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ABSTRACT

In 2004 the European Commission issued Directive 2004/102/EC which, among other things, introduced the concept of requiring wood packaging materials to be "debarked." While previous research has established that as many as one in five North American wood pallets contain at least one occurrence of bark, the process changes required to eliminate or segregate barky defects from pallets have not been adequately defined or quantified. Simulation-based findings as described in this paper indicate that the proposed EC regulation could add $2.7 billion over 10 years to the cost of U.S. pallets alone as they enter international trade markets, and depending on the degree of universal adoption of bark-free regulation, could result in as much as 16 billion additional board feet of lumber being consumed, again in U.S. pallet production alone. Labor, administration, and environmental costs dwarf the capital costs required to make this process transition. The largest potential cost, however, may come in the form of product substitution, as product manufacturers convert to alternative shipping platforms to avoid potential quarantine and return-of-product risk.

Keywords: pallets, phytosanitary regulation, bark-free

Introduction

The production and use of pallets play a surprisingly important role in the U.S. economy. For example, pallets are thought to consume more than half of all U.S. hardwood lumber production (e.g., McCurdy et al. 1988). The more than 400 million new pallets produced per year have an especially important function in terms of increasing demand for low-grade hardwood lumber that might otherwise be destined for lower value uses. The pallet industry has even been noted for its importance at the state level (e.g., Fraser et al. 1990, Michael 1997, Smith 1991).

It has often been said that "pallets move the world" and this statement is not far from the truth (e.g., White and Hamner 2005). For example, nearly 100 percent of U.S. grocery distribution companies and more than 90 percent of U.S. manufacturing firms are thought to utilize solid wood pallets for transportation of their goods (McCurdy and Phelps 1996, Scheerer et al. 1996). Moreover, wood pallets have a critical role in transportation of goods being exported from the United States to foreign buyers. Of note is the more than $75 billion worth of products being shipped annually on wood pallets to the European Union (EU) alone. Not only do these export pallets serve a key economic role in helping to move our products overseas, but they also consume a significant quantity of wood-based materials. Unfortunately, the future of wood pallets as a means for carrying unit loads to the EU is not a bright as it could be. Recent legislation proposed by the European Commission has the potential to drastically reduce the use of wood pallets for exporting to EU countries.

The governance of wood packaging materials used in international trade stems from a series of treaties and regulations. One of the most important is the International Plant Protection Convention (IPPC), which is an international treaty relating to plant health administered by the Food and Agriculture Organization (FAO). FAO established the Interim Commission on Phytosanitary Measures (ICPM) as an interim measure until the New Revised Text of the IPPC comes into force. ICPM published International Standards for Phytosanitary Measures Publication No. 15 (ISPM 15) *Guidelines for Regulating Wood Packaging Material in International Trade* in March 2002 (ICPM 2002). ISPM 15 describes phytosanitary measures to reduce the risk of introduction and/or spread of quarantine pests associated with solid wood packaging materials, including pallets, containers, and dunnage.

After its publication, implementation of ISPM 15 began as approved in its 2002 form. In October 2004, however, the European Commission (EC) issued Directive 2004/102/EC (EU 2004) which put additional restrictions on wood packaging materials related to the raw material composition, specifically, that wood packaging materials be debarked, bark-free, or free of pests in other forms that might be indicated by the physical appearance of the wood itself. The terminology used to describe the concept of debarked wood is varied throughout Directive 2004/102/EC and its predecessor Directive 2000/29/EC, somewhat obscuring the true intent of the EC. With postponement of the proposed directive until January 2009, the latest overview document provided by the EC states simply that "From January 2009, all wood packaging material imported into the EU will have to be debarked" (EU 2006).

Various industries and governmental agencies around the world have interest in determining the impact this directive might have on the wood packaging industry, its customers, and consumers worldwide. Mumford (2002) elucidated the need for proportionate and reasonable response to quarantine regulation in order to fairly, effectively, and efficiently preserve the world's natural resources for future generations without applying undue hardship on current generations. Partly in response to this stated need, and partly to establish a theoretical baseline of potential impact on the total cost of the proposed regulation, this study sought to determine a framework for evaluation of the economic and environmental costs that might be incurred under the most likely scenarios. The objective of the study was to provide contextual detail of the potential implementation costs to U.S. pallet producers and pallet customers for support of international dialogue and implementation of the ultimate regulation.

