
Preservation & Maintenance of Log Structures

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Log & Timber Homes Council,
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Table of Contents

1 Foreward	3		
2 Understanding the Basics	4		
2.1 What is wood?.....	4		
2.2 Insects.....	4		
2.3 Fungi.....	6		
2.3.1 Sapstain	6	4.1.1 Site Drainage & Finish Grade.....	12
2.3.2 Decay Fungi.....	6	4.1.2 Wall Surface Protection	12
3 Controlling the Nature of the Wood.....	8	4.1.3 Overhangs & Gutters	12
3.1 Moisture Control	8	4.1.4 Ventilation of Spaces.....	13
3.2 Wood as a Food Source.....	9	4.2 During Construction	13
3.3 Controlling Environmental Conditions	10	5 The Finish Treatment	14
4 Controlling Design, Site, and Construction Elements.....	12	6 Final Note	15
4.1 Building Design and Location.....	12	6.1 Publications.....	15
		6.2 Web Sites	15
		6.3 Recommendations	17
		6.3.1 Removal of Mildew	17
		6.3.2 Removal of Iron Stain.....	17
		6.3.3 Extractive Bleed.....	17

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Preservation & Maintenance of Log Structures

1 FOREWARD

Log structures became part of the human shelter system early in the development of several civilizations where forests provided the primary indigenous source of building material. When these structures served as only temporary shelter for nomads, log preservation and maintenance were not an issue. However, as civilizations evolved, the need for permanent structures brought new considerations.

Even in ancient log construction, known to have been built before 700 BC in Eastern Europe, certain techniques were used to make log structures endure. Special corner notches that shed water, organic coatings that blocked water penetration and retarded fungal growth, large roof overhangs, stone foundations, and other innovations were used to protect the logs from insects and fungal decay. These inventions were primarily based on the desired durability of the structure and the available materials found locally. Today we have many more options to choose from in making our decisions.

The purpose of this presentation is to include this historical perspective of log maintenance to a discussion relevant to today's log homes. When contemplating designing, building, and living in a log structure, what features, materials, and methods will ensure the permanent quality of the structure?

Preservation & Maintenance of Log Structures

2 UNDERSTANDING THE BASICS

As an owner (or potential owner) of a log home, it is important to understand a few basic facts about wood. A properly maintained solid wood home will avoid costly future repairs. Your preservation and maintenance decisions should be based primarily on your site and geographic location as well as an understanding of the abiotic and biological agents that are harmful to wood. Considerations of local building codes and regulations, successful local practices, and special situations must be factored when evaluating the information presented here.

The Forest Products Laboratory of the US Forest Service published the *Techline* publication on durability titled, *Effect of Climate on Durability of Wood* (see copy at end of this paper). This report includes a map that illustrates the degree of attention required in the different climate regions of the United States to ensure the permanence of log structures. The *International Residential Code for One- & Two-Family Dwellings* also includes valuable references in Ch. 3, Building Planning (Termite Infestation Probability Map; Decay Probability Map).

A comparison of the three maps shows strong similarities and interesting relationships. The decay probability map nearly matches the *Techline* durability map except that the entire Pacific coast is shown to have a low to moderate probability for decay. Both maps illustrate regions of similar relative humidity and precipitation. The termite map indicates the extent of documented colonies, but the probability of termite activity again shows high correlation with areas with greater decay probabilities and climate indexes over 35.

Let us begin our inquiry by focusing our attention on the stuff that dream homes are made of: Wood.

2.1 What is wood?

Wood is a cellular material that makes up the bulk of the tree. Water, tannins, waxes, gums, starches, alkaloids and oils occupy the cell cavities, contributing to the color, odor, taste, decay resistance, and flammability of the wood. It is like a honeycomb composed mainly of dead, hollow, tubular cells. This cellular structure is what gives wood its amazing strength, insulating value and allows it to transport water, oxygen, and nutrients.

An organic material, wood constantly changes the amount of moisture held in its cell structure (aka., moisture content) with changes in its environment (humidity and temperature), absorbing and releasing moisture. Wood in service is also a natural food source for several species of insects and organisms (fungi) and provides shelter and nests for other creatures. It is widely recognized that four elements must be present for a wood-digesting insect or fungus to survive – elimination of any one of these will protect against their damage. The four required elements are:

- Food Source:** Polysaccharides and other carbohydrates that make up the wood cell wall.
- Temperature:** Organisms thrive in the range of 68-97° F (23-36°C); molds and sap stains grow in the 75-85°F (24-29°C) range.
- Oxygen:** Decay organisms require 20% free oxygen in the wood. That's why wood kept totally submerged in water will not rot.
- Water:** Decay organisms typically require 28% - 30% moisture content (MC) in the wood, but some fungi can survive and discolor (stain) the wood with as little as 20% moisture content. Unprotected wood left in contact with water will absorb moisture to near fiber saturation (25% to 30% MC). In higher relative humidity, unseasoned wood dries slowly while dried wood can absorb moisture, allowing the wood to decay for a longer period.

