographics* 23:3.

Feilden, B. M. (1994). *Conservation of Historic Buildings*. Oxford, Boston: Reed Educational and Professional Publishing Ltd.

Feist, William C. (1990). Outdoor Wood Weathering and Protection. In *Archaeological Wood: Properties, Chemistry, and Preservation*, edited by Roger M. Rowell and R. James Barbour. Advances in Chemistry Series 225, Symposium papers from the 196th National Meeting of the American Chemical Society, Los Angeles, California, September 25-30, 1988. American Chemical Society, Washington D.C. 1990, pages 263-300.

Forest Products Laboratory, Forest Service and U.S. Department of Agriculture. (2000). *Wood Handbook: Wood as an Engineering Material*. Washington, D.C.: U.S. Government Printing Office.

Fritsche, Bjørn (2005). Image: Wood Truss Destroyed by Carpenter Ants. Electronic image licensed under the Creative Commons Attribution ShareAlike 2.5 License, http://commons.wikimedia.org/wiki/Image:Holzschaden.jpg, accessed November 23, 2008.

Goerig, David J., and James A. Chatfield (2004). 10 Things You Should Know about Lichens. *Ornamental Plants Annual Reports and Research Reviews 2004.* Special Circular 195, The Ohio State University Bulletin, Extension Research. Electronic document, http://ohioline.osu.edu/sc195/029.html, accessed June 12, 2008.

Grissell, E. E., Malcom T. Sanford, and Thomas R. Fasulo (1999, revised 2007). Common Name: Large Carpenter Bees, Scientific Name: *Xylocopa* spp. (Insecta: Hymenoptera: Apidae: Xylocopinae). Originally published as *DPI Entomology Circular 160*. Updated for this publication as *Featured Creatures*, Department of Entomology and Nematology, Division of Plant Industry. Electronic document, http://creatures.ifas.ufl.edu/misc/bees/xylocopa.htm, accessed January 22, 2009.

Hoadley, R. B. (2000). *Understanding Wood: A Craftsman's Guide to Wood Technology*. Newtown, CT: The Taunton Press.

Kalisch, Jim (2000). Subterranean Termites; Image: *Subterranean Termite Damage to Pine*. Department of Entomology, University of Nebraska – Lincoln. Image supported by a grant from AgrEvo. Electronic image, http://entomology.unl.edu/images/subtermites/subtermites.htm, accessed November 23, 2008.

Keith, David (2000). Subterranean Termites; Image: *Mud tubes on Wall Stud*. Department of Entomology, University of Nebraska – Lincoln. Electronic image, http://entomology.unl.edu/images/subtermites/subtermites.htm, accessed November 23, 2008.

Larsen, K. E. and N. Marstein (2000). *Conservation of Historic Timber Structures: An ecological approach*. Oxford: Butterworth-Heinemann.

Levy, Michael P. (1979). *A Guide to the Inspection of Existing Homes for Wood-Inhabiting Fungi and Insects*. Department of Housing and Urban Development, Office of Policy Development and Research. Washington D.C.

Matero, Frank G., Stephen Curtis, John Hinchman and Judy Peters (2002). *St. Louis Cemetery No. 1 Guidelines for Preservation & Restoration*. Electronic document, http://cml.upenn.edu/nola/pdfs/GuidelinesEnd.pdf, accessed June 2, 2008.

Merchant, Michael (2003). *Insects in the City: Carpenter Ants Around Homes*. FastSheet Ent-1001, House and Landscape Pest Series, Department of Entomology, Texas A&M University, College Station, TX. Electronic document, http://citybugs.tamu.edu/FastSheets/Ent-1001.html, accessed May 27, 2008.
Mitchell, Phil. *Methods of Moisture Content Measurement in the Lumber and Furniture Industries*. Wood Products Notes. Department of Wood and Paper Science, College of Forest Resources, North Carolina State University. Raleigh, North Carolina. Electronic document, http://www.ces.ncsu.edu/nreos/wood/wpn/methods_moisture.htm, accessed July 15, 2008.

