Economics of Treated Wood used in Aquatic Environments

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Treated wood has been used for more than 100 years in end uses that demand strength, flexibility, long-term durability, and cost effectiveness. Typical uses, such as marine piling and railroad ties, are exposed to extreme physical and environmental stresses. Treated wood has been and continues to be selected for many uses where its durability, strength, economy, and aesthetic characteristics make it the material of choice. Many of these uses are installed in or near aquatic environments.

Where federal or state permits are required for project approvals, it has become increasingly difficult to use treated wood because of costly and time-consuming permit applications and consultations. The National Oceanic and Atmospheric Administration (NOAA) Fisheries, which has review and consultation authority on many projects under the authority of the U.S. Endangered Species Act (ESA) and Magnuson-Stevens Act (Essential Fish Habitat), is undertaking an independent scientific review of the environmental impacts of treated wood that will lead to a guideline document. Similar regulatory issues are being debated within Canada. The Western Wood Preservers Institute (WWPI) has been actively promoting a scientifically sound set of risk-based guidelines with the involved federal and state agencies.

The purpose of this chapter is to help readers understand the economic trade-offs involved in selecting treated wood versus alternative materials for construction in aquatic environments. The costs of projects that use treated wood are compared to the costs of similar projects constructed of alternative materials. Based on those project cost differences, economic effects resulting from the availability and use of treated wood in the North American infrastructure within the U.S. and Canada in aquatic environments are evaluated. Economic impacts to end users of treated wood products are considered. Any cost impacts would be borne by federal, state, and local governments, businesses, and individual homeowners.

This paper focuses on those types of projects in which treated wood is now typically used because of its low cost and effective performance. Although treated wood will not result in the lowest overall construction cost for all projects, in projects in which the use of treated wood will allow lower cost, that difference is often significant. Thus, the use of treated wood instead of alternative materials often results in cost savings. This report provides a basis to compare the installed costs of projects using treated wood and alternative materials. Although the initial installed cost may be indicative of life-cycle costs, this report is not a life-cycle cost analysis. Environmental aspects of the products are also not within the scope of this report.

To the extent feasible, data available in published reports or publicly available information was used. However, data specifically related to the use and cost of treated wood in aquatic environments is very limited. In this report, numerous assumptions, supported by professional judgment, experience, and industry expert oversight, are made to progress transparently from facts to calculated reasonable estimates.

Inflation has affected material costs significantly, particularly for steel and concrete. Cost values have been updated from referenced sources' published dates to 2008 using the U.S. Department of Labor Producer Price Indexes (PPI). Dollar values are generally in U.S. dollars. Data from Canada is in Canadian dollars. However, no attempt was made to adjust for currency values, which have varied significantly over the last two decades.

Factors are used in calculations to convert units, such as between cubic feet (cf) and board feet (bf) of lumber. Such factors, and supporting calculations as needed, are included in Appendix 4.4. Treated wood national produc-

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tion was reported nearly annually during the 1990s, but only twice since 2000 and in different formats. Data is used to estimate long-term averages and should be interpreted as the average over approximately 15 y.

Specific wood preservatives, particularly in the waterborne category, have undergone some significant changes and more are expected in the future. Micronized copper products, for example, are gaining market share. However, the products, such as railroad ties, utility poles, pilings, and bridge timbers, continue to reflect the performance needs of the market. As long as the treated-wood product cost effectively meets the needs of the user, as this report documents, then the demand for the products is expected to continue with relative consistency, even as the preservatives in use change.

4.1 Treated Wood Market in Aquatic Environments

The size of the market for treated wood to be used in aquatic environments is estimated in the following sections and associated tables. First, the overall treated wood market in the United States and Canada is defined, primarily based on published industry statistics. The overall market is then subdivided into separate end-product areas, also based primarily on published industry statistics. Evaluation of the market for treated wood in aquatic environments requires a basic definition of "aquatic environments." This is included in Section 4.1.2 below.

With an understanding of the scope of aquatic environments, each main product market is evaluated to determine the size of the aquatic share of that market, likely alternative products that would be used instead of treated wood, and the economic impact of use of those alternatives in aquatic environments.

4.1.1 Treated-wood market analysis

4.1.1.1 U.S. treated wood market

The U.S. wood preserving industry has conducted production and sales surveys over the years based on survey forms that are sent to all known wood preserving facilities in the United States. Since not all respond, the surveyors have extrapolated the data to estimate U.S. and regional statistics. Four survey reports were used in this evaluation. Wood Preservation Statistics 1997 (Micklewright 1998) provided historical U.S. production data covering most years from 1984 to 1997. This is the most recent complete industry report. The 1995 Wood Preserving Industry Production Statistical Report (AWPI 1996) was used for missing years 1993–1995. AWPI 1997 was used for 1996 data. Because 1992 was not covered by these reports, the average of one previous and one following year was used. More recently, Louisiana State University conducted a study focused on 2004 production (Vlosky 2006). The 2004 production data was reported in terms of board feet or pieces (see Appendix Table 4.2A), so this author, as shown in Appendix Table 4.2B, performed conversion to cubic feet. The production data is summarized in Appendix 4.1. Current on-going production is estimated as the average of 1996, 1997, and 2004 years of production data.

The statistical reports summarize production by three preservative classes (creosote, oil borne, and waterborne), by region, and by product type. The primary preservative in the oil-borne category is pentachlorophenol. Copper naphthenate is also an oil-borne preservative. Chromated copper arsenate (CCA) was historically the primary waterborne preservative. However, since voluntary label changes effective in 2003 limited end uses to primarily industrial and agricultural applications, other waterborne preservatives, such as copper quaternary formulations (ACQ), copper azole (CA), and micronized copper formulations, now have a large portion of the waterborne preservative market. CCA continues to be used for heavy-duty type products, such as utility poles, foundations, and pilings. Ammoniacal copper zinc arsenate (ACZA), due to its ability to effectively treat Douglas-fir, remains the predominant waterborne preservative used for aquatic applications in the West.

4.1.1.2 Canadian treated wood market

Production of treated wood in Canada has been reported in statistics published by Wood Preservation Canada (WPC), formerly the Canadian Institute of Treated Wood (CITW). Production statistics used in this paper are based on the Canadian statistics for 1999 (CITW 2001) and are shown in Appendix Tables 4.1D, 4.1E, and 4.1F.

4.1.1.3 Production breakdown by product

Annual production of treated wood by type of product is estimated in the Wood Preservation Industry Statistics 1997 (Micklewright 1998) and is summarized in Appendix Table 4.1C. The percentage estimated for each product out of the total production is applied to the estimated current annual production to estimate current annual production of each product. That is, the production proportions for each product determined by Micklewright for 1997 are assumed to be the same for the current production.

The product breakdown determined from the U.S. statistics is assumed in this evaluation to apply equally to the Canadian treated-wood market. It is recognized that this assumption is probably not completely accurate. However, lack of comparable statistics for Canada, the high level of cross-border trade, and the need to simplify necessitate this assumption.