2.2 Insects

Trees and logs can be attacked and degraded by several biological agents, including insects, plants, fungi, bacterial and viruses. These agents are categorized by issues concerning damage to the wood that restricts its utilization in solid wood

Preservation & Maintenance of Log Structures

building systems. Bacteria and viruses are generally found as pathogens in living trees and generally pose no concern. Insects and fungi, however, do degrade both the living tree and processed logs and timbers. Visual stress grading of houselogs, a requirement for all companies who are members of the Log & Timber Homes Council, requires an understanding of the signs of insect or fungal activity in the living tree, as well as in the log after it has been harvested. The grading process identifies indicators of wood strength and quality based on visual inspection to form judgments about the serviceability of any particular timber for use in a structural application.¹

Compared to the total amount of wood destroyed by decay fungi, insect damage is small. This is not to underestimate the destructive capabilities of insects, but visual stress grading limits the effects of insects in a finished log or timber. If a problem with wood damaging insects is discovered, it should be taken seriously, but log homes have a HUGE advantage over conventionally framed homes - Termite tunnels and other insect activity can be readily seen and easily treated! In log buildings, the symptoms of insect activity do not remain hidden under wall and ceiling finishes.

Many different types of insects attack wood in the living and dead standing tree, as well as wood in service. Bark beetles, carpenter bees, wood boring beetles, termites and carpenter ants are all common residents of forest trees and can also be found in standing log structures. Treatments to control the effects of insects in log homes varies depending on the purpose of the attack.

- ❑ Wood boring beetles (long horned beetles, old furniture beetles, powder post beetles) like dry wood as both food and shelter. They tunnel and bore into the sapwood and heartwood of the tree, such as flathead and roundhead borers that attack dead and dying trees and logs. While some boring beetles, especially the round-headed and flat-headed borers, can cause significant visual and customer relation problems with their relatively large tunnels and often untimely emergence in a finished home, others produce tunnels of such small size that their presence does not affect the structural integrity of the wood. Customers selecting logs made from standing dead timber should understand the life cycles and practical effects of these boring beetles. Most of the boring beetles spend less than two years in a log before emerging as short-lived adults looking for mates and a new standing or downed dead tree to lay eggs in. They will rarely, if ever, re-attack the log they emerged from, so the chances that logs and timbers in service being attacked or re-attacked by these forest dwellers is quite remote. If the logs are processed with the tunneling larvae still in them, their emergence can trigger inquiries and complaints if the human inhabitants are not expecting the nuptial flights of a log's former inhabitants.
- ❑ Bark beetles attack, and often kill, live trees. They do not usually penetrate deeply into the sapwood, but merely feed on the nutritious inner bark and cambium. In the process the moisture and nutrients normally transported up the tree are cut off, leaving behind little more than engravings on the outer surface of the woody cylinder. It is assumed by the very nature of stress grading that the wood remains sound, and no consideration is given to the altered appearance of the log.
- ❑ Wood nesters are another group of insects (primarily carpenter bees and carpenter ants) that dig into exposed wood to build nests and /or brood chambers. Their colonization activity can be discouraged or eliminated by household bug sprays and regular maintenance of the exterior finish treatment. Spraying their entry holes and filling the holes with caulk will discourage future entry or exit. The re-infesting insects need to be treated with an EPA-registered pesticide labeled for use on wood.

Any discussion of boring beetles will ultimately touch on the wide variety of species and sizes of beetles that eat and live in the xylem of trees and attack wood in service.

Precautions against insect problems include visual stress grading of the logs and timbers, the application of good general practice in the design, specification, construction, and maintenance of the home, and periodic inspection techniques. These practices are outlined in the following sections and in other Log & Timber Homes Council literature. More specific information is available in *Log Tech Note 02-01 Controlling Carpenter Bees* and *Log Tech Note 03-02 Termite Prevention & Control*.

¹ Excerpted from The Log & Timber Homes Council Log Grading Program Training & Operations Manual, prepared by Edwin J. Burke, PhD, University of Montana Wood Science and Engineering Laboratory, for the Log Grading Committee of the Log & Timber Homes Council, Building Systems Councils, National Association of Home Builders.

Preservation & Maintenance of Log Structures

Ask your log home representative how they have addressed insect issues in the material they supply. Company philosophies on the subject vary due to primary market area, wood supply, wood species, etc. When selecting a log home company, weigh the protection against insects that they will provide against the probability of insect problems in the region you will be building.

2.3 Fungi

There are three groups of wood attacking fungi: Mold, Sapstain and Decay.

2.3.1 Sapstain

Mold and sapstain fungi feed on the nutrients contained on the wood surface and within the few living cells of the undried sapwood. While not structurally harmful to wood, mold and sapstain cause unsightly discoloration of the wood ranging from black, gray, bluish green and white. When present in wood, they cause the wood to be more porous thereby increasing the rate at which the wood can be wetted to the moisture content conducive for decay.

