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WOOD DECAY ECOSYSTEM IN RESIDENTIAL CONSTRUCTION

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ABSTRACT

Efforts by urban foresters to extend the use life of wood are likely to be most effective when addressed to the construction industry and to areas of existing housing where percentages of owner occupancy are high. In North America, most decay of wood not in contact with the ground results from use of wood with incipient infections or from fungi infecting wood that is wetted from an external source of moisture. The spectacular water-conducting fungi are exceptions to this rule because they are uniquely capable of conducting water from an external source into wood that is otherwise too dry for decay. Fungi able to withstand high temperatures and intermittent desiccation are likely to be important in the decay of exterior wood work. The potential hazard for decay in wood used above ground in a given climate can now be estimated with Scheffer's Climate Index. Use of fungus-free wood during construction is the first step in reducing decay in exterior siding and in preventing rot by a water-conducting fungus. Design features that minimize prolonged wetting of wood by rain seepage and dip treatments of wood are effective means of reducing decay associated with end-grained absorption of water. The performance of dip treatments in protecting wood from decay associated with side-grained absorption of water varies with wood species. Installation of vapor barriers over the soil in crawl spaces effectively controls cool-weather condensation problems on subfloor timbers. Similarly, installation of a vapor barrier on the warm side of walls in heated rooms prevents damage from moisture condensation problems in exterior walls in cool climates.

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INTRODUCTION

In an era with increasing demands being placed upon a diminishing natural resource and with increasing prices for raw materials, there seems to be an economical as well as a biological justification to extend the use life of wood in residential construction. Oftentimes, however, the socio-economic aspects of residential housing problems are confused with the biological aspects of wood deterioration. Therefore, this discussion of wood decay in houses begins with the recognition of settings within U. S. communities where biological aspects of wood decay are consequential. Then, principles of wood decay and protection in North America will be presented.

Urban forestry programs in wood protection are likely to have their greatest impact in areas of existing houses where owner occupancy exceeds 45 percent in the newer areas and is over 80 percent in areas of very old age structure. In these areas, owners usually are willing to make repairs and can afford to do so in an effort to maintain their property values. Consequently, the market value for houses in these sections remains high, and lending institutions readily make loans to prospective buyers (i.e., the investment housing areas). No evidence was found in Baltimore, Maryland, or in any other U. S. city (Harvey et al., 1972) to indicate that housing code enforcement could be effective in areas where market conditions were not conducive to its working.

Another fertile opportunity for an effective program is with the construction industry. With speculative housing, the subsequent owner has no opportunity to affect the construction process. Because builders tend to repeat both good and poor practices (DeGoot and Popham, 1976), minor improvements with individual builders or developers can reap extraordinary percentage gains in problem reduction within populations of houses being constructed in a given community.

DECAY PROCESSES

The concept that wood is food for termites is easily understood (e.g., witness certain pest control industry advertisements), but the concept of wood being destroyed by fungi - filamentous, primitive plants - is not readily grasped. A brief review of the decay processes, therefore, is needed to appreciate the impact of different types of fungi on wood properties and to gain an overview of the relationship between construction detail, wood moisture content, and decay hazards in buildings.

Wood decay must be referenced to cell walls, and with some organisms, to specific layers within cell walls. Lignified cell walls are degraded by one of three basic processes, commonly referred to as white rot, brown rot, and soft rot. These decays are generally distinguished by:

- (1) The gross physical characteristics of the effected wood, including change in color.

- (2) The microscopic pattern of cell wall destruction.
- (3) The chemical changes produced.

White-rot fungi sequentially attack cell wall layers from the lumen outward (Wilcox, 1968). Wall lysis by *Polyporus versicolor* L. ex Fries, for example, begins as erosion troughs intimately associated with and not much wider than the secreting hyphae. Ultimate coalescence of erosion troughs produces the characteristic thin-walled appearance attributed to white-rot attack (Bravery, 1971). These fungi can attack both lignin and cellulose within the cell wall (Cowling, 1961), but lignin is sometimes removed from the wood more rapidly than the cellulosic or other carbohydrate components (Kirk and Moore, 1972; Kirk and Highley, 1973). When cellulose is attacked, it is degraded at about the same rate at which the breakdown products can be metabolized (Cowling, 1961). Thus, reduction of compression and bending strength and of the calorific value by white-rot fungi tends in the main to be proportional to the amount of wood removed, as measured by weight loss (Scheffer, 1936). A bleached appearance is characteristic of white rot, hence the common name.