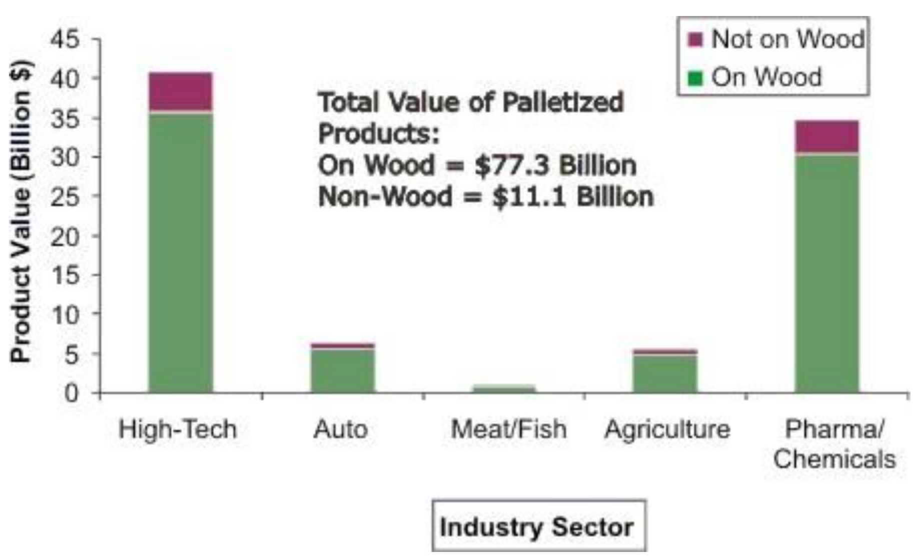
Literature Review

The number of sawmills that typically produce low-grade lumber for the pallet industry and smaller mills that produce less than 5 million board feet of lumber per year has decreased in recent years (Luppold 2005). In addition competing markets for low-grade lumber, especially from overseas wood products industries and the domestic railroad tie industry, has created the most competitive pallet lumber market in history (Brindley and Brindley 2004). The concentration of lumber production in fewer, large mills has been correlated with increasing stumpage and log prices (Luppold 1996). In particular, the hardwood market could be expected to feel price pressure from any increase in grade specification for pallet lumber, as pallet production consumes an estimated 40 to 60 percent of all hardwood lumber produced in the United States (Christoforo et al. 1994). Partially offsetting the additional demand for the lower grade resource is its availability in the changing forest composition as higher quality oak, cherry, and hard maple is replaced by increasing soft maple stocks. The overall average grade of lumber produced from the North American forest may decrease to the benefit of the pallet industry (Luppold 2003).

Pallet production has a much smaller impact on the softwood market. The total volume of softwood lumber and cants produced in the United States in 1995 was 32.2 billion board feet versus 11.9 billion board feet of hardwood lumber and cants (Pease et al. 1996). That year, pallet production consumed an equivalent of only 5.6 percent of the softwood production versus 38 percent of the total hardwood production (Bush et al. 1997). Pallet stock production is considered an insignificant by-product for most large softwood lumber operations, while it is a significant co-product for most hardwood lumber operations. Although no references are available for specific overall lumber market impact by pallet lumber consumption, numerous commentators focus on the hardwood markets when discussing pallet lumber (e.g., Bush et al. 1997, Brindley and Brindley 2004, Christoforo et al. 1994).

The proposed EU bark-free regulations are expected to have the greatest effect on those countries using large amounts of wood pallets as logistical unit-load platforms. The United States clearly is one of these countries. Over 90 percent of U.S. manufacturing firms surveyed in 1993 used solid wood pallets (McCurdy and Phelps 1996), and U.S. wood pallet production was surveyed in 1995 at 411 million new units manufactured from more than 6.5 billion board feet of hardwood and softwood lumber (Reddy et al. 1997). The size of the entire in-use wood pallet pool in the United States is more than 4 billion pallets (Ray et al. 2006). From this pallet pool, approximately 60 to 75 million are used directly in trade with the EU each year (Molina-Murillo et al. 2005), and they carry an estimated $77 billion in trade goods (**Fig. 1**). A further 200,000 or so are sold each year directly to EU manufacturers for their use (Parker 2004). At minimum, these 60 to 75 million pallets would be subject to the proposed EU bark-free pallet regulation. Several major export product manufacturers have hinted that they would require the EU standard for all of their pallets, in order to avoid the logistical problem of maintaining separate pallet inventories (Ray and Deomano 2007). This raises the possibility that the EU standard will become a “de facto” standard imposed on wood pallet production worldwide. Pallet producers are concerned that the magnitude of this impact may cause severe hardship to the worldwide wood pallet industry, perhaps even a gradual elimination of the industry as environmentalists push an agenda to alternative materials (NWPCA 2005a).