4.1.1.4 Production breakdown by market

Treated wood may be installed in many different types of end uses, most of which may at least partially include use in aquatic environments. For this report, the primary end use markets that include significant portions of use in aquatic environments were identified as follows:

- Marine and freshwater structures
- Road and highway transportation structures
- Railroad transportation structures
- Utilities

The volume of treated wood entering each of these markets is estimated in Appendix 4.3 by estimating how much of each product is sold into each end-use market. While all, or nearly all, utility poles can be assigned to the utilities market and cross ties to the railroad market, lumber and timber are spread among several different markets. Consider timbers, for example: 5% are sold into the railroad, 15% to the marine and freshwater construction, and 10% to the roads and highways markets (Appendix Tables 4.3D, 4.3B, and 4.3C, respectively). The remaining 70% are sold to other end-use markets, such as residential or commercial construction or agriculture. Note that the estimated fractions of each product to each market are not supported by industry statistics, because such statistics do not exist. The estimates represent the author's best professional judgment, developed in consultation with treating industry representatives.

The markets listed above account for only approximately 28% of the total treated-wood market. The largest fraction of treated wood is used in residential construction. That market is not discussed in this paper since only a very small fraction of residential construction would be used in aquatic environments.

4.1.1.5 North American production summary

Overall statistics for treated wood are reported in Appendix 4.1 for the U.S. and Canada. The total annual production of treated wood in the U.S. and Canada is estimated to be approximately 640 million and 120 million cubic feet (MCF), respectively.

4.1.2 Aquatic environments definition

Aquatic environments include marine, freshwater, and buffer-zone areas as described below. The marine environment includes salt and brackish water areas, including coastlines, bays, estuaries, and other saltwater or brackish wetland areas. Structures such as marinas, docks, retaining walls, and bridges installed in such areas would be included. Both wood immersed in water and wood installed above the water line are considered to be in marine use.

The freshwater aquatic environment includes areas in, on, over, and immediately adjacent to lakes, rivers, streams, or other wetlands. Structures potentially affected include marinas, docks, retaining walls, and bridges in or crossing freshwater bodies. Both wood immersed in water and wood installed above the water line are considered to be in the freshwater aquatic environment.

The definition of a "buffer zone" is not clear and may vary considerably based on the situation, as well as on the people making the determination. Generally, the land area surrounding a body of water and from which surface water runoff will likely affect the quality or quantity of that water may be considered the buffer zone. Treated wood structures installed in buffer zones around water bodies are likely to be affected by requirements applied to aquatic environments. The overall volume of such wood could be large, including bridges over lowland areas; railroad crossties; utility poles or guardrail posts on routes paralleling streams, lakes, or oceans; and other structures potentially within a contributing drainage pathway. For example, one small area in northeast Oregon contained a major highway, railroad tracks, and utility lines, all of which were located within the buffer zone of the Columbia River (Figure 4.1).

4.1.3 Aquatic use of treated wood in markets

The amount of treated wood used in aquatic environments is estimated for each market area based on an estimate of the fraction of each product used in the market and the fraction of product in that market used in aquatic applications. Consider the roads and highways market for example. Treated wood timbers are used for bridges and other highway structures, but also in other markets. In this paper, it is estimated that 10% of all treated timbers are used in the roads and highways market and that 50% of these are installed in aquatic environments. Thus, 5% (10% x 50%)

Figure 4.1 Example of a buffer zone along the Columbia River in Oregon showing treated wood use in highway guardrails, utility poles and railway ties.

of all treated timbers, or about 3,846,000 cf of treated timbers, are installed in road and highway structures within aquatic environments each year (see Appendix Table 4.3C).

Estimates for other markets and products are made similarly within the applicable portions of Appendix Tables 4.3B through 4.3E and summarized in Appendix Table 4.3F. A summary of the relative size of the markets for aquatic treated wood use is shown in Figure 4.2.

Estimates for use of treated wood in Canadian aquatic environments are made using an assumption that the proportions estimated in the U.S. are the same in Canada. For example, in Appendix Table 4.3B, it is estimated that 4.72% of all treated wood in the U.S. is used in the marine

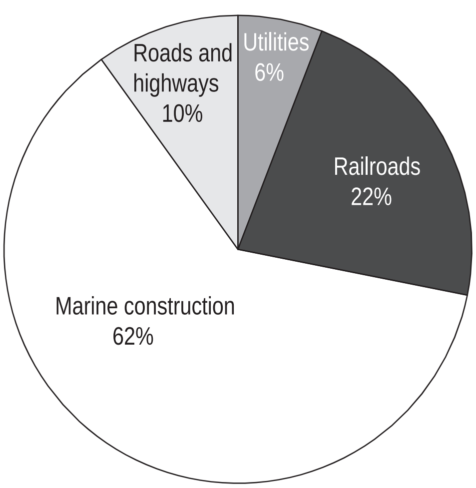

Figure 4.2 Aquatic markets summary. Approximate proportions of treated wood used in various aquatic applications in the United States.

Table 4.1 Aquatic market sizes in the United States and Canada (1000 cf/y).

Market area description	Percent	U.S.	Canada
Utilities	5.84	2,843	545
Railroads	22.29	10,855	2,080
Marine construction	61.94	30,159	5,779
Roads and highways	9.92	4,831	926
Total	100.00	48,688	9,330

and freshwater construction market/aquatic environment use. For Canada, the marine and freshwater construction market is estimated to be 4.72% of the total Canadian treated wood production. The Canadian aquatic markets are estimated in Appendix Table 4.3F. The total aquatic market for treated wood is estimated to be about 8% of all treated wood production. About 49 MCF of treated wood in the U.S. and about 9 MCF in Canada are placed into use in aquatic environments annually (see Table 4.1).

4.2 End-User Markets Analysis

The end users of treated wood products will, if regulations so require, have to select other construction materials for projects in aquatic environments. This section evaluates the potential impacts to these end-user markets. Impacts that would affect the treated wood production industry, such as job and tax revenue losses or shifts, are not addressed in this paper.

4.2.1 Discussion of evaluation methods

In the following sections, identifiable market areas are evaluated separately. For each market, reasonable assumptions are made to estimate the size of the market, the annual spending on treated wood structures in the market, likely alternative construction materials, and the additional cost of using those alternatives to treated wood for the market area. Differences in cost are considered using projects typical of the market in order to develop factors that can be applied broadly to the overall market area being considered.

Where possible, overall project costs are evaluated. For example, in the case studies noted below for the marine and freshwater structures market, total costs for projects are determined by complete project bids. These total costs are then normalized to scale to the amount of treated wood required for the design to produce a dollars-per-cubic-foot-of-treated-wood ($/cf) factor. A cost-difference ratio is determined based on dividing the alternate cost total by the treated wood project cost total. The product of the ratio times the cost factor times the amount of treated wood used in the market is used to estimate the total cost to the market to use the alternative materials. These are explained by example below.