A fungus that utilizes the cell contents in the living sapwood for nourishment causes sapstain. It does not decompose cell wall material, but merely consumes sugars stored in the sapwood of several softwood and hardwood species. Also referred to by some as mold, the filamentous bodies of these fungi pass from cell to cell via existing holes in the walls of the cells. The wood that has been infected will usually take on a blue or black (rarely purple or red) coloration that fades when exposed to sunlight. Sapstain has no marked effect on the strength of wood, and is, therefore, not limited by visual stress grading. Its major effect is on the appearance of the wood, and the increased permeability it gives to the wood, which increases the amount of finish that is absorbed into the stained areas. The coloration of logs taken from standing dead pines is at worst a visual defect, or at best, a highly sought-after feature enhancing the value of the log for cosmetic reasons.

The fungi can live in the standing tree after attack by bark beetles that inoculate the wood with sapstain spores they carry with them from previously affected trees. Generally, this type of infection is well-developed by the time the tree is utilized and will stop spreading when the moisture required by the fungus has left through drying.

Airborne spores can germinate on the ends and exposed sides of stacked logs waiting processing. Stain in these logs can be avoided by cutting and processing in the winter months when the temperatures are too low for fungal growth, by keeping the ends and sides of the logs continually wet (fungi cannot grow when liquid water is present on the log's surface), or by circulating air around surfaced material to dry their surfaces, greatly slowing further growth of existing fungi and preventing the further infection by airborne spores.

2.3.2 Decay Fungi

Decay fungi are the ones that can seriously damage any log or wood structure and the reasons an intelligent maintenance program is so important. Decay fungi feed off the wood cell wall's cellulose and lignin, breaking them down into simple sugars for easy consumption. The effects on the wood vary from brown crumbly cubical size sections to spongy pockets that can spread across and inward from the log surface. The structural damage caused by decayed wood is significant before any outward sign is easily recognized. In fact, nearly 75% of the tension strength of the wood may be lost prior to any softening of the surface, and long before the wood is stringy or crumbly.

Decay is defined in ASTM D-9 as:

"The decomposition of wood substance caused by action of wood-destroying fungi, resulting in softening, loss of strength and weight, and often in change of texture and color."

Preservation & Maintenance of Log Structures

In addition to the inability of a visual inspection to accurately approximate damage due to decay, the loss of strength of wood fibers are the prime reasons that decay is limited. Advanced decay is not allowed in any structural grade of wood.²

Two categories of decay are:

1. **Live-tree decay** that thrives in the living tree and generally attacks the heartwood, ceasing growth activities when the tree is cut and subsequently dried, and
2. **Service decay** that thrives on and in the dead tree (and wood in service), generally attacking the sapwood, thriving due to the presence of moisture.

Live-tree decay cannot survive the drying that occurs after the tree is harvested and will not reactivate upon re-wetting when a timber is put in service. Pocket rot, or peck, appears as isolated areas of either white or brown decayed wood surrounded by normal, sound wood. The reduction in strength for the affected areas is predictable. For this reason, scattered patches of some of these live-tree decays, such as the brown peck and white speck (both referred to as pocket rots) are allowed in the lower grades of wall logs, so long as the pockets are well scattered and do not account for a significant volume of the log.

Service decay requires a different approach. These fungi will enter dormancy if either the temperature or moisture requirements are not sufficient and wait for more favorable conditions to begin growth and the decay process again.

For the purposes of log grading, fungal decay of wood can be seen in two distinct phases -- incipient and advanced decay. Incipient decay is the manifestation on the wood surface of the beginning stages of decay and is recognized as a slight discoloration of unseasoned wood, without the marked softening of the wood structure. One stage of incipient decay, "firm red heart" merely discolors the wood and does not significantly affect the strength of the wood fibers. Inspection for incipient and advanced decay is directed at all surfaces of the timber, with more attention given to the heartwood, knots, checks, splits and any other such defect.

Advanced decay, or rot, is extensive in its damage and usually quite easily identified. The affected area is usually soft to the touch and is often discolored or bleached and may be evidenced by toadstools, thick mats of spore-bearing structures, conks, or other fungal fruiting bodies. Only pieces free of advanced service decay or containing firm red heart or very limited amounts of live-tree decay can be allowed into the structural grades.

It is important to recognize that a dried, uninfected log or timber is not immune to further decay. Once dried, wood left exposed to precipitation or placed in contact with the ground may return to the fiber saturation point (approximately 30% moisture content), where the wood cell wall has reabsorbed enough water to saturate the cell wall. If the piece has sapwood exposed, or does not have decay-resistant heartwood, it is likely that decay will begin and will continue until steps are taken to re-dry the piece and remove it from water exposure or ground contact.

For more information on insects and fungi, refer to the *Wood Handbook: Wood as an Engineering Material* (FPL-GTR-113) and other Forest Service publications. Your state university agricultural extension is also an excellent source of information.