Figure 1. Product value by industry sector of U.S. exports to the European Union (source: U.S. Department of Commerce, Harmonized Trade Schedule, 2004 data).



EU leadership has taken a hard line on the issue thus far supporting the implementation of the rule as formulated. The Director General for Health and Consumer Protection for the European Commission has stated that "the risk-aversion policy [for the European Union] has been set at zero…" and that "…as regulators we hear all the time that a new regulation will wipe out an industry" (NWPCA 2006). At this point in time, enforcement of the proposed regulation by the EU is due to begin in March of 2009.

Underlying the proposed directive is an interest in reducing environmental risks to the forests of Europe posed by invasive species. Quarantined pest data collected at Australian ports indicated that about 0.3 percent of ISPM-stamped pallets had both insects and bark (IFQRG 2005) and about 0.1 percent were similarly found in a study of six U.S. ports (Haake et al. 2006). The actual amount of expected decrease in environmental risk due to enforcement of "bark-free" regulation is not well established for any specific forest species, geographic region, or inspection protocol (IUFRO 2006, IFQRG 2006), and "infestation of marked wood packaging is rare" (IFQRG 2006). By introducing complex regulation differentiated from the global ISPM 15 standard, the proposed directive may increase the cost of the global trade goods system (NWPCA 2005b) while ignoring the environmental benefits that accrue to utilization of carbon-neutral wood pallets (Skog and Nicholson 2000) and the environmental cost in additional wood consumption of required sawing to clear lumber (Araman et al. 2003, Steele 1984, Kuenzi 2002). Furthermore, the introduction of regional modifications to the accepted world phytosanitary standard for wood packaging (ICPM 2002) promises to increase the level of diversity and complexity of pallet standards (Portman 2005). It may also introduce economic inefficiency similar to those stemming from the lack of harmonization of world pallet size standards (Raballand and Aldaz-Carroll 2005).

Of particular concern to the wood packaging industry is the lack of a clear definition of the bark requirement actually targeted by the EC directive. The definitive document, EC Directive 2004/102/EC, refers to six different descriptions of a bark-free state: "stripped of its bark" (9 times); "free of grub holes" (3 times); "debarked" (5 times); "bark-free" (11 times); "roughly squared" (9 times); and "made from debarked round wood" (specifically with respect to wood packaging) (EU 2004). This range of descriptive terminology has led to speculation of the exact definition of the "bark-free" requirement, and the relevant risk associated with any specific definition. In response, the IPPC has initiated an international survey to measure bark occurrence on wood packaging marked as in compliance with ISPM 15 (IPPC 2007). This survey requires participating inspection agencies to measure each occurrence of remnant bark on the pallet.

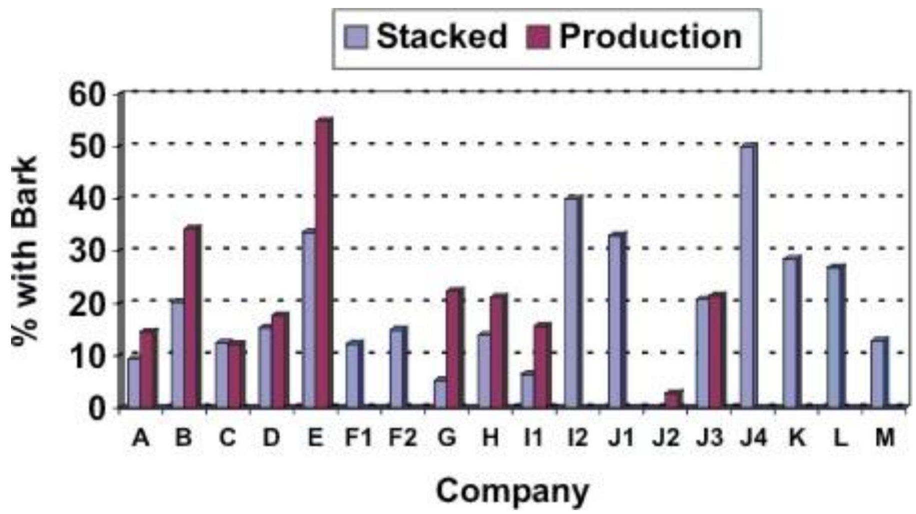
This may prove to be problematic. Ray (2006) has quantified high levels of alpha-type (**Fig. 2a**) and beta-type (**Fig. 2b**) risk of error in detection of bark occurrences on wood pallets as manufactured in current processes. Confirmed high levels of inspection error would cast doubt on the effectiveness of an inspection protocol and ultimately, the EC directive.