Myers, John H., revised by Gary L. Hume (1979, revised 1984). Preservation Brief No. 8: *Aluminum and Vinyl Siding on Historic Buildings: The Appropriateness of Substitute Materials for Resurfacing Historic Wood Frame Buildings.* National Park Service, U.S. Department of the Interior.

National Trust of Australia (NSW), Guidelines for Cemetery Conservation. Electronic Document, http://www.nsw.nationaltrust.org.au/cemsappd.html, accessed August 3, 2008.

Old House Web (2008). *Termites, Ants and Other Wood-Destroying Organisms*. Electronic document, http://www.oldhouseweb.com/stories/Detailed/10324.shtml, accessed August 9, 2008.

Paine, C. (1983). Restoration of the Billings Estate Cemetery. *Bulletin of the Association for Preservation Technology*, Vol. 15, No. 4, pp. 60-65

PixOnTrax (2006). Image: Hibernaculum sweepings.jpg. Electronic image released into the public domain by the author, http://en.wikipedia.org/wiki/Image:Hibernaculum_sweepings.jpg, accessed November 18, 2008.

Ridout, B. (2000). *Timber Decay in Buildings: The Conservation Approach to Treatment*. London; New York: E & FN Spon.

Scheffrahn, Rudolph H., and Nan-Yao Su (2000). Florida Dampwood Termites, *Neotermes castaneus* (Burmeister), *Neotermes jouteli* (Banks), and *Neotermes luykxi* Nickle and Collins (Insecta: Isoptera: Kalotermitidae). Image: *Neotermes jouteli* soldier

and pseudergates in exposed galleries. Publication #EENY122, University of Florida IFAS Extension. Electronic image, http://edis.ifas.ufl.edu/IN279#FIGURE%202, accessed November 23, 2008.

Soller, Jon (2005). *Resolving Common Epoxy Issues & Problems*. Soller Composites. Electronic document, http://www.sollercomposites.com/images/Resolving%20Common%20Epoxy%20Issues.doc, accessed November 29, 2008.
Southern Pine Council (2008). *The Formosan Termite: A Super Bug*. Electronic document, http://www.southernpine.com/termiteinfo.shtml, accessed November 23, 2008.

Strangstad, L. (1995). *A Graveyard Preservation Primer*. American Association for State and Local History Book Series, AltaMira Press.

Swearingen, John (2004). *Le Décor – St. Astier Lime Paints*. GreenHomeGuide. Electronic document, http://www.greenhomeguide.com/index.php/product_detail/422/C134, accessed July 6, 2008.

Termite Treatment.com (2008). *Termite Treatment Directory*. Electronic document, http://wwwtermitetreatment.com/, accessed May 24, 2008.

Texas Historical Commission (Date Unknown). *Texas Preservation Guidelines*. Electronic document, http://www.thc.state.tx.us/publications/guidelines/Preservecem.pdf, accessed July 12, 2008.

Unger, A., A. P. Schniewind, and W. Unger (2001). *Conservation of Wood Artifacts, A Handbook*. Berlin; Heidelberg; New York; Barcelona; Hong Kong; London; Milan; Paris; Singapore; Tokyo: Springer.
.
Vail, Karen M., Edward E. Burgess and Charles Pless (2002). *Wood-Destroying Organisms Licensing Manual: WDO*. Electronic document, http://eppserver.ag.utk.edu/psep/secondlevel/thirdlevel/WDO/WDOindex.htm, accessed July 20, 2008.

Watts, Anthony (2007). *Bad Paint Job = Rising Surface Temperatures Part 2: A Test of Wood Surface Temperatures Related to Paint*. Electronic document, http://www.norcalblogs.com/watts/2007/05/bad_paint_job_rising_surface_t.html, accessed May 23, 2008.

Weaver, M. E. and F. G. Matero (1997). *Conserving Buildings: Guide to Techniques and Materials, Revised Edition*. New York; Chichester; Weinheim; Brisbane; Singapore; Toronto: John Wiley & Sons, Inc.

Wikipedia (2008a). Linseed Oil. Electronic document, http://en.wikipedia.org/wiki/Linseed_oil, accessed November 28, 2008.