Assume the following factors:

- Project cost using treated wood: $100,000
- Treated wood required: 10,000 cf
- Project cost using alternative material: $150,000

The following cost factors can be calculated:

- Treated wood unit cost = $100,000/10,000 cf = $10.00/cf
- Alternative cost ratio = $150,000/$100,000 = 1.5

If 10,000,000 cf of treated wood is used each year in similar projects that will be changed to alternative material designs, then the annual cost impact will be determined as follows:

- New cost to market: 10,000,000 cf x $10.00/cf x 1.5 = $150,000,000
- Existing cost to market: 10,000,000 cf x $10.00 = $100,000,000
- Added cost to market: $150,000,000 - $100,000,000 = $50,000,000

These calculations are completed for each major market area in the associated tables.

4.2.2 Marine and freshwater structures

4.2.2.1 Market

Marine and freshwater structures help us use and/or enjoy the water. For the purpose of this paper, a wide range of projects are included, ranging from large marine harbor facilities for ocean-going freight, Navy and Coast Guard piers, navigational aids, pile dikes, and passenger service terminals and marinas for commercial and pleasure craft to smaller private and commercial marinas and docks. Customers for such projects include federal, state, and local government agencies, commercial developers, private user associations, and private individuals. Treated wood products used in these structures include piling (other than foundation piling), timbers, and lumber. This market totals about 30 MCF of treated wood per year, which is about 5% of the total treated wood produced.

Table 4.2 Approximate market share for treated wood products used for marine and freshwater applications.

Product	Market (%)	U.S. volume (1000 cf/y)
Piling	60	4,840
Timbers	15	11,537
Lumber	4	13,782

4.2.2.2 Use of treated wood and alternative materials

Volumes of treated wood used for the marine and freshwater market are estimated in Table 4.2 based on the industry statistics. All of the materials in this category are used in aquatic environments. The factors listed below are used to estimate the market size in Appendix Table 4.3B. The factors are considered to be reasonable estimates based on professional judgment and review and consensus opinion of industry experts.

4.2.2.3 Cost evaluation

Smith (2003) compared the costs of using treated wood and alternative materials for marine construction. In one case study, Genoa's on the Bay (WWPI, Undated 2), the project was first designed and bid for steel and concrete and later redesigned and bid for treated wood in order to lower costs. Another case involved a Seattle Port Authority project to construct over 410 ft of fender system, including pilings and timbers for heavy-duty use. This project was first bid for treated wood and was then redesigned and re-bid using steel due to regulatory issues. These case studies provide a good "apples-to-apples" type comparison for this market area. Costs are updated to 2008.

The Port of San Francisco confirms that they depend on treated wood due to its cost and structural advantages (G. Thomas, Port of San Francisco, CA, personal communication, 23 March 2005). Alternative materials for fender systems generally cost two to three times more than treated wood. Plastic tends to deform and does not provide adequate protection from ships. Steel tends to be too rigid and thus may damage ships and is about two to three times more costly than treated wood. Like steel, tropical hardwood tends to be too rigid and also tends to split under stress. Treated wood has the ideal amount of flexibility or elasticity to allow it to bend and absorb shock while returning to its original form. It is also the most cost-effective material.

Treated wood pilings with pre-applied outer layers of fiberglass, polyethylene, or PVC are also now being sold and installed in aquatic applications where the buyer chooses these products due the perceived improvement in environmental protection. Such coated treated wood pilings cost about two to three times as much as uncoated treated pilings (M. Wright, Wood Preservers of Warsaw, VA, personal communication, 2006).

The most competitive alternative materials were determined to be concrete and steel. Plastic was also considered, but was generally found to be less competitive. In the Genoa's on the Bay case, the construction cost using concrete and steel was found to be 3.5 times more expensive (Appendix Table 4.5B). In the Seattle Port case, steel was found to be 2.4 times more expensive than treated wood (Appendix Table 4.5C). Since these two projects represent smaller and larger scale projects, the two were simply averaged to estimate the typical increased cost to builders if treated wood could not be used. The same factor of 2.9 is used for this aquatic environments evaluation to estimate the market impact (Appendix Table 4.5A).

If marine and freshwater facility owners were required to use alternative materials instead of treated wood, the additional cost is estimated to be about $4.5 billion in the U.S. and $870 million in Canada each year (see in Appendix Table 4.5A).

4.2.3 Road and highway transportation structures market

4.2.3.1 Market

Road and highway transportation structures include bridges, retaining walls, guardrails and posts, signs, and fencing. Products used for these structures include timbers, piling, fence posts, and other products. "Other products," as defined in the Wood Preservation Statistics 1997 (Micklewright 1998), include roofing shakes and miscellaneous products. Thirty-one percent of the "other" volume is products typically used in transportation, including highway crossing planks, panels, and flanges, glulam beams, bridge timbers, and highway posts and guardrails. The U.S. roads and highways market consumes about 12 MCF of treated wood per year, amounting to about 1.9% of all U.S. treated wood.

The size of the roads and highways aquatic market is estimated using the factors in Table 4.3. These factors are applied in Appendix Tables 4.3C and 4.3F to estimate the volume of treated wood used by the roads and highways market in aquatic environments. The aquatic market size is estimated to represent 4.8 MCF of treated wood in the United States and 926,000 cf in Canada annually, representing about 0.8% of the overall treated wood market.

Table 4.3 Approximate market share for treated wood products used in various highway applications and the proportion of that material used in aquatic environments.

Product	Market (%)	Aquatic (%)	U.S. volume (1000 cf/y)
Timbers	10	50	3,846
Piling	10	75	605
Other products	31	10	313
Fence posts	5	10	68

4.2.3.2 Use of treated wood and alternative materials

Smith (2003) assessed the impacts of using alternative materials, primarily steel and concrete, for treated wood in California, but did not study transportation structures in detail. He did, however, draw pertinent parallels to residential/commercial construction, utility poles, and marine construction.

Treated wood offers some significant advantages for use in short span bridges (Dave Clemens, Wheeler Lumber, Inc., Bloomington, MN, personal communication, January 2005). In addition to lower direct costs compared to cast-in-place and pre-cast concrete designs (see Appendix Table 4.6C), advantages include the following:

- Treated timber bridge arrives as a pre-manufactured kit, allowing construction completion in half the time required for cast-in-place concrete.
- Treated timber bridges can be installing during below freezing weather, allowing more flexibility to owners and potentially lower costs.
- Inspection costs may be less for treated timber bridges due to reduced material testing and construction time.
- In remote sites, the pre-manufactured design and lower weight of treated timber simplifies and lowers the cost of installation.
- Treated timber offers good resistance to road salt.
- Treated timber is often preferred for aesthetic reasons in rural settings.