Figure 2a. Alpha-type error (false positive) in pallet board. Bark-free wane as it typically darkens is difficult to distinguish from a distance from real bark. This example was incorrectly identified by 7 of 20 inspectors as a bark occurrence (from Ray 2006).

Figure 2b. Beta-type error (false negative) in pallet board. Bark pocket residing on the bottom of the pallet not visible to inspectors. This pallet was incorrectly passed as "bark-free" by 20 of 20 inspectors (from Ray 2006).

In order to ascertain the potential impact of a bark-free standard, in terms of number of pallets that might be impacted by a "debarking" or "bark-free" requirement, Ray and Deomano (2007) visited 15 sawmills, pallet producers, and pallet customer locations. Bark-occurrence data on pallets in stock was collected from all but two of these locations. In collecting data on the actual occurrences of bark on pallet wood, the data collection methodology of their study initially followed an unofficial standard of a "credit card" size of bark occurrence. But, this concept proved unworkable in actual inspection practice, and they modified their data collection to a scheme deemed reasonable in practice and compliant with the intent of the regulation. **Figure 3** is a summary graphic illustrating the results of inspection of 5,584 solid wood pallets and crates. Production facilities were visited in three different geographic regions (Pennsylvania, Ontario, and Washington) to determine whether regional differences in pallet bark populations could be detected. The alphabetic identification of the companies on the x-axis of the figure identify individual companies, and in the case of alphanumeric identifiers, different types of pallets at the same company. At 10 of the pallet production facilities and three of the customer facilities, data was collected on the number of pallets with bark or barky-type defects relative to bark-free pallets. The statistics reflected in **Figure 3** led to the understanding that bark and barky-defect occurrences are quite prevalent on solid wood pallets in North America, even if produced from debarked lumber. The authors conclude that typically one in five pallets and containers produced from solid wood in North America contain at least one occurrence of bark remnant or barky defect.

Figure 3. Pallets inspected for bark occurrence by company and whether inspected as stacked or in production (Ray and Deomano 2007).



Unfortunately, an exact specification defining a “bark-free” state is not explicitly stated in 2004/102/EC, and enforcement of the regulation is likely to be varied by geographic and cultural standards. Bark occurrences on the wane portion of lumber, for example, typically have a narrow, triangular shape that abruptly ends where a debarker was effective in removing the bark (**Fig. 4a**). Bark pockets normally appear as long, narrow defects in pallet stringers (**Fig. 4b**) or deckboards (**Fig. 4c**). Other “barky defects” that could be identified as potential pest harbors are commonly found in pallet blocks (**Fig. 4d**), deckboards (**Fig. 4e**), and stringers (**Fig. 4f**) (Ray and Deomano 2007) and are the result of several types of unsound defects commonly found in pallet cants (Araman et al. 2003).

Figure 4a through 4f. Typical bark occurrences on pallets (from Ray and Deomano 2007).

Figure 4a. Remnant bark on wane after debarking.

Figure 4b. Bark pocket in pallet stringer.

Figure 4c. Bark pocket in pallet deckboard.

Figure 4d. "Barky" defect in pallet block.

Figure 4e. "Barky" defect in pallet deckboard.

Figure 4f. "Barky" defect in pallet stringer.

Methodology

Seventy-seven interviews were conducted, in a variety of settings, with people familiar with the workings of both the international phytosanitary standards and the global logistics community. Government officials and industry trade representatives from the EU, Canada, and the United States were surveyed, in most cases through telephone interviews, to establish the relative positions taken by those countries toward the proposed regulation, and to frame the issue for further data collection and analysis. Fifteen pallet producers, suppliers, and customers were visited and interviewed informally to establish the detail necessary for proper analysis of the problem. During these visits, pallet production methods, storage procedures, and shipping standards were reviewed with operational personnel. Cost components (e.g., raw material, labor, processing alternatives, etc.) of these processes were discussed, and the issue of bark-free production was explored with respect to what process changes would necessarily be required. Managers at more than a dozen additional companies using wood pallets for export, representing the food, plastics, and high-tech industries were informally interviewed as to their knowledge of this issue, and their reactions to each of several possible outcomes were noted. For the customer interviews, informality and confidentiality were given a high priority because of pallet suppliers' reluctance to prematurely raise the issue into prominence in the eyes of their customers.

Selection of participating government and trade officials was made through investigation of agencies and organizations most involved in the topic. Selection of the data collection locations was made with pallet industry assistance. In this regard, representatives of the National Wooden Pallet and Container Association (U.S.) and the Canadian Wood Pallet and Container Association targeted and recruited companies for participation in the study.