Wikipedia (2008b). Tung Oil. Electronic document, http://en.wikipedia.org/wiki/Tung_oil, accessed November 28, 2008.

Williams, R. S., M. T. Knaebe and W. C. Feist. (1996). *Finishes for Exterior Wood: A Comprehensive Guide to the Painting/Staining and Maintenance of Homes, Decks, Log Structures and More.* Madison, Wisconsin: U. S. Department of Agriculture, Forest Service, Forest Products Laboratory.

Williams, R.S. and William C. Feist (1999a). *Water Repellents and Water-Repellant Preservatives for Wood*. Madison, Wisconsin: U. S. Department of Agriculture, Forest Service, Forest Products Laboratory.

Williams, R.S. and William C. Feist (1999b). *Selection and Application of Exterior Stains for Wood.* Madison, Wisconsin: U. S. Department of Agriculture, Forest Service, Forest Products Laboratory.

Winkler, Erhard M. (1986). The Measurement of Weathering Rates on Stone Structures, A Geologist's View. *Bulletin of the Association for Preservation Technology*, Vol. 18, No. 4, pp. 65-70.

Witsch, Hartmut (2006). Image: Xylotabanmale1.jpg. Electronic image licensed under Creative Commons Attribution 2.5, http://en.wikipedia.org/wiki/Image:Xylotabanmale1.jpg, accessed November 18, 2008.

Zinkova, Mila (2007). Image: Bee Carpenter in Hole.jpg. Electronic image released into the public domain by author, http://en.wikipedia.org/wiki/Image:Bee_Carpenter_in_hole.jpg, accessed November 18, 2008.

APPENDICES

Sample Wooden Marker Condition Assessment Form

Research Needs for Wooden Artifacts in Cemeteries

Figure A-1. Sample Wooden Marker Condition Assessment Form
(Adapted from the National Center for Preservation Technology and Training)

CONDITIONS ASSESSMENT FORM

Site:		
Street Address:		
City:	**County:**	**State:**
UTM Coordinates:		
Owner:		
Contact:		**Phone:**
Surveyor:		**Date:**
Weather *(circle all that apply):* hot warm cool cold dry humid sunny rain/snow/fog overcast windy		

IDENTIFICATION:

Plot identification:	
	plot designation:
Name(s) of interred:	
First burial date:	**Last burial date:**
Inscription:	
Carver (if known):	**Location of mark:**

DESCRIPTION:

Type of artifact *(circle one):* marker family name marker grave enclosure other *(describe):*			
Type of marker *(circle all that apply):* head marker foot marker ground tablet ruin cross obelisk funeral home plaque bedstead Other *(describe)*:			
Dimensions (marker):	**Height:**	**Width:**	**Depth (or L):**
Dimensions (base/other):	**Height:**	**Width:**	**Depth (or L):**
Orientation *(circle one):* North South East West unknown			

Interment status *(circle one):* active inactive abandoned	
Condition of marker*(circle all that apply):* standing fragment relocated ruin altered replica tilted sunken failed partially failed missing elements	
Insect presence *(circle all that apply)*: none detected live insects bore holes frass mud tubes other *(describe)*:	
Moss/Decay fungi presence *(circle all that apply):* moss mildew/mold mushrooms other fungal fruiting bodies *(describe):*	
Moisture content location:	**Reading:**
Moisture content (location 2):	**Reading:**
Type of interment *(circle one):* individual family undeterminable	
Ornament *(circle all that apply):* urn sculpture cross plaque incised decoration relief decoration ornamental vase none other *(describe):*	
Furniture *(circle all that apply):* sculpture container/vase plaque immortelles none	
Landscape *(circle all that apply):* brick asphalt concrete soil grass vegetation other	
Enclosure *(circle all that apply):* curb wall fence none	
Enclosure Description:	
Enclosure Condition *(circle all that apply):* standing ruin fragment relocated altered replica tilted sunken failed partially failed missing elements	
Insect presence *(circle all that apply)*: none detected live insects bore holes frass mud tubes other *(describe)*:	
Moss/Decay fungi presence *(circle all that apply):* moss mildew/mold mushrooms other fungal fruiting bodies *(describe):*	
Moisture content location:	**Reading:**