² Excerpted from The Log & Timber Homes Council Log Grading Program Training & Operations Manual, prepared by Edwin J. Burke, PhD, University of Montana Wood Science and Engineering Laboratory, for the Log Grading Committee of the Log & Timber Homes Council, Building Systems Councils, National Association of Home Builders.

Preservation & Maintenance of Log Structures

3 CONTROLLING THE NATURE OF THE WOOD

Regarding wood durability, the only elements we can manage are the presence of **water** and the availability of a food source: **the wood itself**.

3.1 Moisture Control

Moisture in log structures is from one of two sources: Original moisture from the tree that remains in the incompletely seasoned log and moisture that has entered dried wood from the environment.

The moisture present in the wood naturally is referred to as its initial moisture content, expressed as a percentage of its dry weight. The living tree typically has a moisture content that is greater than the fiber saturation point (FSP; generally accepted as 30% moisture content) and can be as high as 200% or greater in some domestic species. For wood products used in normal household environments (e.g., finish flooring), the wood is dried to 6% to 12% prior to milling to closely approximate the interior equilibrium moisture content it will attain in service, thereby minimizing the potential for movement or dimensional change due to moisture content change after installation. Most structural lumber products, such as 2x6 studs and 2x10 floor joists, are dried to between 15% to 19% moisture content for reasonable dimensional stability after they have been installed. Due to the large cross section of logs typically used in log structures, it is very difficult to guarantee specific moisture content throughout the piece. While the wood within 1" of the surface may measure less than 20% with a moisture meter, the piece can be expected to have greater moisture content within it.

A log's moisture content is significant for several reasons:

- ❑ Wood will continue to lose moisture through evaporation until it reaches equilibrium with the temperature and relative humidity of the surrounding environment. This moisture content, known as the Equilibrium Moisture Content, or EMC, varies with the small, day-to-day fluctuations in the temperature and humidity and with the large, seasonal differences in these two factors. At 95% humidity, the moisture content of the wood can be expected to be well above 20%; it drops to about 9% at 50% humidity. At any given humidity level, the higher the temperature, the lower the moisture content. The impact of the climate is described in ICC 400, *Standard on the Design and Construction of Log Structures*, now in its 4th printing for the 2021 edition. ICC 400 identifies the design moisture content (MC_D) at the point when the logs are milled/crafted for assembly. MC_D is used to determine weight, structure and other properties that affect the builder. After a few years of seasonal cycles, the EMC is reached and affects thermal performance. ICC 400 refers to this as service moisture content (MC_S).
- ❑ Dimensional change is likely to occur due to this initial loss of moisture, called seasoning, generating significant dimensional change seen as shrinkage as the cell walls shrink and densify. The release of the stress created when the cells collectively shrink may be heard as a loud pop and appears as a crack (or check) running along the grain on the surface of the piece. Checks typically extend radially to the heart of the log. Upward facing checks will collect rain and must be protected from water entry and/or treated to eliminate the detrimental potential of water sitting in the log. ICC 400 does not limit the change from MC_D to MC_S for determining settling but recognizes that different methods of log building may involve slumping, compaction, or shrinkage. It allows the designer/builder to determine settling by selecting a specific path for estimating settling -- a prescriptive method, a table of settling allowance, calculation methods, engineering analysis, testing, or provide data from a field study.
- ❑ Wood will also shrink and swell after reaching an initial EMC as the atmosphere around the wood changes in temperature and relative humidity. This shrinking and swelling seen in seasoned wood in service is known as movement; this movement plays a role in the complicated process of wood weathering as well as causing minor annoyances such as sticking doors and loosened furniture joints.
- ❑ Discoloration by sapstaining fungi may become evident when higher moisture content is combined with seasonal high temperatures. This is much less of a problem during the cooler seasons and in dry climates.

Preservation & Maintenance of Log Structures

- ❑ The physical properties of wood benefit as moisture content is reduced. Less moisture means lower weight and easier handling; outer cells take stains and other treatments better; interior sanding quality improves and becomes easier. Mechanical properties also improve as the wood becomes stiffer and harder to compress. The greatest benefit may be to the hardness of the exposed surface in compression perpendicular to grain.

Each log home supplier has made a series of decisions regarding the wood products they manufacture and offer to the consumer. To manage moisture content, several options may be employed, each providing different opportunities and results over any given period of time. Regardless of the option selected below, wall-log producers may choose to utilize their accredited log grading authority to certify the design moisture content of their logs.