Brown-rot fungi, in contrast, decompose the cellulosic components through the entire cross section of the cell walls at a rate, during early stages of decay, much faster than these breakdown products can be metabolized (Cowling, 1961). Thus, bending and compression strengths are reduced much faster than wood substance is lost (Mizumoto, 1966; Cartwright and Findlay, 1950). Lignin in the cell walls may be altered but is not decomposed. Wood attacked by these fungi has a brownish discoloration and a characteristic pattern of cubical checking due to shortening of the cellulose chain molecules.

Brown-rot fungi generally have a high tolerance for copper which is enhanced by low substrate pH (Young, 1961). White-rot fungi are intolerant of copper but have a greater tolerance to zinc than do brown-rot fungi (Richards, 1925).

A pattern of degradation similar to brown rot (Merrill et al., 1965), but caused by mold fungi, can also be important in composite wood products. On solid wood products, molds are important chiefly where discolorations are objectionable. But in fiberboard, where xylem tissue units have a large surface/volume ratio and, consequently, have a relatively large surface area that can be colonized by these fungi, the slow cellulose decomposition by mold fungi significantly reduces product strength. Species of *Aspergillus* and *Penicillium* and cellulosic ascomycetes such as *Chaetomium globosum* Kunze, but not typical wood decay fungi, are the important deteriorators of wood fiberboards used in buildings in the United States (Merrill et al., 1965; Merrill, 1965).

The previously discussed white- and brown-rotting fungi are basidiomycetes (i.e., a familiar type being those that produce bracket or mushroom-shaped fruiting bodies). A third type of wood deterioration, a soft rot, is caused by Ascomycetes and Fungi Imperfecti (Duncan, 1960). These fungi characteristically grow within the secondary wall of wood cells and enzymat-

ically dissolve the wall substance to form cavities that are oriented either helically around or parallel to the long axis of the cell. Soft rot resembles brown rot in that lignin is not markedly attacked (Savory and Pinon, 1958). About one-fourth of the soft-rot fungi studied by Duncan (1960) were more tolerant of sodium fluoride, sodium chromate, sodium arsenate, and zinc chloride than were the Basidiomycetes tested. Soft-rot can occur with extreme wetness, where typical decay fungi do not thrive. In construction soft rot is important in water cooling towers and on treated wood in soil. Marine fungi, which botanically are like those causing soft rot, colonize wood in cooling towers when seawater is used; when fresh water is used, terrestrial florae develop (Eaton, 1972).

Associations

White-rot fungi are associated more frequently with angiospermous than gymnospermous wood used above ground (Duncan and Lombard, 1965); in contact with the soil, both woods are attacked by brown- and white-rot fungi. Both types of decay fungi occur in residential and farm buildings; but, interestingly, brown rotters are almost exclusively responsible for decay in wooden boats (Cowling, 1957). In laboratory studies, softwoods, as a class, are more resistant to soft rot than are hardwoods (Savory, 1954). Explanations for the prevalence of brown-rot fungi in coniferous products not in contact with the soil are not fully developed. With the brown-rotters, *Lenzites saepiaria* and *L. trabea*, and the white-rotter, *Coriolus versicolor*, spore germination was better on pine than on sweetgum, respectively (Toole, 1971); but there seems to be no differences between the cellulase-inducing effects of hardwoods versus those of softwoods that would explain the preference of white rotters for hardwoods and brown rotters for softwoods (Highley, 1973). The ease with which *Chaetomium globosum*, a soft rotter, attacks hardwoods may be related to the availability of the xylan in the wall (Levy, 1973); but with white- and brown-rot fungi, there is no clear relationship between relative rates of removal of the major components and the resistance of woods to decay (Kirk and Highley, 1973). One quantitative study of organisms in pine and birch posts suggests the possibility of a bacteria-soft rot fungus association (Butcher, 1971). Basidiomycetes tended to be negatively associated with other organisms.

Moisture, Temperature Relations

For wood decay of any type to occur, a wood-destroying fungus must be brought into contact with an acceptable food source (i.e., susceptible wood substrate) and supplied with a life-supporting supply of moisture and oxygen at a temperature that is compatible with growth.