Having defined the issues surrounding "debarked" or "bark-free" pallets and measured the magnitude of product impact on a representative sample of North American pallet producers, computer modeling techniques were devised (as described in detail in the following section) to quantify the different cost components of bark-free pallet production and simulate them over three possible future scenarios.

The general modeling methodology was to establish production and cost range estimates from the interviewed and cited sources, represent these point estimates and ranges in formulated spreadsheet scenarios of the different investment levels, and generate year-to-year estimates of the various costs. These annual costs were summed over a determined period of 10 years to cover the expected time until the regulatory transition had been concluded to a steady-state. For those variables in the modeled scenarios for which the potential ranges were relatively wide, simulation techniques of generating random numbers from appropriate statistical distributions were used to generate representative averages, which were then plugged into the modeled scenarios. Finally, the calculated value of each scenario was multiplied by its probability and summed, resulting in an expected value (cost) of all of the scenarios combined. This general methodology of modeling events under uncertainty is similar to techniques commonly used in corporate strategic planning and operational analysis (Ray 1998).

Data Collection and Model Formulation

Data determined necessary to the modeling effort were collected from the sources as summarized in **Table 1**. These data were used to develop sensitivity models to examine three different scenarios.

Table 1. Baseline data used in economic simulation exercise.

Variable category	Variable	Data point estimate or range	Source
Economic impacts	Total number of pallets produced and recycled (U.S.)	695 million/yr.	NWPCA
	Total number of pallets in use (U.S.)	4.2 billion	NWPCA
	Total U.S. pallets used for export of products to EU per year	63 million	Molina-Murillo et al. (2005)
	Value of U.S. pallets sold to EU companies as export pallets	$2.726 million	Parker (2004)
	Total number of pallet operations	2,948	U.S. Bureau of Census
	Total number of employees (U.S.)	51,000	U.S. Bureau of Census
	Average employees/operation	17	Calculated
	Annual pallet industry payroll	$1.154 billion	U.S. Bureau of Census
	Fringe and benefit ratio	35% to 55%	Author estimate from interviews
	Annual pallet industry payroll + fringe and benefits	$1.674 billion	Calculated
	Salary cost per employee to a pallet company	$22,633	U.S. Bureau of Census
	Cost per employee w/fringe and benefits	$32,818	Calculated
	Employee cost per pallet produced (U.S.) without bark-free requirement	$2.39	Calculated
	Employee cost per pallet produced (U.S.) with bark-free requirement	$2.53 to $2.81	Calculated
	Cost of capital equipment needed to sort out bark (U.S. $)	$0 to $100,000	Author estimate from interviews
	Administration cost per "special" pallet	$0.50	Ray et al. (2006)
Value of products exported by the U.S. to the EU by industry sector (billion $ US)	High Tech	$40.9	U.S. Dept of Commerce
	Auto	$6.3	U.S. Dept of Commerce
	Meat/Fish	$0.98	U.S. Dept of Commerce
	Agriculture	$5.465	U.S. Dept of Commerce
	Pharmaceuticals/Chemicals	$34.8	U.S. Dept of Commerce
	% of wood pallets used in the five sectors above	85% to 92%	NWPCA
	% of wood pallets used in High-Tech and Pharmaceuticals/Chemicals only	25% to 60%	U.S. Dept of Commerce
Environmental cost	Yield loss for zero wane allowance	Softwood: 5% to 8% Hardwood: 18% to 30%	Kuenzi (2002) Steele (1984)
	Hardwood pallet lumber cost / bf	$0.34	Phone survey 2/15/2006
	Softwood pallet lumber cost / bf	$0.19	Phone survey 2/15/2006
	Board footage per standard manufactured pallet	20	NWPCA
	Ratio of hardwood/softwood pallets produced	2:1	NWPCA

Scenario 1 (EU-Only) – Bark-free pallets for EU-export use only

Under this scenario, the cost of producing the requisite number of bark-free pallets for shipment of U.S. products solely to the EU was examined. Pallets produced for domestic consumption would still be allowed to contain occurrences of remnant bark.

Scenario 2 (Universal) – All U.S. pallet production is forced to conform to bark-free standards over the determined transition period

This projected scenario is based on potential universal acceptance of the bark-free standard, and pallet customers' preference to avoid separate inventories of European and domestic-use-only pallets.