4.2.3.3 Cost evaluation

The cost of alternatives to treated wood was estimated to be about two times higher than for treated wood (Smith 2003). Cost increases for steel and concrete are incorporated into the current tables. Several applications of alternative materials that are similar to projects applicable to the roads and highways market are listed in Appendix Table 4.6B with the unit material cost for each. Cost data for short-span bridges is presented in Appendix Table 4.6C. This represents a small, but significant segment of the road and highway transportation market. Recognizing that the alternative material factor for these bridges is smaller than for the other applications considered in Appendix Table 4.6B, the overall factor to be used in this evaluation is lower than for the calculated average. An alternative material factor of 2.0 is used for this evaluation.

The material cost and ratios determined in Appendix Table 4.6B are used in Appendix Table 4.6A to estimate the overall market cost impacts. Note that only material cost differences are assumed to be significant in this market. Labor is assumed to be equal for the installation of the alternative materials. Requiring alternative materials to treated wood installed for roads and highway structures in aquatic environments would increase costs annually by about $72 million in the U.S. and $14 million in Canada.

4.2.4 Railroad transportation structures

4.2.4.1 Market

The railroad market for treated wood is large (Appendix Table 4.7D). The railroads operate over 260,000 mi of track in the U.S. and Canada. Most treated wood in this market is used for replacement ties inserted during the normal maintenance of existing track. According to the Railway Tie Association (RTA), the demand for treated wood in 2007 was approximately 20 million ties or approximately 74 MCF of treated wood (Norrell 2008, Crossties 2008; see Appendix Table 4.7D). The market also includes treated timbers and piling for bridges.

The volume of the railroad market, based on Wood Preservation Statistics 1997, is estimated at about 68 MCF for ties only and about 72 MCF for all treated wood, estimates that are very close to current projections by the railroad industry. The Wood Preservation Statistics estimate may include additional scope, such as industrial and public investment in railroad structures, and is reasonably close

Table 4.4 Approximate market share for treated wood products used in various railroad applications and the proportion of that material used in aquatic environments.

Product	Market (%)	Aquatic (%)	U.S. volume (1000 cf/y)
Cross ties	100	10	6,790
Switch & bridge ties	100	40	2,142
Timber	5	50	1,923

for the purpose of this evaluation. Thus, it will be used for further analysis. The railroad market accounts for about 12% of all treated wood.

Historically, railroads, as well as public roads, have been developed to follow streams, rivers, lakes, and coastlines. Thus, a significant portion of railroad track is in the aquatic environments located adjacent to these water bodies. For this study, it is conservatively estimated that 10% of track is located within aquatic environments. The size of the railroad aquatic market is estimated based on the factors in Table 4.4. These factors are applied in Appendix Table 4.3D to estimate the volume of treated wood used by the railroad market in aquatic environments.

4.2.4.2 Use of treated wood and alternative materials

Smith (2003) discussed the potential alternative materials and associated issues for each in detail. The alternative products to treated wood for railroad applications are concrete, steel, and plastic. Concrete offers the best long-term complete replacement alternative to treated wood, but also requires the complete rebuilding of the rail bed, including deeper ballast. Concrete ties cannot simply be inserted into existing wood-tie track systems. While not fully proven or accepted, indications are that plastic or steel ties can be inserted into existing tracks among wood ties.

If treated wood could not be used in aquatic environments, including buffer zones, then the railroad industry would attempt to use plastic or steel ties for maintenance replacements in existing track in aquatic environments, while simultaneously beginning a transition to concrete-tie track systems. The use of dissimilar/unproven materials in these maintenance applications would create significant long-term problems even if a transition were made to all concrete-tie supported track. The transition would have to be spread over a number of years, since complete rebuilding of these tracks would be involved. This evaluation assumes completion over 15 y.

Thus, the railroads would face increased costs in two ways. First, ties purchased for maintenance would have to be plastic, steel, or concrete. Second, the railroads would have to do complete rebuilds of tracks to accomplish the transition from a treated wood design to a concrete design.

This evaluation assumes that such a transition is possible. However, the capacity to produce concrete and plastic ties in the volume required does not now exist and would have to be built. Further, the railroads lack the equipment needed to rebuild an additional 1,500 mi/y from wood to concrete tie systems. Thus, substantial effort on the part of the railroads and the supporting industries would be required to accomplish this transition.

This evaluation also assumes that crossties of dissimilar materials can be used in maintenance of existing wood-tie rail systems. However, the use of dissimilar or unproven materials in short-term maintenance applications could mean significant costs in terms of both extra maintenance required and possible safety issues (derailments, etc.) that can be created when the track bed is subjected to uneven wear and tear.

4.2.4.3 Cost evaluation

The cost of routine replacement of ties for maintenance is calculated using the average increase in costs for concrete and plastic (Smith 2003), with updated costs provided by the railroad industry (Zeta-Tech 2006). This results in an alternative-material project factor of 1.6 (see Appendix Table 4.7B).

The cost of rebuilding track from treated wood to concrete also follows the evaluation of Smith (2003), but is modified to include the 10% of existing track miles estimated to be in aquatic environments (Appendix Table 4.7C). The cost per mile to rebuild track is assumed to be the average of a low range cost of $550,000 and a high range cost of $900,000.

Costs for both routine tie replacement and rebuilding to a concrete tie design are included in the annual total impact to the railroads. The total cost to U.S. and Canadian railroads would be about $170 million and $32 million per year, respectively, for routine tie replacements (Appendix Table 4.7A) plus about $1.0 billion and $210 million, respectively, for rebuilding over each of 15 y (Appendix Table 4.7C). Thus, if treated wood could not be used, the total annual projected increase in costs to railroads to use alternative materials would be approximately $1.2 billion in the United States and $240 million in Canada over the next 15 y.

4.2.5 Utilities

4.2.5.1 Market

Treated wood is used by utilities for poles and cross arms. Most poles are treated with pentachlorophenol although significant numbers are also treated with other oil-borne preservatives, waterborne preservatives, and creosote. Poles and cross arms are used to support electrical and communication wires. The Utility Solid Waste Activities Group, a utility industry organization, reports that there are currently about 130-135 million treated wood poles in service in the U.S. and that over 99% of distribution poles purchased are treated wood (USWAG 2005). Treated-wood sales to the utilities market is estimated to be about 57 MCF or about 2 million poles per year in the U.S. and accounts for about 9% of the U.S. treated-wood market.

Applying the market share factors in Table 4.5 to estimate the volume of treated wood used by the utility market in aquatic environments indicates that utilities now annually place 2.8 MCF and 545,000 cf of treated wood in aquatic zones in the United States and Canada, respectively (Appendix Tables 4.3E and 4.3F).

4.2.5.2 Use of treated wood and alternative materials

The alternatives to wood poles for supporting electric distribution and transmission lines include steel, concrete, plastic, and fiber reinforced composites (Smith, 2003). Steel and concrete are the most common alternatives and are currently used by utilities in many applications. Utility industry comments to the EPA (USWAG 2005) stated:

> The most critical factors in an electric utility's selection of materials for transmission and distribution poles are safety, reliability, and functionality. Treated wood poles are superior to the alternatives in all three categories, and they are more cost-effective.

Table 4.5 Approximate market share for treated wood products used in various utility applications and the proportion of that material used in aquatic environments.