Wood has to be above its fiber saturation point, with at least a trace of water on the surface wood cell walls, for serious decay to occur. The minimum wood moisture content that will permit decay fungi to grow has been variously estimated from 24 (cf. Cartwright and Findlay, 1950) to 31 percent

(Ammer, 1964). Once established, decay fungi produce 0.55 gm of water for every gram of cellulose they decompose (Ammer, 1964). This accentuates the adverse aspects of any condition which retards drying. Attempts to control decay in laminated beams by filling decay packets with an epoxy resin-sawdust mixture, for example, were unsuccessful because the infected beams did not dry fast enough to stop decay (Erickson, Aichlmayr, and Petteys, 1971). For a practicable working limit providing a margin of safety, a moisture content of less than 20 percent is commonly recommended for protection of rood against decay.

Hold fungi can not obtain moisture for mycelial development directly from the atmosphere, but they can get it from hygroscopic materials which absorb moisture from the air if the relative humidity is high. Molds will grow on the surfaces of air-dry wood at relative humidities above 85 percent (Block, 1953; Coppock and Cookson, 1951). This undoubtedly contributes to the problem of mold fungi on exterior wood in humid climates; but condensation on the surface of wood, cooled by heat radiation at night, is a more important source of moisture for these fungi.

The wood-destroying basidiomycetes may be arranged in three general temperature groups: (1) a low-temperature group which grows best at 24° C or below. (2) an intermediate group, growing best between 24° and 32°C. and (3) a high-temperature group with optimum temperatures for growth at 32°C or above (Humphrey and Siggers, 1933). The latter group contains fungi that are important in wood or the exterior of buildings. Optimum temperatures for soft-rot fungi are between 22° and 38° C (Duncan, 1960; Kerner-Gang, 1970).

Decay-Resistant Wood

The use of preservative-treated or naturally decay-resistant wood eliminates the food source. Heartwood of some tree species such as California redwood, black locust, old-growth baldcypress (Table 1) are resistant to decay fungi, such as *L. trabea*, that commonly attack wood not in contact with the soil (USDA Forest Products Laboratory, 1974). But many of these "resistant" heartwoods are susceptible to *Poria incrassata* (Diller and Koch, 1959; Humphrey, 1923) and possibly to other soil-inhabiting decay fungi. Extensive decay by *P. incrassata* has been seen in all-heart cypress buildings (Verrall, 1968). Therefore, it is suggested that wood foundation materials be constructed of a preservative-treated wood or of naturally durable heartwood specifically known to be resistant to decay fungi in the areas of its proposed use.

Prior experience with heartwoods from old-growth trees isn't a reliable index for performance of wood from second-growth trees. The heartwood of younger, second-growth trees of "durable" species may not be as resistant to decay as was the heartwood of the more slowly grown virgin timber. Higher decay resistance in heartwood of black locust and teak, for example, has been found associated with slow tree growth (Scheffer and Cowling, 1966). Similarly, heartwoods of slow-growing, small-diameter hickory, green ash, blackjack and red oak are more resistant to decay than the same wood from faster growing trees on other sites (Carter, Amburgey, Manwiller, 1975).

The sapwood of all tree species, even the "durable" species, is susceptible to decay. It can be protected from decay by treatment with wood preservatives, but good quality control over the treatment process is a must for foundation materials (Percival, 1975).

Soil Contact

For wood in contact with the ground, the soil usually provides a continuous source of moisture and external nutrients for decay fungi; buffers the wood against extreme diurnal temperature variations; may contribute an established inoculum of decay fungi; and provides an oxygen supply that becomes progressively more restricted with increasing depth below groundline. In building construction, foundation pilings driven to depths below the normal water table will not have sufficient oxygen to support growth of decay fungi. But should the water table be lowered below the pilings, once in place, decay can develop. In temperate and tropical climates, all wood in contact with soil between the water table and ground line must be either all heart of a few decay-resistant species or treated with a preservative approved for ground contact.