- ❑ Some log home suppliers have invested in kilns to dry their logs, thus “preshrinking” the wood, reducing the weight of the logs, making them easier to mill, crystallizing the pitch in resinous species, and killing any insects or organisms that may have invaded the live tree. Some companies further warrant specific moisture content, managing kiln time and cycles accordingly. Drying quickly may produce checks (separations between the wood fibers). The checks help visual stress graders who are trying to establish slope of grain (straighter = stronger) while adding a task to the sealing of the stacked logs (treat and seal all upper ward facing checks).
- ❑ Other wall-log producers use standing dead timbers that have low moisture content (typically at or below 20%) when they arrive for milling. They will need to consider other factors like sapstain.
- ❑ Air-drying is another common method that involves the particular storage of timbers over a period of time providing airflow to evaporate the moisture from the wood prior to incorporating the wood into a structure. Air-dried material can have moisture content ranging from 12% to 30% depending on drying time, method, and climate.
- ❑ Some companies use green or unseasoned wood, although it is often partially air dried before it is milled. The term “green” describes the wood as it arrives at the company’s yard as a raw material without any processing to reduce moisture. These companies design their buildings to allow for moisture loss and shrinkage after the building has been constructed.
- ❑ Others shape laminated beams (with minimal moisture content) into wall-logs to reduce the log’s tendency to shrink, twist, warp, and check.

3.2 Wood as a Food Source

Log home suppliers have a couple options beyond the management of moisture in the wood to control insects and/or decay from attacking the wood for food.

- ❑ Some wood species deter insect and fungal attack due to the natural extractives and oils present in the wood. Moisture content in these species is less of an issue for durability of the wood in service.

Refer to the *Wood Handbook: Wood as an Engineering Material* (FPL-GTR-113) and other Forest Service publications for specific details about the durability of various wood species.

- ❑ A chemical wood treatment process can be used. For wood species that are not naturally resistant to insect and fungal attack, EPA-registered wood preservatives are designed to make the wood unsuitable as a food source. Many log manufacturers use these preservative treatments to protect the wood, prevent decay, and/or kill insects that ingest the wood.

Preservation & Maintenance of Log Structures

Pressure treatment is a carefully monitored method of forcing preservatives deep into the structure of the wood cells. The wood materials are placed in a long, steel cylinder that is sealed and then filled with the treatment solution (the solution may include other treatments such as biocide). The solution is pressurized in the cylinder to achieve maximum absorption and penetration of the preservatives.

Dip treatment involves submersion of the wood products in a water-borne solution. Often, dip treatments combine biocides for surface treatment of fungi and preservative salts in solution. Dip treating processes must balance the temperature of the solution, concentration of the salts (while maintaining them in solution), compatibility with biocides and other treatments, and submersion time. This balance effects how effectively the salts diffuse throughout the cross-section of the wood.

Topical treatments include biocides, preservatives, brighteners, and other applications that are sprayed or brushed onto the surface of the wood. Most topical treatments are limited to protecting the outer layers of cells (up to ¼" deep). The homeowner or builder on the job site can apply most topical treatments if they have not been applied before delivery.

Regardless of the method used, understand the nature of the treatment used. Borate salts are excellent for deterring insects and decay, but they also require protection. Without proper finish, the salts can leach out of the wood, leaving it vulnerable.

During and after construction, diligent attention to the following precautions can eliminate potential food sources and prove to be very inexpensive insurance against the possibilities of insect attack.

- Remove all woody debris from the construction site prior to backfilling the foundation.
- Carefully inspect firewood, furniture, and mulch before bringing them onto the building location.
- Store firewood away from log walls, as both wood ingesting and wood nesting insects can migrate to the walls from infested firewood.

As stated earlier, the attached *Tecline* reprint of the durability map of the United States should be used to determine the maintenance requirements of the various regions of the country. Please note that guidelines for many building materials vary by climate and region. Concrete is a prime example. Mixtures and composition of concrete are different in cold and hot climates.

Differences exist by region for the use and maintenance of wood in construction! Regardless of the product you choose, follow a maintenance program suited to your location and building design.

3.3 Controlling Environmental Conditions

In addition to fungi and insects, the weathering process is a cause of wood and wood finish degradation. The combinations of exposures in the weathering process are: Ultraviolet rays (sunlight), moisture, temperature, and wind abrasion. Depending upon the wood species, the process of erosion can wear away up to a quarter of an inch or more of wood per century.

- Ultraviolet (UV) Light** - UV causes a breakdown in the exposed lignin component of the wood cells, giving rise to color changes and the weakening of surface wood fibers. Lighter woods tend to darken and gray. Dark woods bleach out and gray. This color change is natural, normal, and does not pose any structural concerns. If the appearance of gray wood is aesthetically unappealing, pigmented stains should be applied according to the stain manufacturer's instructions.
- Moisture** - Wood swells and shrinks in response to the level of humidity or continual wetting by rainwater runoff. The repeated wetting by roof runoff splashing off a deck onto the log wall is a typical area of concern. This is why ICC 400 Section 306 requires roof overhangs be designed to move water away from the walls.

Preservation & Maintenance of Log Structures

- ❑ **Temperature** - Increased temperatures accelerate the deterioration process caused by UV. For log homes, elevated surface temperatures increase the rate of moisture evaporation within the logs thereby causing more checking. Subsequent freezing and thawing of absorbed water contributes to checking and cracking as well.
- ❑ **Abrasion** - The mechanical action of wind, sand, and dirt can be a factor in the rate of surface degradation and removal of wood or exterior finish material. Windblown particles can have a sandblasting effect.