Product	Market (%)	Aquatic (%)	U.S. volume (1000 cf/y)
Poles	95	5	2,740
Cross arms	95	5	103

4.2.5.3 Cost evaluation

For some utility structures, steel or concrete may be lower in cost than treated wood, particularly for the larger transmission structures. Where that is the case, utilities are already purchasing the alternative materials. The costs for those structures are not reflected in this evaluation because this is based on current sales figures for treated wood. Only utility structures currently being built with treated wood are considered.

The typical treated wood utility pole is Class 4, 45-ft long (American National Standards Institute 2008). Steel was shown to be the most competitive at about 1.71 times the cost of treated wood. This includes extra costs to provide protection against electrocution for raptors, a common concern, especially in aquatic environments. The relative costs for steel, fiberglass, and concrete and the estimated added costs to the utility market are shown in Appendix Table 4.8B.

An alternative comparison is made in Appendix Table 4.8C using two reports obtained from the American Iron and Steel Institute (AISC) web site, with prices adjusted to 2008 levels based on U.S. Bureau of Labor Producer Price Index for Metals and Metal Products. George (2001) reports on a project using 163 poles of mostly Class 5-50 ft long and Class 3-60 ft long, in which the steel pole price was approximately 4% less than the wood pole price. However, after adjusting to current material pricing, the steel would be approximately 45% more than the wood price. McMillan (n.d.) listed the price of a 45-ft, class-4 steel pole at 18% more than the same wood pole. After adjusting to current pricing, the steel pole would be approximately 79% more than the wood pole price. Thus, the previous conclusion by Smith (2003) that steel poles would cost approximately 71% more than comparable wood poles is in substantial agreement with data provided by the steel industry.

The proponents of alternative pole materials tend to *assume* that treated wood will only last about 30 y, while *assuming* that alternative materials will last much longer with less maintenance. However, utilities have developed a proven record that treated wood poles, with proper scheduled inspections and maintenance, provide service up to 70 y (USWAG 2004). The life expectancy of alternative material poles is yet to be proven. Kleinfelder (2007) notes that "steel distribution poles have only been widely used for about 10 y. So the steel pole industry is still young and we continue to understand more with each maintenance cycle completed." He points out that there are various causes of corrosion and that it can progress rapidly, may lead to failure, and may be difficult to repair. Thus, steel distribution poles, like treated wood poles, require scheduled inspections, maintenance, and repair.

Requiring the use of alternative materials instead of treated wood would cost the utilities industry about $61 million in the United States and about $12 million in Canada annually.

4.3 Conclusion

Treated wood continues to have a large role in the construction and maintenance of infrastructure in North America. It is used widely in major market areas for the following:

- Marine and commercial construction for docks, marinas, boardwalks, retaining walls, and pilings
- Residential applications such as decks and personal docks
- Railroad and highway transportation facilities for cross-ties, bridge timbers and pilings, guard rails, sign posts, and retaining walls
- Utilities for poles and cross arms

Treated wood is selected for these uses due to its versatility, durability, and cost effectiveness.

Approximately 640 MCF of wood are treated annually in the United States along with about 120 MCF in Canada. Requiring alternative materials in place of treated wood in the aquatic environments in the United States and Canada for the various markets would, as shown in Table 4.6, increase annual installation costs by $5.9 billion in the U.S. and about $1.1 billion in Canada, for a total North American cost impact of $7.0 billion.

Table 4.6 Approximate economic impact of requiring substitution of treated wood with alternative materials for aquatic applications.

	Annual increased costs (millions)	
Market area	United States	Canada
Marine construction	$4,557	$873
Roads and highways	$72	$14
Railroads	$169	$32
Railroads system replacement	$1,048	$209
Utilities	$61	$12
Total	$5,907	$1,141

Many treated wood applications occur in or near to aquatic environments that include salt and freshwater bodies and the buffer zones around them. Agencies, seeking to protect aquatic environments, may restrict the use of treated wood in these areas. The decision to restrict treated wood use and require substitute materials can have a major impact on the owners of these facilities. The result will likely be reduced infrastructure replacement and enhancement. As such, it is imperative that decisions regarding material use be based upon sound available science that assesses all of the impacts of the various materials.

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Appendices

Appendix 4.1 Treated-wood market size

Appendix Table 4.1A U.S. treated-wood production data 1997 (1000 cf/y).

Year	Creosote	Oilborne	Waterborne	Total
1984	137,597	53,610	301,697	492,904
1985	128,750	52,535	328,677	509,962
1986	118,749	49,484	375,458	543,691
1987	97,822	48,557	418,984	565,363
1988	90,481	47,869	450,565	588,915
1989	89,870	49,386	406,941	546,197
1990	93,193	46,592	437,675	577,460
1991	87,610	43,490	424,370	555,470
1992	89,871	39,823	447,437	577,131
1993	92,132	36,155	470,504	598,791
1994	94,547	41,297	496,883	632,727
1995	91,751	32,764	450,596	575,111
1996	86,512	33,494	467,855	587,861
1997	97,389	35,843	581,382	714,614
2004	95,279	45,521	473,656	614,456
Typical annual U.S. production	93,060	38,286	507,631	638,977

Sources: AWPI (1997) for 1993-1996, with 1992 estimated as average of each previous and following year; Micklewright (1998).

Appendix Table 4.1B Production of treated wood in the United States by region, 1997.

		Preservative (1000 cf)				
Region	Number of plants	Creosote	Oilborne	Waterborne	All	Percent of total
Northeast	44	10,756		49,950	60,706	8.50
Northcentral	81	22,028	4,375	86,058	112,461	15.74
Southeast	135	9,693	3,840	189,485	203,018	28.42
Southcentral	122	45,276	17,488	164,000	226,764	31.74
Rocky Mountain	23	2,352	2,230	17,601	22,183	3.10
Pacific Coast	40	7,205	7,910	74,205	89,320	12.50
All regions	445	97,310	35,843	581,299	714,452	100.00

Source: Micklewright (1998), Table 2.

Appendix Table 4.1C Production of treated wood in the United States by product, 1997.

Product	Preservative (1000 cf)				Fraction of all (%)	Projected current production (1000 cf)
	Creosote	Oilborne	Waterborne	All		
Crossties	75,939	0	0	75,939	10.63	67,901
Switch & bridge ties	5,920	0	68	5,988	0.84	5,354
Poles	9,421	31,972	23,128	64,521	9.03	57,692
Cross arms	2	2,374	49	2,425	0.34	2,168
Piling	1,343	0	7,678	9,021	1.26	8,066
Fence posts	500	544	14,061	15,105	2.11	13,506
Lumber	1,026	421	383,892	385,339	53.92	344,554
Timbers	1,450	53	84,516	86,019	12.04	76,914
Specialty products	0	0	18,906	18,906	2.65	16,905
Landscape timbers	3	3	20,713	20,719	2.90	18,526
Plywood	0	0	19,345	19,345	2.71	17,297
Other products	1,785	476	9,026	11,287	1.58	10,092
All products	97,389	35,843	581,382	714,614	100.00	638,977

Source: Micklewright (1998), Table 3.