Aboveground Exposure

In contrast, wood used above ground is dependent upon an external, sometimes intermittent source of moisture; is subject to a wide range of seasonal and diurnal temperatures; lacks any source of external nutrients save for airborne debris; and where it is well aerated, it is subject to rapid surface drying. Within the contiguous United States, orientation of a house has a greater influence on the maximum temperature reached in wood parts of houses than does geographic location (Heyer, 1963). Temperature in walls and roof can rise appreciably above ambient air temperature.

Exterior Construction

Only fungi able to withstand high temperatures and intermittent desiccation are likely to decay exterior woodwork, but as Verrall mentions (1966) few reports of fungi in buildings indicate the parts of buildings attacked. Three xerophytic fungi, *L. saepiaria*, *L. trabea*, and *Schizophyllum commune*, are frequently found in exterior woodwork (Verrall, 1966). *Odontia spathulata* and *L. saepiaria* comprised approximately 25 percent of the fungi associated with decay in wood buildings in New York (Silverborg, 1953).

The moisture content of exterior woodwork is determined by rain wetting, seepage, and the rate at which drying occurs. Water is absorbed through the end-grained surfaces of wood more rapidly than through surfaces cut parallel to the grain. Building designs which minimize rain seepage through end-grained surfaces reduce decay hazard (Schein, 1968) whereas designs that accentuate end-grained absorption promote decay (Verrall, 1966). And where decay-susceptible wood is exposed to end-grained absorption, between-species differences in wood absorptivity do not alter the decay hazard (Scheffer, Verrall, and Harvey, 1963).

The occurrence of decay problems principally at the ends of exterior siding reflects these principles. Drop siding becomes wet from rain seepage at the end joints, butted against trim. Siding from sapstained lumber is also more prone to decay than is fungus-free siding. Infestations of stain and decay fungi that can start in sapwood lumber as it is air-dried in the lumberyard, make the wood more absorptive. Furthermore, some decay fungi, once established, can survive years in dry sapwood (Theden, 1972) and when such wood is rewetted, the fungi revive. Recommended decay-preventive measures include effective use of stain control chemicals or kiln drying lumber going into exterior siding and use of building design features such as an extensive roof overhang, not using sheathing paper that is impervious to water vapor, and capping the ends of drop siding at building corners in regions of high rainfall.

Experiences with decay in sapwood siding on buildings in the U. S. Gulf States emphasize the importance of using dry, fungus-free lumber (Verrall, 1951; 1960). In siding, suspected as being stained or having incipient decay at time of installation, decay developed soon after construction. In contrast, siding produced from kiln-dried wood had essentially no decay after 5 - 10 years service, even though installed on buildings with less than an 8-inch overhang, with nonbreathing sheathing papers, and with siding butted to trim-construction practices that are conducive to decay development. Moreover, fungus-free siding used to replace previously decayed 6-year-old siding lasted 10 years without decay, despite the fact that the building design was not changed. This indicated that the condition of aiding at time of installation was extremely important and that poor building design alone does not necessarily lead to heavy decay.

The decay-preventive role of sound wood in relatively thin siding, where wetting is minimal and drying rapid, does not apply to exposed beams, steps, or even to fascia. With the latter, a slow rate of drying contributes to a high decay hazard that is independent of the quality of wood prior to construction. For example, large, exposed beams and planks can be wetted through open surface checks and by water creeping between structural timbers. Likewise, fascia boards behind defective gutters have little opportunity to dry rapidly.

The use of dry wood and of construction methods to keep wood dry are basic building precautions (Scheffer and Verrall, 1973), but some exterior wood is invariably exposed to rain. Fascia and other parts of the roof trim are frequently wetted by water curling under shingles at the roof edge. Exterior decks and bases of porch posts or door frames are frequently exposed to rain, splashing rain, or surface drainage. Wood decay frequently occurs in these locations (Verrall, 1966; De Groot and Dickerhoof, 1975; Peterson and Levi, 1975) unless the wood is protected in some way from decay.

Dip treating precut lumber with wood preservatives effectively prevents decay that is dependent upon end-grained absorption of water (Hubert, 1934; Verrall, 1965; Scheffer, Verrall, and Harvey, 1971). The vulnerability of end-grained surfaces to wetting is more than offset by a correspondingly greater absorption of preservatives. The performance of dip treatments in protecting wood from decay associated with side-grain absorption varies with wood species. Dip treated test flooring units of mill-run Douglas-fir and

western hemlock, for example, performed well for 15 years while other more decay-susceptible species, comparably treated, were not sound at ten years of exposure in Wisconsin and Mississippi (Scheffer, Verrall, and Harvey, 1971). Exposed structures such as wooden decks and steps should be constructed of wood that has high natural decay resistance or has been pressure treated (Anderson, Heebink, and Oviatt, 1972; Verrall, 1952, 1966).