Moisture content (location 2):	**Reading:**
Grade slope *(circle one):* positive negative cross-slope none	
Degree of grade *(circle one):* 0 (low) 1 2 3 (high)	

Surveyor:	**Date:**	**Plot identification:**
Weather *(circle all that apply):* hot warm cool cold dry humid sunny rain/snow/fog overcast windy		

MATERIALS: *Check appropriate fields*

Type of Treatment/Finish	Primary structure	Base	Ornament	Roof
Untreated Wood				
Oiled Wood				
Painted Wood				
Varnish/ Clear-coated Wood				
Pressure-treated Wood				
Unknown Treatment				
Limewash				
Other				

	Primary structure	Base	Surface Finish	Ornament	Roof
History of Repairs					

CONDITIONS: *Rank conditions from 0 (low) to 3 (high)*

Conditions	Primary structure	Base	Surface Finish	Ornament	Roof
Collapse	0 1 2 3	0 1 2 3		0 1 2 3	0 1 2 3
Fragmentation	0 1 2 3	0 1 2 3		0 1 2 3	0 1 2 3
Decay/Punky	0 1 2 3	0 1 2 3		0 1 2 3	0 1 2 3
Checking/Splitting	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3
Exfoliation	0 1 2 3	0 1 2 3		0 1 2 3	0 1 2 3
Insect Damage	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3
Finish detachment			0 1 2 3		
Missing Elements	0 1 2 3	0 1 2 3		0 1 2 3	0 1 2 3
Bio-growth	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3
Vegetation	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3	0 1 2 3

Alterations	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
Open/missing joints	0	1	2	3	0	1	2	3					0	1	2	3	0	1	2	3
Soiling	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
Graffiti	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
Other *(describe):*	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3

Rank conditions from 0 (poor) to 3 (high)

	Primary structure				**Base**				**Surface Finish**				**Ornament**				**Roof**			
Overall Condition (0=poor 3=high)	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
Overall Integrity (0=poor 3=high)	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3

Comments:

CONDITIONS SURVEY DEFINITIONS

Site: Full name of cemetery with no abbreviations
Street Address: Approximate address of the cemetery, with no abbreviations.
City: City in which the cemetery is located, with no abbreviations.
County: County in which the cemetery is located, with no abbreviations.
State: State (no abbreviations) in which the cemetery is located, followed by the two-letter postal abbreviation for the state (ex. Louisiana--LA).
UTM Coordinates: A set of coordinates (easting and northing) that indicates a unique location according to the Universal Transmercator Grid appearing on maps of the United States Geological Survey (USGS). Indicate the centermost coordinate within the cemetery boundary (include Zone, Easting and Northing coordinates).
Owner: Full name of the owner of the cemetery, with no abbreviations.
Contact: The name of the person representing the cemetery owner.
Phone: The telephone number of the contact person for the cemetery.
Surveyor: The first and last name of the surveyor.
Date: Date of the survey (ex: 01/01/2002)
Weather: Weather conditions at the time when survey form completed.

IDENTIFICATION:

Plot identification: Includes block number and plot number on site map.
Name(s) of interred: First and last name(s) of interred.
First burial date: Date of earliest interment (ex: 1802)
Last burial date: Date of most recent interment (ex: 2002)
Inscription: A transcription of the tomb or marker inscription recorded in the language in which it has been written. Include abbreviations, punctuation and historic spellings. The transcription is a document of what the surveyor sees and *should not include any guesses*.
Carver (if known): First and last name (if available) of marker carver. The carver may "sign" his or her work on the base of the marker or tomb, on the rear elevation, or on the top of the marker. Often, the carver's "signature" is in a different font than the inscription on the tomb or marker. Signatures are extremely rare on wooden artifacts.
Location of mark: Location of the stone carver's "signature" in terms of geographic orientation. It may be found on the top, rear, bottom, or on the side of the stone.