Appendix Table 4.1D Canadian treated wood statistics, 1999.

Product group	Preservative (1000 cf)				% of total
	CCA	CREO	PCP/PCPT	All preservatives	
Ties	0	5,886	0	5,886	4.81
Posts	11,580	0	483	12,063	9.85
Lumber, timber & plywood	65,692	403	44	66,139	54.01
Poles & piling	5,732	955	4,511	11,197	9.14
Treating service only	27,083	52	30	27,165	22.18
Totals	110,087	7,295	5,068	122,450	100.00

Source: CITW (2001).

Appendix Table 4.1E Canadian treated wood production by region, 1999.

Regions	Preservatives (1000 cf)				Percent of total
	CCA	CREO	PCP/PCPT	Region totals	
British Columbia	18,371	2,728	1,888	22,987	18.77
Prairie	22,891	0	1,235	24,126	19.70
Ontario	38,087	1,036	97	39,220	32.03
Quebec	21,898	3,434	1,510	26,842	21.92
Atlantic	8,838	97	338	9,274	7.57
Totals	110,087	7,295	5,068	122,450	100.00

Source: CITW (2001).

Appendix 4.2 Treated-wood production, 2004

Appendix Table 4.2A Production by treated wood product and preservative (2004).[a]

Product	Waterborne	Oil-borne	Creosote	Total	Fire retardants
Dimension lumber (bf)	4,689,004,022	12,674,426	5,075,827	4,706,754,275	13,044,399
Radius edge heavy decking	467,255,790	0	0	467,255,790	0
Boards, 1-inch	384,016,716	0	540,000	384,556,716	331,595
Pickets	373,800,017	0	0	373,800,017	0
Landscape timbers	244,990,200	302,400	67,500	245,360,100	0
Highway construction material	30,757,056	8,100,000	0	38,857,056	0
Glued-laminated beams	21,155,400	8,987,654	0	30,143,054	0
Timbers >4x4	1,634,913	3,388,500	3,836,430	8,859,843	343,202
Piling (cft)	22,256,693	0	849,528	23,106,221	0
Plywood (ft^2-3/8 basis)	413,523,186	27,000	0	413,550,186	72,866,091
Decorative parts (pieces)	141,824,141	270,000	0	142,094,141	4,860,000
Fence posts	34,313,660	1,471,948	13,760,758	49,546,366	0
Railroad crossties	0	540	17,322,771	17,323,311	0
Poles	1,734,088	1,572,888	639,984	3,946,960	0
Agricultural stakes	2,118,220	0	0	2,118,220	0
Switch & bridge ties	589,050	4,590	1,132,639	1,726,279	0
Electric utility crossarms	218,929	1,217,700	810	1,437,439	0

* Vlosky (2006).

Appendix Table 4.2B Production by treated-wood product and preservative (2004).

		Preservative (1000 cf)				
Product	Measure per cf	Waterborne	Oil-borne	Creosote	Total	Fire retardants
Dimension lumber	17	275,824	746	299	276,868	767
Radius edge heavy decking	17	27,486	0	0	27,486	0
Boards, 1-inch	17	22,589	0	32	22,621	20
Pickets	17	21,988	0	0	21,988	0
Landscape timbers	12	20,416	25	6	20,447	0
Highway construction material	12	2,563	675	0	3,238	0
Glued-laminated beams	17	1,244	529	0	1,773	0
Timbers >4x4	12	136	282	320	738	29
Piling	1	22,257	0	850	23,106	0
Plywood	32	12,923	1	0	12,923	2,277
	Cf/piece					
Decorative parts	0					
Fence posts	0.51	17,514	751	7,024	25,289	0
Railroad crossties	3.72	0	2	64,419	64,421	0
Poles	25.6	44,393	40,266	16,384	101,042	0
Agricultural stakes	0.39	832	0	0	832	0
Switch & bridge ties	5.25	3,093	24	5,946	9,063	0
Electric utility crossarms	1.82	399	2,220	1	2,620	0
Totals		473,656	45,521	95,279	614,456	3,092

Appendix 4.3 U.S. and Canadian treated-wood market analysis

Appendix Table 4.3A Annual estimated U.S. and Canadian sales of treated wood.

Preservative	U.S. volume (1000 cf)	Canadian volume (1000 cf)	Total volume (1000 cf)
Waterborne	507,631	110,087	617,718
Oil borne	38,286	5,068	43,354
Creosote	93,060	7,295	100,355
All treated wood	638,977	122,450	761,427

Note: Tables 4.3B–3F evaluate only the U.S. market. The percentages of treated wood used in each end market are then applied to Canadian treated-wood production in Table 4.3F.

Appendix Table 4.3B U.S. marine and freshwater treated-wood construction market.

			Estimated marine construction aquatic market			
Product (all preservatives)	Volume (1000 cf)	Market %	Market (1000 cf/y)	Aquatic %	Aquatic (1000 cf/y)	1000 bf/y
Piling	8,066	60.0	4,840	100.0	4,840	58,077
Lumber	344,554	4.0	13,782	100.0	13,782	165,386
Timber	76,914	15.0	11,537	100.0	11,537	138,446
All products	638,977		30,159		30,159	361,908
Percent of treated wood market			4.72%		4.72%	

Appendix Table 4.3C U.S. Roads and highways treated-wood market.

			Estimated roads and highways aquatic market			
Product (all preservatives)	Volume (1000 cf)	Market %	Market (1000 cf/y)	Aquatic %	Aquatic (1000 cf/y)	1000 bf/y
Timber	76,914	10.0	7,691	50.0	3,846	46,149
Piling	8,066	10.0	807	75.0	605	7,260
Other products (posts, guardrails, bridge timbers, and crossing panels)	10,092	31.0	3,129	10.0	313	5,319
Fence posts	13,506	5.0	675	10.0	68	1,148
All products	638,977		12,302		4,831	59,875
Percent of treated wood market			1.93%		0.76%	

Appendix Table 4.3D U.S. railroad treated-wood market.

			Estimated railroad aquatic market			
Product (all preservatives)	Volume (1000 cf)	Market %	Market (1000 cf/y)	Aquatic %	Aquatic (1000 cf/y)	1000 bf/y
Cross ties	67,901	100.0	67,901	10.0	6,790	81,482
Switch and bridge ties	5,354	100.0	5,354	40.0	2,142	25,700
Timber	76,914	5.0	3,846	50.0	1,923	23,074
All products	638,977		77,101		10,855	130,256
Percent of treated wood market			12.07%		1.70%	

Appendix Table 4.3E U.S. utilities treated-wood market.