Paint film have a varied influence on rain wetting of wood. Oil paint is sufficiently impervious to rain to keep wood too dry to support decay, so long as joints are sealed (Scheffer, Verrall, and Harvey, 1971). Once the seal of paint is broken, however, the paint tends to retard drying and, at least near the joint, favors decay (Verrall, 1966; Sedziak, Shields, and Krzyzewski, 1970).

INTERIOR CONSTRUCTION

Typically, the extent of decay in interior construction is largely dependent upon the duration that the wood remains moistened above its fiber saturation point. Thus, wood wetted from defective plumbing in the laundry or bathroom or wood beneath defective roofing is likely to have a high moisture content for days, if not months, in succession. Some of the most costly damage by decay fungi to residential single-family houses in Mobile County, Alabama (De Groot and Dickerhoof, 1975), occurred either in roofs or in laundry room floors.

Seasonal patterns of moisture condensation within buildings may also create a decay hazard. Floors over an enclosed crawl space are subject to decay in cool climates where moisture from the soil beneath the house condenses on perimeter subfloor timbers. The hazard has been noted mostly in areas where the mean temperature for January is 45°F or less and annual precipitation averages 20 inches or more. Its impact is increased when homeowners close vents to crawl-space areas during the winter months to preserve heat. Because of underfloor condensation, the sills and joists in basementless houses in northern United States can rot out within 5 to 15 years after construction (Diller, 1965). Not all houses are affected. An easy way to determine if a house already built is endangered is to examine the crawl space for perceptible moisture on the inner face of the north headers or sills in winter, especially near corners. Persistently moist or softened wood is indicative of hazardous conditions (Diller, 1950).

Vapor-resistant coverings, such as heavy roll roofing, asphalt-impregnated felts, or polyethylene membranes, over the soil in the crawl-space area will prevent this problem. Soil covers under houses previously known to have extensive underfloor dampness kept the moisture content of subfloor timbers below 20 percent for many years (Diller, 1965). When the soil was covered, closing the vents in the perimeter wall did not create condensation problem (Diller, 1946). Thus, it seems likely that insulating perimeter walls and closing vents of crawl-space areas in current housing to conserve energy will not create a decay hazard if adequate soil covers are used.

In regions where the average January temperature is 35°F or less,

vapor barriers must also be installed on the warm (heated) side of exterior walls to prevent migration of moisture, generated in ordinary household functions, into walls where it would condense (Anderson and Sherwood, 1974). To be effective, these vapor barriers must be continuous. Small openings around improperly sealed outlet boxes or incomplete attachment of insulation and vapor barriers to wall studs, sills, and top plates will permit circulation patterns that can produce serious condensation problems within exterior walls.

With the advent of summer cooling for rooms that are to be heated in winter, the decision as to where to locate the vapor barrier in an exterior wall becomes more complex. Isolated examples of moisture condensation of wood in air-cooled buildings have been observed (Mei and Woolrich, 1965; Verrall, 1962), but there is no estimate of the importance of this problem to housing, at large. Same condensation problem have been associated with high quality, tight construction, the assumption being that loose construction of problem-free, air-cooled houses permits sufficient ventilation of the exterior walls to avoid condensation hazards (Mei and Woolrich, 1965). One possible method of solving this problem may be to place the vapor barrier inside the insulation where its temperature will always be above the dew-point of the warm side condition (Mei, 1961). Long periods of moisture condensation within walls may be necessary for problems to develop. Brief durations of excessive moisture in the exterior walls of a test house in Athens, Georgia, for example, did not result in significant hazard that might cause wood decay or paint peeling (Duff, 1971).