DESCRIPTION:

Type of artifact:
Marker: any non-tomb mortuary structure which does not accommodate an interment and whose form is often sculptural.
Types of artifacts present:

- *Head marker*: An upright wood slab or plank embedded in the ground.
- *Foot marker*: An inscribed upright wood slab or plank embedded in the ground that is associated with and commonly smaller than a headstone. It is typically inscribed with initials or a single word describing family position (e.g., “Mother”).
- *Ground tablet*: An inscribed marker laid flush with or slightly above ground level.
- *Ruin*: A marker that has been destroyed and no longer retains its original shape.

- *Cross*: a cross, with or without inscription, placed in the ground or supported by a pedestal.
- *Pedestal obelisk*: A monumental, four-sided wood shaft, usually monolithic and tapering to a pyramidal tip, and sometimes stands on a pedestal.
- *Funeral home plaque:* A small wood plaque that is the only marker (for recent burials).
- *Bedstead*: a marker with a head marker, foot marker, and side rails designed to imitate the form of a bed.

Family name marker: A large head marker inscribed with the name of the family to whom the plot belongs. A family name marker does not indicate a burial--it only indicates a family plot.

Dimensions: The height, width and depth (or length) of the primary marker, base, if any, and other features of the marker, in inches.

Orientation: Compass direction of the primary face or surface that contains the inscription (the orientation of unmarked graves is "unknown").

Interment status:

- *Active*: A body has been interred in the past twenty years.
- *Inactive*: No bodies have been interred in over twenty years, but the space is still usable because it is sealed. (Most grave markers and tombs in the American Cemetery are "inactive.")
- *Abandoned*: The tomb/marker is open, vacant, or derelict.

State of interment:

- *Standing*: The tomb or marker maintains its structural form and support.
- *Ruin*: The tomb or marker has been destroyed through collapse or demolition.
- *Fragment*: A piece or pieces of an enclosure or marker that have dissociated from the original fabric. The enclosure or marker no longer reads as a whole.
- *Relocated*: The marker has been moved from its original site and relocated to another portion of the cemetery. (Note: relocation of a marker must be verified through historic documentation.)
- *Altered*: The enclosure or marker has been modified through patching or reassembly, or by replacing parts of the monument.
- *Replica*: The original enclosure or marker has been removed from its original site and replaced with an exact copy. (Note: replication of an enclosure or marker may be indicated on the new gravestone inscription, but this must be verified through historic documentation.)
- *Tilted*: The tomb or marker has shifted horizontally due to settling of the earth.
- *Sunken*: The tomb or marker has shifted below or partially below grade.
- *Failed*: The marker, enclosure, or other artifact has completely collapsed.
- *Partially Failed*: Portions of the marker, enclosure, or other artifact have collapsed.
- *Missing Elements*: Elements of the enclosure, marker, or other artifact are missing. They may be located on the ground nearby or completely absent. Missing elements that have been recovered should be identified on the condition assessment form and placed in proximity to the original artifact.

Insect Presence

- *None Detected:* There is no evidence of insects or insect activity, either on the above-ground portion of the artifact or on the below-ground portion.
- *Live Insects:* Live insects were identified on or within the artifact.
- *Bore Holes:* Insect bore holes were identified
- *Frass:* Insect fecal pellets or wood shavings were identified within or near the artifact
- *Mud Tubes:* Subterranean termite mud tubes were identified on the artifact.
- *Other:* Additional forms of insect damage not included on the form should be noted.

Moss/Decay Fungi Presence

- *Moss:* Moss is an indicator of high moisture content; its presence should be recorded for additional monitoring and/or testing.
- *Mildew/Mold:* Mildew and Mold are indicators of high humidity/moisture conditions.
- *Mushrooms:* Advanced wood decay is sometimes evidenced by the presence of mushrooms.
- *Other Fungal Fruiting Bodies:* White, cottony masses, slimes, and other forms of fungal fruiting bodies that are not listed should be described here.

Moisture Content Location and Reading

Record the location where any moisture readings were taken (e.g., near ground-line, on face) and the results.

Type of interment:

- *Individual:* The marker contains only one interment.
- *Family:* The marker contains two or more interments from the same or related family.
- *Undeterminable:* Interment representation is not clear (unmarked graves are *always* "undeterminable").