			Estimated utilities aquatic market			
Product (all preservatives)	Volume (1000 cf)	Market %	Market (1000 cf/y)	Aquatic %	Aquatic (1000 cf/y)	(1000 bf/y)
Poles	57,692	95.0	54,807	5.0	2,740	32,884
Cross arms	2,168	95.0	2,060	5.0	103	1,236
All products	638,977		56,867		2,843	34,120
Percent of treated wood market			8.90%		0.44%	

Appendix Table 4.3F U.S. and Canadian aquatic treated-wood markets summary.[a]

Market area description	Percent	1000 cf/y		1000 bf/y	
		U.S.	Canada	U.S.	Canada
Utilities	5.84	2,843	545	34,120	6,539
Railroads	22.29	10,855	2,080	130,256	24,962
Marine construction	61.94	30,159	5,779	361,908	69,354
Roads and highways	9.92	4,831	926	59,875	11,474
Total	100.00	48,688	9,330	827,699	112,328
Aquatic market as percent of treated wood market		7.62%			

a. Canadian aquatic markets estimated as same proportion of total treated wood as U.S. markets.

Appendix 4.4 Constants and conversion factors

Wood density	26	lb/cf	26	lb/cf
	0.351	ton/cy	26000	lb/1000cf

Conversions between nominal measure and net (actual) measure
Production statistics for lumber are based on actual lumber measure.
Volume reported as cubic feet (cf) (12 in. x 12 in. x 12in.) or board feet (bf) (12 in. x 12 in. x 1 in.)

1.0 cf (nominal)	=	12	bf (nom)	
1.0 cf (actual)	=	17	bf (nom)	Use for waterborne
1.0 cf (actual)	=	12	bf (actual)	Use for creosote and oilborne

Conversion to board feet	Nominal/actual		Area	Fraction		Factor
Typical lumber dimensions	Width (in.)	Thickness (in.)	(sq in.)	(actual to nominal)	(nominal to actual)	(bf per actual cf)
1 x 6 board (actual)	5.50	0.75	4.13	68.75%		
1 x 6 board (nominal)	6.00	1.00	6.00		145.45%	17.45455
2 x 4 board (actual)	3.50	1.50	5.25	65.63%		
2 x 4 board (nominal)	4.00	2.00	8.00		152.38%	18.28571
2 x 6 board (actual)	5.50	1.50	8.25	68.75%		
2 x 6 board (nominal)	6.00	2.00	12.00		145.45%	17.45455
2 x 8 board (actual)	7.25	1.50	10.88	67.97%		
2 x 8 board (nominal)	8.00	2.00	16.00		147.13%	17.65517
Average ratio (bf as % of cf)			67.45%		148.32%	17.80

Conversion factor to use (nominal board foot per actual cubic foot) 17

Railroad tie conversion	In.	In.	Ft	Cf/tie
Standard dimensions	7	9	8.5	3.72
Standard dimensions	7	9	12	5.25

Fence post conversion	In.	In.	Ft.	Cf/post
Fence posts	3.5	3.5	6	0.51

Average pole size	C4-45 ft			
Cf/pole	25.6		Cf/pole	
	In.	In.	Ft	Cf/post
Typical utility crossarm	3.5 in.	7.5 in.	10 ft	1.82

Agricultural stakes	3-in. diam x 8 ft = 0.39 cf/stake
Plywood (3/8 in. basis)	1 cf = 12 in. x 8/3 = 32 ft^2 plywood/cf

Appendix 4.5 Marine and freshwater treated-wood aquatic market

Appendix Table 4.5A Marine/freshwater market impact calculation

	United States	Canada
Marine sales (cf/y)	30,159,029	5,779,495
Treated-wood marine use average unit price	$13.57/cf	
Annual marine use treated-wood sales	$409,190,422	$78,414,791
Average unit treated-wood project cost	$77.34/cf	
Annual treated-wood projects cost	$2,332,504,089	$446,987,053
Average installed cost ratio of alternatives to treated wood	2.95	
Annual cost of projects using alternatives	$6,889,288,155	$1,320,221,742
Increased annual cost for alternative materials	$4,556,784,066	$873,234,689

Appendix Table 4.5B Case study: Genoa's on the Bay.

Treated wood	Diameter (in.)	Length (ft)	Quantity	Unit cost ($)	Amount ($)	Cf
Piling	12	55	7	577.50	4,042.50	302
Piling	16	60	12	630.00	7,560.00	1,005
Installation			19	650	12,350.00	
Total cost					23,952.50	1,308
Unit cost of material ($/cf)					8.87	
Unit cost of installation ($/cf)					9.44	
Unit cost installed ($/cf)					18.32	
Steel/concrete	Diameter (in.)	Length (ft)	Quantity	Amount		
Piling	12	55	7	37,350.00		
Piling	16	60	12	18,500.00		
Installation			19	Included		
Subtotal				55,850.00		
Estimated 2008 pricing (1.51 factor)				84,333.50		
Ratio installed cost steel/concrete to treated wood				3.52		

Appendix Table 4.5C Case study: Terminal 91, Pier 90, Port of Seattle.

Material	Quantity		Conversion		Quantity
Piling (9 in. tip/16 in. butt)	42	piles	70	cf/pile	2,940 (cf)
Timber	14000	bf	12	bf/cf	1,167 (cf)
Total treated wood used					4,107 (cf)
Treated wood material cost					$75,000
Installed cost based on treated wood					$560,000
Unit material cost of treated wood					$18.26/cf
Unit treated wood installed cost					$136.36/cf
Revised cost using steel instead of treated wood					$885,000
Estimated 2008 pricing (1.51 factor)					$1,336,350
Ratio installed cost steel to treated wood					2.39

Note: Project includes 410 LF of wharf fender system that was first bid for treated wood and then changed to steel. Information from Manson Construction.

Appendix 4.6 Roads and highways aquatic market

Appendix Table 4.6A Roads and highways impact calculation.

	United States	Canada
Roads and highways treated wood sales (cf)	4,831,083	925,800
Unit treated wood sales price ($/cf)	15.00	
Value of roads and highway t.w. sales ($/y)	72,466,241	13,886,995
Ratio of alternative materials to treated wood	2.00	
Cost of alternative materials for road/hwy use ($/y)	144,932,482	27,773,989
Increased cost to road/hwy market ($/y)	72,466,241	13,886,995

Appendix Table 4.6B Comparison to markets of similar use.

Similar use markets	Unit material cost ($/cf)	Ratio
Treated wood pole	17.58	1.71
Marine construction	13.57	2.93
Average	15.57	2.32
Factors to use	15.00	2.00

Appendix Table 4.6C Short-span bridges.

Bridge construction material	Unit cost ($/sq ft)	Ratio
Treated timber slab span	74.52	
Cast-in-place reinforced concrete slab span	119.97	1.61
Pre-cast concrete beam/cast in place deck	130.92	1.76

Appendix 4.7 Railroads treated-wood aquatic market

Appendix Table 4.7A Railroad impact calculation.