The most spectacular type of decay in buildings is caused by two fungi that are uniquely capable of conducting water from an external source of moisture through tough, water-conducting strands of mycelium to wood that is otherwise too dry for decay. Large areas of flooring and walls can be destroyed each year, unless the fungus is stopped. *Poria incrassata* (Berk. and Curt.) Burt. occurs primarily in southern United States and probably extends southward into Mexico and Central America (Verrall, 1968). *Merulius lacrymans* Fr. [or *Serpula lacrimans* (Fr.) Cooke] is the northern counterpart of *P. incrassata*. *S. lacrimans* is the principal wood-decay fungus in unheated crawl spaces and cool damp cellars in eastern Canada (Sedziak, Shields, Krzyzewski, King, and McKnight, 1969). *P. incrassata* occurs sporadically in residential construction. Unlike typical decay which starts from air-disseminated spores, infected lumber from storage yards may be a common means of bringing *P. incrassata* into buildings. Use of dry, uninfected lumber during construction and clearing construction sites of all residual wood forms are obviously control recommendations. Active attacks can be stopped by breaking the contact between susceptible wood and the source of moisture. The water conducted from the external water supply into the wood is essential for growth of the decay fungus. Once the water supply is broken and the infected wood allowed to dry, the fungus will die. Only wood too weak to support its load then need be replaced (Verrall, 1968).

Table 1.--Grouping of some United States woods according to heartwood decay^{1/}

<u>Resistant or very resistant</u>	<u>Moderately resistant</u>	<u>Slightly or nonresistant</u>
Baldcypress (old growth) ^{2/}	Bald cypress (young growth) ^{1/}	
Catalpa	Douglas-fir	Alder
Cedars	Honeylocust	Ashes
cherry, black	Larch, western	Aspens
chestnut	Oak, swamp chestnut	Basswood
Cypress, Arizona	Pine, eastern white ^{2/}	Beech
Junipers	Southern pine:	Birches
Locust, black ^{3/}	Longleaf ^{2/}	Buckeye
Mesquite	slash ^{2/}	Butternut
Mulberry, red ^{3/}	Tamarack	Cottonwood
Oak:		elms
Bur		Hackberry
Chestnut		Hemlocks
Gambel		Hickories
Oregon white		Magnolia
Post		Maples
White		Oak (red and black species)
Osage-orange ^{3/}		Pines
Redwood		(other than longleaf, slash and eastern white)
Sassafras		Poplars
Walnut, black		spruces
Yew, Pacific ^{3/}		Sweetgum
		True firs
		(western and eastern)

Table 1. (cont'd.)

<u>Resistant or very resistant</u>	<u>Moderately resistant</u>	<u>Slightly or nonresistant</u>
		Willows
		Yellow — poplar

1/ Taken from Wood Handbook: wood as an engineering material. U.S. Dep. Agric. For. Serv., Forest Products Laboratory, Agric. Handbook No. 72 (1974).

2/ The southern and eastern pines and baldcypress are now largely second growth with a large proportion of sapwood. Consequently, substantial quantities of heartwood lumber of these species are not available.

3/ These woods have exceptionally high decay resistance.

CLIMATIC VARIATION

In an attempt to evaluate the relative contribution of precipitation and temperature to decay, Scheffer (1971) developed a formula that estimates the potential of a climate to promote decay of off-the-ground wood structures.

$$\text{Climate Index} = \frac{\sum_{\text{Jan}}^{\text{Dec}} [(T-35) (D-3)]}{30}$$

T is the mean monthly temperature (°F); D, the mean number of days in the month with 0.01 inch or more of precipitation; and $\sum_{\text{Jan}}^{\text{Dec}}$ is the summation of products for the respective months, January through December. The sum of products is arbitrarily divided by 30 to make the index for the United States fall largely within the range of 0 - 100, which was subdivided into three hazard areas. Areas rating less than 35 were considered the least favorable for decay; 30 to 65, intermediate; and more than 65, the most conducive to decay (Fig. 1).

Further comparisons of surveys in Mobile County, Alabama, (DeGroot and Dickerhoof) and in Raleigh, N.C., (Peterson and Levi) with the Scheffer Index suggests that the Scheffer index reflects relative decay incidence in older homes, but not in the never house.