Ornament: Ornament is *integral to the structure of the tomb or marker*.

- *Urn*: A cylindrical container with a foot that is integral to the structure of the tomb or marker. It may be open or closed.
- *Sculpture*: Any masonry ornament integral to the structure of the marker which is not a plaque, urn, or relief or incised decoration.
- *Cross:* A cross that is integral to the structure of the marker.
- *Plaque:* A thin, flat piece of cast metal applied to a marker.
- *Relief decoration:* Decorated carved relief above a background plane.
- *Incised decoration:* Decorated carved incision below a background plane.
- *Ornamental vase:* Vase that is integral to the structure of the marker.
- *None:* No ornament present on the marker.

Furniture: objects related to but *not permanently attached* to the marker.

- *Sculpture:* Any three-dimensional object not permanently attached to the tomb or marker. Sculpture may include urns, figures, crosses, etc.
- *Container/vase*: A container not permanently attached to the tomb or marker that holds flowers or other immortelles.

- *Plaque:* A commemorative tablet or medallion unattached to the tomb or marker.
- *Immortelles*: Temporary ephemeral offerings.

Landscape: The setting surrounding the artifact or marker. May include one or more of the following: brick, asphalt, concrete, soil, grass, vegetation or other ("other" includes leaves).

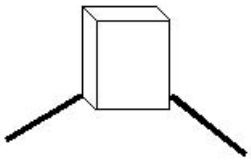
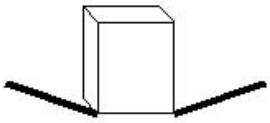
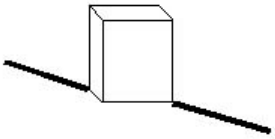
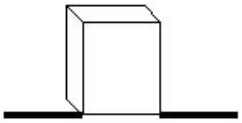
Enclosure: A curb, wall or fence separating a tomb, marker or family plot from the remainder of the cemetery.

- *Curb*: A low wood or other material edging that surrounds the plot and is six inches high or less.
- *Wall*: A non-wood structure that surrounds the plot and is greater than six inches in height.
- *Fence*: A metal or wood enclosure that surrounds the plot.

Grade slope: The slope of the land on which the artifact or marker lies.

- *Positive:* The artifact or marker is at the top of a rise.
- *Negative:* The artifact is at the bottom of a rise.
- *Cross-slope:* The artifact intersects a slope.
- *None:* The artifact is on flat ground.

TYPES OF GRADE SLOPE:

Positive slope	Negative slope	Cross-slope	No slope
			

Degree of slope: Rated from 0 (low) to 3 (high). (Degree of grade does not need to be indicated if there is no slope).

MATERIALS:

Primary structure: The portion of the artifact or marker which contains the inscription.

Base: The lowest element of the artifact marker that supports the primary structure (ex: bricks or concrete supporting a basal marker).

Ornament: Decorative elements that are an integral part of the artifact or marker. These include most urns, crosses, sculpture, plaques, and all relief and incised decoration.

Roof: The top covering of a grave house.

Types of Treatment/Finish:

- *Untreated Wood:* Artifact has no evidence of ever having a protective finish or treatment.

- *Oiled Wood:* Artifact has oily sheen, is darker than untreated wood.
- *Painted Wood*: Artifact has evidence of a film-forming opaque coating. Typically seen at the base or in areas protected from the environment.
- *Varnish/Clear-coated Wood*: Artifact has a clear film finish. With age it will likely appear brittle, yellow, cracking or flaking.
- *Pressure Treated Wood:* Artifact is constructed of pressure-treated lumber.
- *Unknown Treatment*: A finish is evident but is unknown.
- *Limewash*: A thin exterior coating of calcium or magnesium carbonate (lime) and water. Usually white, although may be tinted, it tends to be somewhat chalky to the touch as it ages.

History of repairs: Indicate visible or historical repairs made to the artifact. Indicate repairs on the primary structure, base, ornament, surface finish and roof.

CONDITIONS:

Conditions: Indicate degree of deterioration for the primary structure, base, surface finish, ornament and roof.