	United States	Canada
Railroad sales (cf/y)	10,854,686	2,080,127
Eq. ties	2,918,907	559,362
Treated-wood railroads use average unit price ($/cf)	9.14	
Annual railroads use treated-wood sales ($)	99,242,840	19,018,301
Average unit treated-wood installed cost ($/cf)	25.55	
Annual treated-wood installed cost ($)	277,296,170	53,139,370
Average installed-cost ratio of alternatives to treated wood	1.61	
Annual cost of using alternatives ($)	446,293,592	85,525,019
Annual increased cost to railroads for alternative materials ($)	168,997,421	32,385,649

Appendix Table 4.7B Estimated installed costs of railway ties in new track system.

	Creosote-treated wood		Concrete		Plastic/steel	
System component	Factors	Costs	Factors	Costs	Factors	Costs
Cross tie ($)		34.00		80.00		68.00
Size	7”x9”x8’6”		11”x9”x8’6”		7”x9”x8’6”	
Spacing (inches)	19.5		24		19.5	
Weight (lb)	200		700		217	
Hardware, new ($)		20.00		21.00		20.00
Ties per mile of track	3,249		2,640		3,249	
Labor and equipment to install						
Installation cost per tie ($)		39.00		102.00		45.00
Transportation to job ($)		2.00		7.00		2.17
Assume distance is	400 mile		Same as wood		Same as wood	
Car load is	80,000 lb		Same as wood		Same as wood	
Car load of ties	400 ties		114 ties		369	
Cost per loaded car-mile ($)	2.00		Same as wood		Same as wood	
Installed cost per tie w/new hardware ($)		95.00		210.00		135.17
Installed cost per mile ($)		308,677		554,400		439,199
Ratio alternative to treated wood cost				1.80		1.42
Ratio of alternative to treated wood		1.61				
Unit treated wood tie material cost		9.14/cf				
Unit treated wood tie installed cost		25.55/cf				

Appendix Table 4.7C Evaluation of replacement to maintenance of existing costs.

Description	United States		Canada	
Existing track in U.S. & Canada (miles)	216,818		43,281	
Track in aquatic environment, 10% of total miles	21,682		4,328	
Average annual maintenance cost (2x $/mile and 2.5%/y)	15,433.85		15,433.85	
Annual railways maintenance ($)	334,633,566		66,799,133	
	High range	Low range	High range	Low range
Cost to replace existing railways ($/mile)	900,000	550,000	900,000	550,000
Cost of new aquatic area railways ($)	19,513,620,000	11,924,990,000	3,895,284,358	2,380,451,552
Replacement cost spread over 15 y				
Annual replacement cost ($)	1,300,908,000	794,999,333	259,685,624	158,696,770
Ratio of replacement to maintenance annual cost	3.89	2.38	3.89	2.38
Annual mid-range replacement cost estimate ($)	1,047,953,667		209,191,197	

Appendix Table 4.7D Railroad statistics, 2007.

Region	Total track miles occupied	New wood ties
Eastern U.S. Class 1	73,192	5,819,000
Western U.S. Class 1	93,626	6,648,788
Regional and shortline railraoads[a]	50,000	4,383,000
U.S. total	216,818	
Canada	33,300	3,033,333
Canadian regional and shortline railroads[b]	9,981	
Canada total	43,281	
Total	260,099	19,884,121
Totals (cf)		73,944,075

a. Jim Gauntt, Railway Tie Association, for miles of Regional and Short Line track, personal communication, 2008.
b. Prorated to same ratio of mainline as in U.S.
Sources: Norrell (2008) and Crossties (2008).

Appendix 4.8 Utilities aquatic market

Appendix Table 4.8A Utilities market impact calculation.

	United States	Canada
Pole sales (cf/y)	2,740,365	544,885
Average pole size	C4-45 ft	
Cubic feet per pole (cf/pole)	25.6	
Poles purchased annually	107,046	21,285
Unit price of treated-wood pole ($)	450	
Annual value of treated-wood pole sales ($)	48,170,485	9,578,050
Unit installed cost of treated-wood pole ($)	800	
Annual installed cost of treated-wood poles ($)	85,636,417	17,027,644
Ratio of installed cost alternative to wood	1.71	
Annual installed cost of alternative materials ($)	146,652,364	29,159,840
Annual increased cost to utilities for alternative materials ($)	61,015,947	12,132,196

Appendix Table 4.8B Alternative pole materials comparison.

Description	Treated wood	Fiber-glass	Steel	Concrete
New and replacement poles ($/pole)	450	1,000	500	500
Freight ($/pole)	50	50	120	200
Installation ($/pole)	300	300	300	600
Pole steps ($/pole)	0	150	150	150
Steps installation ($/pole)	0	150	150	150
Raptor protection ($/pole)	0	0	150	150
Installed total cost, each ($/pole)	800	1,650	1,370	1,750
Ratio of alternative-to-treated-wood installed cost		2.06	1.71	2.19
Typical treated wood unit cost	450	/pole	$17.58	/cf

Appendix Table 4.8C Price comparisons from the American Iron and Steel Institute (www.steel.org).

Description	# poles	Wood price ($) including ground	Steel price ($)	Ratio
George (2001) data [a]	163	101,242	97,171	0.96
Estimated 2008 pricing (1.51 factor)[b]	163	101,242	146,728	
Estimated 2008 average per pole	1	621.12	900.17	1.45
McMillan (n.d.)	45-ft, Class 4	265.00	314.00	1.18
Pricing updated to 2008 (1.51 factor)[b]		265.00	474.14	1.79
Mean 2008 ratio, alternative to treated				1.62

a. Poles sizes from 40-3 to 70.2; 64% were 55-5 and 60-3

b. U.S. Bureau of Labor (2008).

Appendix 4.9 Summary of end-user costs by market

Appendix Table 4.9A U.S. aquatic market.

	Treated wood		Alternate materials	
Market area description	Sales ($/y)	Installed cost ($/y)	Installed cost ($/y)	Increased cost ($/y)
Marine construction	409,190,422	2,332,504,089	6,889,288,155	4,556,784,066
Roads and highways[a]	72,466,241	72,466,241	144,932,482	72,466,241
Railroads	99,242,840	277,296,170	446,293,592	168,997,421
Railroads system replacement (15 y)		0	1,047,953,667	1,047,953,667
Utilities	48,170,485	85,636,417	146,652,364	61,015,947
Total	629,069,988	2,767,902,917	8,675,120,259	5,907,217,342

a. Change in installation/labor cost assumed not significant for road/highway markets.

Appendix Table 4.9B Canadian aquatic market, all costs are in ($/y).

	Treated wood		Alternate materials	
Market area description	Sales	Installed cost	Installed cost	Increased cost
Marine construction	78,414,791	446,987,053	1,320,221,742	873,234,689
Roads and highways[a]	13,886,995	13,886,995	27,773,989	13,886,995
Railroads	19,018,301	53,139,370	85,525,019	32,385,649
Railroads system replacement (15 y)		0	209,191,197	209,191,197
Utilities	9,578,050	17,027,644	29,159,840	12,132,196
Total	120,898,136	531,041,062	1,671,871,788	1,140,830,726

a. Change in installation/labor cost assumed not significant for road/highway markets.