Incidence of decay problem in houses surveyed in Mobile County, Alabama,^{1/} and in Raleigh, North Carolina.^{2/}

HouseAge years	Raleigh, N. C. - 66 ^{3/}		Mobile Co. - 99 ^{3/}		
	% with decay	95% confidence interval	House built	% with decay	95% confidence interval ^{4/}
0 - 5	3	0 - 6	1970-73	15	3 - 27
6 - 10		2 - 10	60-69	24	17 - 31
11 - 20	19	14 - 24	50-59	34	25 - 43
20+	19	13 - 25	40-49	25	11-37

^{1/} De Groot and Dickerhoof

^{2/} Peterson and Levi

^{3/} Scheffer Index

^{4/} Compiled from published data by R. C. De Groot

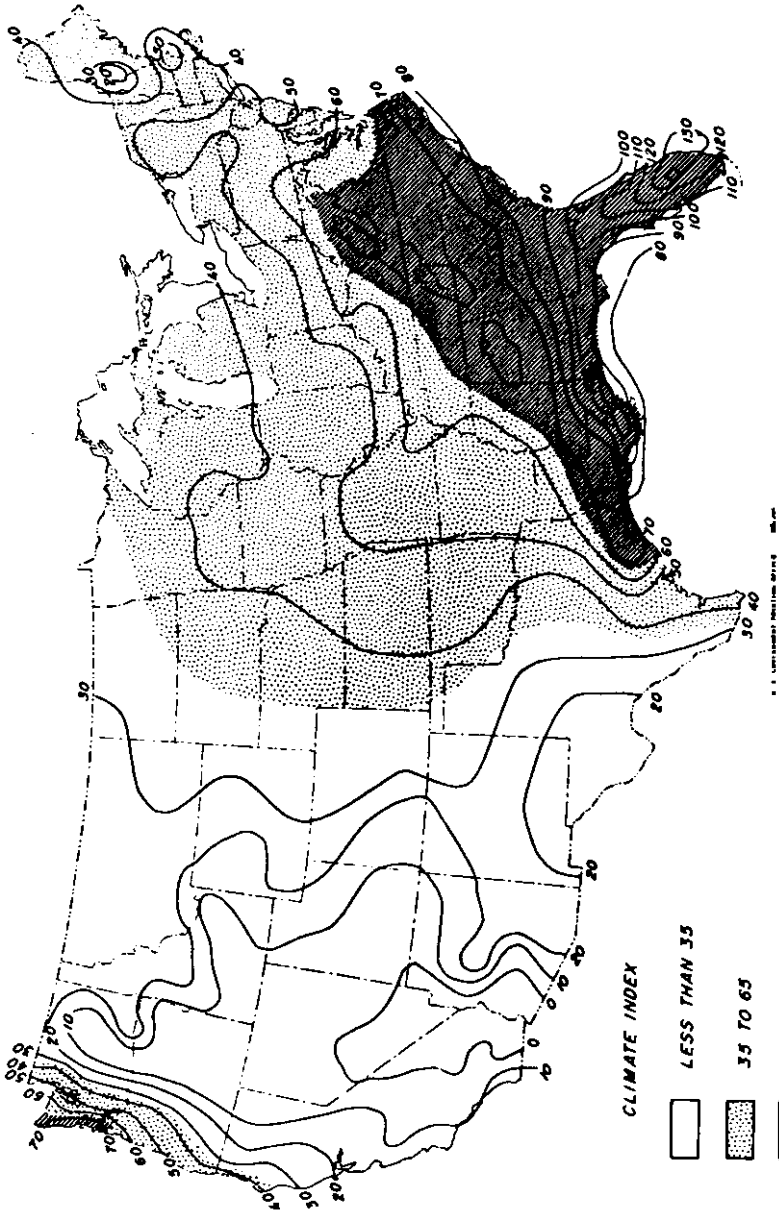


Figure 1. --Climate-index map for estimating partial decay in wood structures above ground

Nonetheless, the Scheffer Index provides, for the first time, a quantitative comparison of different geographic areas in terms of potential hazards for decay of wood above ground. The coastal areas of Washington and northern Oregon, for example, have a decay hazard for untreated wood comparable to the coastal region of North Carolina. What this means in terms of degrees of damage or actual decay incidence and repair costs in existing structures has yet to be determined. This index does provide the overview needed for developing detailed studies into the relationships between actual hazard and climate so that building regulations can be quantitatively related to hazards for biological damage in the same way that building regulations are addressed to quantitatively defined potential hazards of wind load or seismic shock.

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