Preservation & Maintenance of Log Structures

4 CONTROLLING DESIGN, SITE, AND CONSTRUCTION ELEMENTS

Eliminating the potential entry of moisture will help combat decay in walls and foundations, and around doors and windows. The factors below should be considered regardless of your selected source of log building materials.

4.1 Building Design and Location

There are important preventive steps that can be taken to greatly reduce the costs of exterior maintenance.

4.1.1 Site Drainage & Finish Grade

The first major consideration is the selection of the building site. Locate the log home on a site where rainwater and melting snow will drain away from the structure on all sides. If this is not possible, crown the area where the house is built, and alter natural drainage by using swales, retaining walls, ditches, or sub-surface drain systems before beginning construction.

Do not allow the lower course of logs to come in contact with the ground. Earth/wood contact greatly enhances chances of colonization by termites and decay fungi. As a consequence, it is recommended that the foundation wall be constructed in such a manner that there be ample distance between the logs and earth. It should also be high enough to prevent rainwater from splashing on the logs.

Lastly, when landscaping the home, use common sense to prevent the introduction of insects through mulch and plantings.

4.1.2 Wall Surface Protection

Moisture from rain and even condensation can run down the face of the wall and move in and through any number of cracks in the wall. This is particularly acute around doors and windows, upward facing checks, and corners. ICC 400 addresses moisture protection in Section 306.2.

A few tips:

- Never design into the structure any ledges that will hold standing water.
- Always apply flashing as drip cap over windows and doors. Water that gets behind the exterior trim can travel long distances undetected.
- Apply additional finish treatment to exposed surfaces at corners to protect the wood from possible standing moisture. Encourage drainage out and away from corners by incorporating joinery techniques. Ventilation can also be employed to encourage evaporation of moisture from corners.

4.1.3 Overhangs & Gutters

Two effective features to be built into a log home are a wide roof overhang and the installation of gutters because they move roof runoff away from the log wall surfaces. These options are particularly desirable in areas of high rainfall. Wider overhangs also provide the benefit of shading the wall from the sun and UV.

ICC 400 sets minimum projections at 12 inches or more as determined by the wall height (O_H = measurement in feet from the bottom of the sill/bottom plate log to the bottom of the overhang). For an 8-foot, one story design, the overhang would be $O_H/8 = 1'-0''$. For a 2-story design with a 16-foot wall, the minimum overhang becomes 1.5' (18"). If logs project out from the wall at the corners at roof beams, or elsewhere, add the projection distance to the overhang. Structural roof

Preservation & Maintenance of Log Structures

members of logs or sawn lumber should not be allowed to project beyond the protective eaves. If they do, they will become easily wetted and susceptible to decay.

4.1.4 Ventilation of Spaces

As the home is being constructed, make certain that the attic and crawl space areas are adequately vented to prevent the accumulation of moisture within the living space. The soil in crawl spaces can be covered with polyethylene and held down with ballast (bricks) to reduce the relative humidity of the air in sub-floor spaces. Be certain to seal seams and edges in the space.

4.2 During Construction

During the construction phase, it's important to prevent the damaging effects of mold and mildew. As mentioned earlier, mold and sapstain make the wood more porous, increasing its tendency to absorb rainwater and high humidity, thus increasing the chances of decay. And, some wood species and wood preservatives resist mold and mildew, but proper care for the logs is still warranted.

Attempt to keep the logs as mildew-free as possible while the home is being built. Some manufacturers pre-treat their logs with a wood preservative to minimize any major outbreaks of fungus during the construction phase. Even if they are pretreated, care should be taken at delivery to store the wood products properly. When the logs are delivered, prevent them from touching the ground or each other by placing stickers (spacers) between them. This procedure, by allowing air circulation between the logs, will help relieve any build-up of moisture and heat caused by the drying logs thereby reducing the chances of fungal attack. Be sure that the stacks of material are kept covered (lumber wrap or opaque polyethylene) and, if possible, located in a shaded area.

If mold and mildew are present, removed the fungi with products specifically designed for log home use. Follow the label instructions precisely **or**, treat with the following caustic solution. Wear goggles, rubber gloves and necessary clothing to prevent eye and skin contact. Also shield plants and shrubs from contact.

- 1 cup Trisodium Phosphate or non-ammoniated detergent
- 1 quart of household bleach
- 3 quarts of warm water.

Apply the solution onto the affected area with a hand-pump garden sprayer. Allow the solution to set for 5-10 minutes and pressure rinse thoroughly with clean fresh water. (Note: It is very important that the rinse is sufficient to remove all cleaning chemicals. Chlorine left in the wood can damage coatings applied over it.) This treatment will kill the fungal growth as well as clean the log surface. However, it will not prevent the future occurrence of these organisms if conditions are suitable.