Scenario 3 (Replacement) – Wood pallets suffer complete market replacement by alternative shipping platform

This scenario is considered possible because of potential problems that could be incurred at port inspections due to complications of enforcement of the bark-free standard. Since the product value of two major product sectors (high tech and pharmaceuticals/chemicals) is very high relative to the cost of either wood or plastic pallets, it is likely that customers will switch to the more costly plastic platform to avoid detainment or return of product shipments. The relative product value of these sectors is demonstrated in **Figure 1**. Even though these two sectors represent a large percentage of the product value of U.S. exports to the EU, they represent a smaller portion of the pallet usage, resulting in a much higher product value to pallet cost ratio.

One of the first issues to be considered was the terminology used to describe the condition of the targeted pallets. The common terminology centered on "debarked" pallets, or presumably, pallets that had been manufactured from lumber produced from debarked logs. Therefore, much of the cost speculation relegated the problem to only those pallet producers who were using lumber from logs that had not been debarked. Therefore, a common misconception that had arisen in early consideration of the issue was that the total cost was simply the cost incurred by the 15 to 20 percent of the U.S. sawmills operating without debarking equipment (USNR 2005).

Sampling of the representative pallets illustrated in **Figure 3**, however, demonstrated that considerable bark occurrences are also found on "debarked" pallets, due to incomplete efficacy of debarking technology (**Figs. 5a and 5b**) and the ubiquitous presence of other types of barky characteristics of wood (Ray and Deomano 2007). Since significant bark occurrences were found whether the lumber used had been produced from debarked logs or not, the investigation of cost related to eliminating bark from the manufactured pallets turned to examination of sorting techniques versus sawing to clear lumber, or a combination of both.

Figure 5a. Debarked softwood logs from a large sawmill in the U.S. Pacific Northwest.

Figure 5b. Bark remnant on hardwood pallet cants in the Northeastern United States.

The realistic options, then, to produce bark-free pallets and containers for export are to sort out bark, and/or to saw to clear surfaces or purchase defect-free lumber. The first option will be referred to as the sorting option; the second options is referred to as yield-reduction options.

Calculation of Capital Cost Under Different Sorting Options

The first cost component modeled was capital cost under different assumptions of capital investment by pallet companies for sortation machinery and solutions. These could include pallet mills sorting out bark or barky defects at one of four stages: in pallet cants, in pallet lumber, in pallet components, or in the pallets themselves. While the actual investment by pallet mills could and would vary widely, we sought to quantify four credible levels of investment and have them act as a representative sample of the actual investment scenario population.

- *Level 1 – $100,000 investment:* this would approximately represent an automatic pallet component sorting process, with computer scanning of pallet stock for barky defect and multiple stacking stations;
- *Level 2 – $50,000 investment:* this would approximately represent automated sorting of manufactured pallets, including a manually operated grading station with pallet-inverter table, and a diverter to dedicated stackers for barky and bark-free pallets;
- *Level 3 – $10,000 investment:* this would approximately represent an in-house process engineering solution to ease manual sortation of the selected type; and

- *Level 4 – $0 investment:* this would approximately represent an additional-labor only solution, where sorting is done manually without capital investment.

Calculated capital costs per export pallet are shown in **Table 2** (Scenario 1, EU-Only) and **Table 3** (Scenario 2, Universal). The investment level per mill is explained above. Based on interviews of pallet industry leaders, the number of mills at each investment category for the EU-Only scenario was calculated based on the assumption that two-thirds of the existing pallet mills would make no specific capital investment in producing bark-free pallets within a 10-year time frame, and that the remaining one-third would approach bark-free production strategies at the following percentages: 15 percent of the bark-free investing participants (5% of all pallet mills) would invest at Level 1; 35 percent of the bark-free investing participants (12% of all pallet mills) would invest at Level 2; and the remaining 50 percent of the bark-free investing participants (17% of all pallet mills) would invest at Level 3. It was also assumed that 20 percent of all pallet mills that did not make specific capital investment to produce bark-free pallets (13% of all pallet mills) would still attempt to make bark-free pallets for the EU market, using manual sorting techniques only. The number of mills investing in each of these scenarios was increased incrementally over the bark-free transition period as shown in Equation [**1**]. The total investment was then accumulated as indicated by the rate and investment level of the investing mills.

Table 2. Capital costs of bark-free pallets at differing levels of capital investment for Scenario 1, EU-Only.