0 = no deterioration
1 = slight deterioration
2 = moderate deterioration
3 = significant or total deterioration

Forms of deterioration include:

- *Collapse*: Complete or partial failure of the structure.
- *Fragmentation*: Fragments from an artifact that have dissociated from the original fabric. The artifact no longer reads as a whole.
- *Checking/Splitting*: Fractures of various lengths on the surface material that have not developed into fragments. Indicates severe weathering.
- *Exfoliation*: Loss of wood fibers along the surface of an element.
- *Insect damage*: Bore holes that have resulted in a loss of structural integrity
- *Finish detachment:* The failure of surface finish attachment to masonry resulting in flaking, peeling or complete loss of material.
- *Missing Elements*: Few to many missing pieces that may or may not be found nearby.
- *Bio-growth*: Growth of microflora (usually algae, fungi or lichen) on the surface of the tomb or marker.
- *Vegetation*: Growth of macro plant forms (ivy, moss, grass, vines, etc.) or their roots.
- *Alterations:* Intentional modifications to the original fabric.
- *Open/missing joints*: Loss or deterioration of mortar between masonry units.
- *Soiling*: Surface deposits usually dark in color that are caused by moisture, pollution or anthropogenic origins (bird droppings, paint, etc.).
- *Graffiti*: Intentionally inscribed or applied markings, often the result of vandalism but may also occur from gravestone rubbings. May include visible footprints or cat scratches.

Overall condition: Rank the overall state of the entire tomb or marker.

0 = extremely deteriorated condition (structural failure)

1 = poor condition (significant threat to structure and/or total loss of decorative features)
2 = moderate deterioration (structurally stable, significant or progressive loss of decorative features)
3 = good condition (structurally stable, decorative features and finishes largely intact)

Overall integrity: Rank the overall authenticity and retention of original fabric for the entire tomb or marker.

0 = total loss of integrity (25% or less of original materials remain, or an overwhelming presence of inappropriate replacement materials or alterations)
1 = low integrity (26% - 50% of original materials remain, or a significant presence of inappropriate replacement materials or alterations)
2 = moderate integrity (51% - 75% of original materials remain, or an obvious presence of tolerable replacement materials or alterations)
3 = high integrity (76% or more of original materials remain, or a minimal presence of tolerable replacement materials or alterations)
Inappropriate replacement materials or alterations: Replacement materials or alterations that are not in keeping with historic materials and/or use of the artifact.

Comments: Please include any comments you may have regarding the artifact.

Research Needs for Wooden Artifacts in Cemeteries

This reference manual for wooden artifacts in cemeteries is based on current knowledge and readily available practices. During the course of the research that led to this manual, several research needs were noted that could improve the documentation and care of wooden artifacts. Although one might argue that wood is wood and outdoor exposure is outdoor exposure, wooden artifacts in cemeteries are indeed different from wood building products in exterior environments. They are smaller than buildings, are often exposed to harsh environmental conditions with minimal maintenance, and typically develop a desirable "historic" appearance over time that is as much a part of the artifact as the original artifact itself. As such, commonly-used procedures for repairing, painting, or replacing damaged or missing components may not be appropriate. In fact, a number of philosophical issues should be considered when embarking on any of the research needs given below. Such issues may include:

- A philosophical discussion of the realities of trying to preserve a monument that will eventually succumb to decay.
- Philosophical questions regarding effective carpentry repairs, repair joints, and the use of adhesives and consolidants. Should marker bases or enclosure corner posts be repaired with pressure-treated lumber? What about pre-treatment with borate rods or wood preservatives? Should alternative materials, such as steel or composite (PVC) be considered? Are adhesives necessary for wood-wood repairs? Since epoxies pose a problem by restricting the flow of moisture through the member or element, is there an alternative when an adhesive might be used?
- Is it acceptable to modify ground elevation around wooden markers in cemeteries to provide better drainage? Is ground drainage and moisture management compatible with sound archaeological and historic preservation practice?

Considering the issues raised above, the following research needs have been identified by area, not necessarily by priority.