Before cleaning the exterior of a building or a stained roof, confirm the nature and condition of the soil treatment. It is possible that the cleaning agent being used is not compatible with the soil treatment, and there could be a detrimental effect on termite soil treatment chemicals applied around the home. The soil pH is known to have a major impact on performance of termiticides because it affects how rapidly a compound degrades. The pH is used to describe whether soil is acidic (pH less than 7) or alkaline (pH above 7). Most soils have pH values between 4 and 8. In general, termiticides used today persist longer in acidic soil than in alkaline soil. In any case, take measures to shed cleaning agent runoff away from building (three to four feet), thereby protecting soil treatments.

Preservation & Maintenance of Log Structures

5 THE FINISH TREATMENT

After construction, water absorption must continue to be controlled through regular maintenance with a water repellent treatment, stain, or coating. Select a product that is labeled for use on log homes. The weather factors (sunlight, water, temperature) can be mitigated with the proper finish treatment, provided that the home is properly designed for its location.

The finish treatment should possess, at minimum, the following characteristics:

- Exceptional water resistance/water repellency
- Mold and mildewcidal protection.
- Allow for moisture vapor transfer

Some products offer additional benefits of wood preservation, abrasion resistance, and control against ultraviolet light and fading.

Maintenance product manufacturers typically recommend the following steps for the care and maintenance of log homes:

- Always start with a clean surface, free of mill glaze. Mill glaze can inhibit or interfere with the finish treatment. Consult your dealer or log home representative if you are in doubt about mill glaze. They will also be a good source for availability of mill glaze removal products.
- Clean the logs with the bleach/TSP solution recommended above or select one of the cleaning products available specifically for logs. Always, make sure that all products used are compatible with each other.
- Apply a protective finish.

Consult your representative for recommendations for the proper finish treatment.

- Select products that are specifically labeled for use on log homes and follow the label directions and surface preparation instructions exactly.
- Select a product suitable for the geographical location in which you are building, keeping in mind the type of wood and the moisture content present at time of initial application. (Note: A wood moisture meter is the surest way to know the true moisture content of the wood.) Some products require that the wood "season" for a period before application. Others may not. Read the labels and all instructional materials before you begin.

Preservation & Maintenance of Log Structures

6 FINAL NOTE

This paper has attempted to provide a greater understanding of wood, the product choices available from Log & Timber Homes Council members, the implications of your building site and building design, and their impact on your decisions as you develop your working knowledge of log home maintenance. It is not intended to encourage belief that log homes are somehow more of a problem or require more maintenance than other types of wood sided homes. That simply isn't true. However, the unique aspect of most log homes is that the logs themselves are what make up the structural soundness of the building. Because of this, clear understanding of how to care for them is vitally important. This understanding will help to insure years of enjoyable, trouble free, log home living.

For more information, refer to these publications and web sites:

6.1 Publications

- ANSI/ICC 400 *Standard on the Design and Construction of Log Structures*, International Codes Council, <https://www.iccsafe.org>
- Wood Handbook: Wood as an Engineering Material (FPL-GTR-113)
- Selection and Application of Exterior Stains for Wood*, Forest Products Laboratory, General Technical Report FPL-GTR-106
- Selection and Use of Preservative-Treated Wood*, Publication No. 7299, Forest Products Society
- Quality Drying of Softwood Lumber Guidebook-Checklist*, Forest Products Laboratory, General Technical Report FPL-IMP-GTR-1
- Air Drying of Lumber*, Forest Products Laboratory, General Technical Report FPL-GTR-117
- Dry Kiln Operators Manual*, Forest Products Laboratory, Agricultural Handbook #188

6.2 Web Sites

American Wood Council	http://www.awc.org/
American Plywood Association	http://www.apawood.org/
Forest Products Laboratory, USDA	http://www.fpl.fs.fed.us/
The Forest Products Society	http://www.forestprod.org/
Southern Pine Council	http://www.southernpine.com/
U.S. Department of Housing and Urban Development	http://www.hud.gov/

For more information on termites, see Log Tech Note 03-02 Termite Prevention & Control and these additional websites:

ARS Operation Full Stop	https://www.ars.usda.gov/news-events/news/research-news/2003/operation-full-stop-means-lights-out-for-termites/
Louisiana State University	http://www.agctr.lsu.edu/termites
University of Hawaii	https://guides.library.manoa.hawaii.edu/entomology
University of Nebraska Institute of Agricultural and Natural Resources	https://passel-old.unl.edu/pages/printinformationmodule.php?idinformationmodule=1029338910
University of California	http://www.ipm.ucdavis.edu/PMG/PESTNOTES
University of Toronto	https://artsci.calendar.utoronto.ca/section/Forest-Conservation-and-Forest-Biomaterials-Science

Preservation & Maintenance of Log Structures

Preservation & Maintenance of Log Structures

6.3 Recommendations

Recommendations contained within Forest Products Laboratory publications include:

6.3.1 Removal of Mildew

Commercially available wood cleaners work quite effectively to remove mildew and other stains on wood. Dissolving 1-part liquid household bleach can also make mildew cleaner and some powdered detergent in 2 to 4 parts water. Allow the wood to dry for 1 or 2 days before refinishing.