	Level 1	**Level 2**	**Level 3**	**Level 4**	**10-year totals**
Investment per mill	$100,000	$50,000	$10,000	$0	
# of mills (%)	147 (5%)	344 (12%)	491 (17%)	393 (13%)	1,376 (47%)
Total investment	$14,740,000	$17,196,667	$4,913,333	$0	$36,850,000
# export pallets produced per plant/yr	203,528	65,420	30,529	19,081	
# export pallets produced	165 million	124 million	83 million	41 million	412 million
Capital cost per export pallet	$0.05	$0.08	$0.03	$0.00	$0.05

The number of bark-free pallets produced in both **Tables 2 and 3** was calculated as a function of the total number of pallets required, expected productivity of each type of pallet operation at each level of investment, and expected number of operations that will make each level of investment each year of the transition period (Equation [**1**]).

$$E(\#\ \text{pallets})_i = \sum_j \frac{\text{Total EU pallets/yr} \times A_i}{\#\ \text{of plants}_i} \qquad [1]$$

where:

Total EU pallets/yr = 75 million (from Molina-Murillo et al. 2005)
i = category of investment level (100,000–50,000–10,000–0)
j = year of transition period (1,2,3,...,10)
A = assumed percentage of demand filled by plants in each category (40%, 30%, 20%, and 10% for Scenario 1; 30%, 30%, 35%, and 5% for Scenario 2)

The resulting calculation shows that in Scenario 1, EU-Only, a total of 412 million bark-free pallets will be produced over a 10-year transition period, far fewer than the current demand rate of 750 million for 10 years. This occurs because less than full production of bark-free pallets is achieved until the full number of companies required to fill production make the bark-free process transition. For the model developed, it was assumed that this full demand is not met until the tenth year of the transition, when the bark-free pallet production system should hit steady-state. This expectation is based on the current conversion rate of the pallet industry to the heat-treating process required by ISPM 15; at this point in time, 5 years after the implementation of the regulation, significant production conversion potential and market demand growth for heat-treated pallets are still seen. The assumption was made that another 5 years of conversion and demand growth will stabilize the supply and demand for heat-treated pallets; therefore, it was assumed that a similar 10-year period will be required for an implemented "bark-free" policy to reach steady-state.

A different distribution of bark-free pallet supply resulting in higher per pallet investment costs occurs under the assumptions of Scenario 2, Universal (**Table 3**). In this scenario, since all pallet producers are gradually forced into bark-free pallet production, the export to EU market is filled more evenly across the industry. For this study it was assumed that under this universal bark-free scenario, 50 percent of the producers will respond at the Level 3 – $10,000 investment option, and that at the assumed rate of production under this option these producers will capture 36 percent of the EU export market, or 248 million of the 683 million bark-free pallets produced. The impact of this is that the producers opting for the higher levels of investment will realize lower returns on those investments as they capture significantly less of the market share per mill. Note that even with a universal requirement of a bark-free specification, the wood pallet industry is not likely to be able to convert fast enough to fill the entire 10-year demand; this short-fall will occur in the first 5 years, after which the supply of bark-free pallets will outstrip the EU demand.

Table 3. Capital costs of bark-free pallets at differing levels of capital investment for Scenario 2, Universal.

	Level 1	**Level 2**	**Level 3**	**Level 4**	**10-year totals**
Investment per mill	$100,000	$50,000	$10,000	$0	
# of mills (%)	295 (10%)	737 (25%)	1,474 (50%)	442 (15%)	2,948 (100%)
Total investment	$29,480,000	$36,850,000	$14,740,000	$0	$81,070,000
# Export pallets produced per plant/yr	76,323	30,529	17,809	8,480	
# Export pallets produced	124 million	265 million	248 million	46 million	683 million
Capital cost per export pallet	$0.13	$0.16	$0.06	$0.00	$0.12

Yield Loss Calculations

The sorting options considered result in no net loss of lumber yield if the bark-free requirement is applied to export pallets only (Scenario 1, EU-Only) because the barky components can be utilized in non-export production; thus, no increase in pallet raw material cost is assigned. If the bark-free requirement is extended to all North American production (Scenario 2, Universal), however, then the barky lumber or components that are sorted out are in fact recorded as yield loss since they cannot be used in any pallet product. The yield-reduction alternatives were evaluated at levels of yield loss as randomly simulated between the yield-loss ranges produced by studies performed by researchers at Oregon State University for softwood (5% to 8%) (Kuenzi 2002) and the U.S. Forest Service for hardwood (18% to 30%) (Steele 1984). Both studies evaluated the yield differential between sawing to allowable wane versus sawing to squared-edge lumber, a differential that, in effect, is the same as sawing to squared-edge to eliminate all remnant bark. These estimates do not capture defect due to barky defect other than bark in wane and are made on grade lumber; lower-grade pallet stock would lose proportionately more, but lacking study data, grade lumber data was used to be conservative. In addition, Araman et al. (2003) found that hardwood pallet cants, which theoretically are bark-free, contained anywhere from 2.28 to 4.92 percent unsound defect on average, depending on species. This produces an additional yield loss beyond the estimates used in this simulation.