Documentation Needs

- Documentation guidelines - a field form designed specifically for wooden artifact assessment, mapping, and documentation is needed, including how to identify available historic documents to help identify illegible monuments. The sample documentation form provided in this manual serves as an example but may not address all the potential needs for individual artifact assessment, wood condition, and possible remedial measures.

Technical Needs

- Condition assessment – the visual and probing techniques described in this manual provide a viable means of assessing wooden artifacts, particularly above ground. Techniques that would allow for enhanced assessment, particularly below ground, would provide the means to determine the condition of wood embedded in the ground without disturbing the soil that supports the artifact. Once loosened, the soil does not provide as firm a foundation and subsequent damage to the artifact can occur. If deterioration is found, disturbing the soil may be necessary to implement remedial treatments or repairs. However, if the wood is in good condition below ground, disturbing the soil should be avoided. Techniques for below-ground assessment would provide the means to accomplish this.
- Condition assessment – Nondestructive testing methods should be researched that have potential for better assessing the internal and below-ground areas of wooden artifacts.
- Durability - research on the durability and desirability of applying wood preservatives and water repellent preservatives with ultraviolet light blockers, borate treatments, and lime-based washes to wooden artifacts in cemeteries is lacking. How long do they last? How significant are any visual impacts (color changes)? What maintenance schedule is required if these means of enhancing durability are used? Lime-based washes have been used for centuries on exterior adobe, masonry, and wood surfaces. Do they have a role in extending the service life of cemetery artifacts?
- Use of consolidants - the options for consolidating a wooden artifact, including the benefits, methodology, long-term implications, and cost should be explored. Consolidants are used for the repair of wood in historic structures and museum artifacts but, as this project has revealed, consolidants have not provided satisfactory long-term results when exposed to the elements with minimal maintenance. Is there a role for consolidants in the repair of wooden cemetery artifacts and how might that role be determined? As new consolidants become available, their potential for extending the life of wooden artifacts in cemeteries should be considered.
- Cleaning solutions – identifying suitable cleaning solutions (if any) and materials (such as natural bristle brushes) that could extend the service life of wood components in cemetery artifacts. Cleaners are used for stone monuments but little research has been conducted on suitable cleaners for severely weathered wood products. Cleaning solutions exist for wood products with minor weathering (such as house siding) but the recommended surface preparation and cleaning is likely too destructive to small fragile artifacts that have had little or no regular cleaning or maintenance.
- Interpreting illegible monuments - is there a methodology to improve legibility of weathered markers for historic documentation purposes? This

may be as "simple" as enhancing photographs in Adobe Photoshop, but other potential methods should be identified and investigated. Micro-laser scanning techniques, digital radioscopy, and infrared thermography have potential for enabling "reading" of severely weathered markers.

Education Needs

- Workshops on wooden artifacts - educating the public on the fragile nature of the markers and effective management and maintenance practices would help to preserve not only the artifacts but also the cultural landscapes in which they exist.
- History of the use of wooden artifacts in cemeteries - a document on wooden markers and their socio-economic and cultural significance within the U.S., including historic photographs and historical treatments would help cemetery stewards to better understand the role wooden artifacts have in their local cultural heritage.
- Repair manual - a manual for the repair of wooden cemetery artifacts would be an invaluable resource for laypersons as well as professionals that must repair these artifacts. The manual could also include a list of skilled historic preservation craftspeople and/or state or regional websites that provide such information, a list of sources for reclaimed wood, and a list of universities, organizations, or companies that provide species identification.
- Treatment database - a comprehensive database of pesticides, biocides, mildewcides, water repellent preservatives, penetrating oils, and lime-based whitewashes, and their environmental impacts, health, safety, and handling concerns, cost, method of application, effectiveness, and reapplication timeline would serve a much broader audience than cemetery stewards but would be a valuable resource when considering chemical treatments.
- Resource list - a means for finding trained professionals with backgrounds or experience with historic preservation projects would be useful. Beyond the list typically maintained by many state historic preservation officers, the list could also include exterminators, landscape managers, carpenters, conservators, preservationists, etc. This would address the frequently asked question "where does one go to find a trained professional who can approach the project with sensitivity and knowledge of historic preservation practices and goals?"