Suggested formula:

1/3-cup household detergent

1-quart (5%) sodium hypochlorite (liquid household bleach)

3 quarts warm water

(1 cup = 0.2 L; 1 quart = 0.9 L)

Caution: Do not use a detergent that contains ammonia; ammonia reacts with chlorine-containing bleach to form a poisonous gas. Many liquid detergents may contain other additives that react with bleach.

6.3.2 Removal of Iron Stain

A common form of staining on wood surfaces results from contamination with iron. A portion of the extractives in wood includes a group of chemicals collectively called tannins. The amount of tannins depends on species; oak, redwood, and cedar are rich in tannins. Tannins react with iron to form a blue-black stain on wood. Note the darker color of the iron stain. Common causes of iron stain include use of ungalvanized or poorly galvanized fasteners, cleaning with steel wool or a wire brush, and contact of the wood.

Iron stain can be removed by scrubbing the stained area with a aqueous solution of oxalic acid in water. Oxalic acid is usually sold at drugstores and hardware stores. Dissolve 1 to 4 oz of oxalic acid in 1 qt of hot water. Scrub stained area using a stiff-bristle brush. Thoroughly rinse with water after treatment. [Note: 1 qt = 0.9 liter; 1 oz = 28 g]

Caution: Oxalic acid is toxic. Wear rubber gloves and avoid contact with skin. Work in a well-ventilated area. Avoid splashing the solution on plants because it can damage the foliage. Wash hands before eating or using tobacco products. Store in a locked space out of reach of children.

6.3.3 Extractive Bleed

A common cause of discoloration is extractive bleed. All species contain extractives, but extractive bleed is most prevalent on highly colored woods. The discoloration often occurs around fasteners because the hole in the wood caused by the fastener cuts many wood cells. These cut cells increase water absorption. Water dissolves the extractives, and when the wood dries, the extractives accumulate at the surface and sunlight causes them to polymerize.

If extractive bleed is a problem, the extractives can be removed by scrubbing the wood with soap and water. Do not use a wire brush because the brush will contaminate the surface with iron, which will cause iron stain.

Preservation & Maintenance of Log Structures

TECHLINE Durability

Effect of Climate on Durability of Wood

Climate has an important bearing on the relative rate of wood decay and thus the expected service life of wood exposed to the weather. Researchers at the Forest Products Laboratory have devised a climate index map to predict relative decay hazard regions in the United States.

The map is based on mean monthly temperature and number of rainy days. The most severe location in the United States is the Southeast, where rainfall is high and weather is warm and humid. In the Northeast and Midwest, decay advances at a somewhat slower rate. In the Northwest, the decay hazard is moderate near the coast but it can be severe on the coast. Decay is less hazardous in most of the Southwest because this region is very dry.

In mountainous regions, localized areas with marked differences in temperature and rainfall occur. Index differences due to this factor are not reflected in the map. Where climate is relatively uniform over wide areas, the map can be used with confidence.

The climate index map primarily estimates the decay hazard of wood exposed above ground to weather. With certain restrictions, the map can also be used to determine the

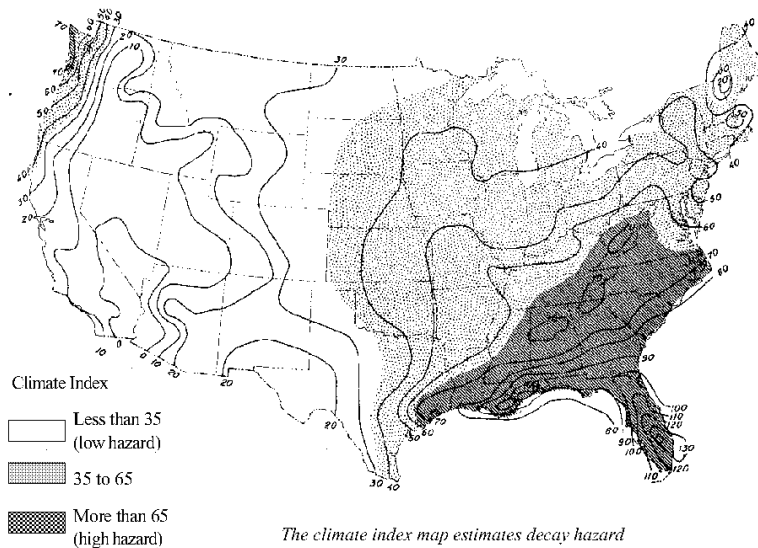
hazard for wood in contact with the ground. Any place where wood contacts the soil should be considered a high decay hazard, indicating pressure treatment of wood with a preservative.

Homeowners, architects, builders, and marina operators can use this map for help in selecting the wood species or preservative treatment that will ensure maximum service life of wooden structures.

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Reference

Scheffer, T.C. 1972. A climate index for estimating potential decay in wood structures above ground. *Forest Prod. J.* 21(10): 25-31.



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