Modeling these yield loss relationships allows an understanding of price increase relationships for combinations of yield loss and the resulting price increase. For reference, Tait (2005) stated that based on the common implementation of bark-free pallet achievement in the United Kingdom, the requirement typically adds 10 to 15 percent to the lumber raw material cost of the “bark-free” pallet. Any realistic estimation of the actual lumber impact a specific manufacturer might realize would depend on the type of pallet being manufactured and the region in which it is being manufactured. To demonstrate the potential impact for manufacturers that currently have a $3 to $10 per pallet lumber cost, **Figure 6** was produced. **Figure 6** illustrates the differential impact on raw material prices for typical hardwood and softwood pallets of 20 board feet if a 10-percent increase in hardwood lumber prices and a 2.5-percent increase in softwood lumber prices occurred in combination with the expected yield loss for a bark-free requirement. As the Figure shows, hardwood pallet producers are likely to realize much higher impact on their lumber cost under the conditions of Scenario 2, Universal bark free than their softwood competitors.

Figure 6. Bark-free impact on lumber cost for a typical pallet of 20 board feet for base raw material costs of $3 to $10 (US) per pallet. Percentages indicate % cost increase for lumber above the producer’s current base raw material cost per pallet.

Lumber Price Increase Calculations

The actual expected yield loss should exert considerable influence on lumber demand and prices, and may in fact result in much higher price increases than the assumptions of 10 percent and 2.5 percent made in **Figure 6**. Taking into account the possibility of more available low-grade lumber due to a changing forest composition, the range of lumber price increase used in Scenario 2 modeling includes 0 percent as its lower threshold. Using a randomly simulated price range that is based on a standard deviation of one-third the mean value, the simulation produces random price events normally distributed between 0 and three standard deviations above the mean price. Based on interviews of lumber producers in the study, the historical volatility of lumber prices, and the increasing competition of other wood products for the lower-grade wood, 33 percent and 7.5 percent were used for hardwood and softwood, respectively, as the mean lumber price increases in Scenario 2’s modeling effort. Therefore, the represented price increase ranges for simulation of the expected market conditions created by Scenario 2, Universal, exclusive of yield loss, follow a normal distribution between 0 and 66 percent for hardwood, and 0 and 15 percent for softwood.

Lumber price increases associated with simulated yield-loss were in turn simulated based on distribution estimates of historical trends, the relative size of pallet production to total hardwood and softwood lumber consumption, and interviews with persons familiar with lumber market price movements. Based on these simulations, the raw material cost component of 100 replications of Scenario 2 showed average increases of 57 percent for hardwood and 14 percent for softwood (**Fig. 7**). These raw material cost increases under Scenario 2 are captured in the final calculations under environmental costs, as discussed later in the paper. Results reflected in **Figure 7** use price increase assumptions of N(0.33, 0.1) for hardwood, N(0.075, 0.025) for softwood, and yield loss ranges of U(0.18 to 0.30) for hardwood and U(0.05 to 0.08) for softwood. The function used to generate each of the points in **Figure 5** is given in Equation [**2**].

$$E(\text{\% price increase})_i = \frac{I_i}{B_i} = \frac{(B_i * L_i) + (RND[LnvN(\mu_s, \sigma_s^2)])_i}{F_i * (RND[U(Pu, Pl)]/1000)_i} \qquad [2]$$

where:

$E(\text{\% price increase})_i$ = Expected value of % lumber price increase per pallet for simulated point i and

I_i = lumber price increase per pallet, for simulated point i, i = 1 to 100

B_i = baseline lumber price, per pallet, for simulated point i, i = 1 to 100

μ_s = mean price increase for simulated point i, i = 1 to 100; s = 0.33 for hardwood, s = 0.075 for softwood

σ^2_s = standard deviation price increase for simulated point i, i = 1 to 100; s = 0.1 for hardwood, s = 0.025 for softwood

F_i = bf per pallet for simulated point I (set at constant of 20 bf for this exercise)

Pu = Upper limit of likely pallet lumber price range, per mbf (500 for this exercise)

Pl = Lower limit of likely pallet lumber price range, per mbf (150 for this exercise)

L_i = yield loss for simulated point i, i = 1 to 100; U[0.18, 0.30] for hardwood, U[0.05, 0.08] for softwood.

Figure 7. Simulated pallet lumber cost increases under Scenario 2.

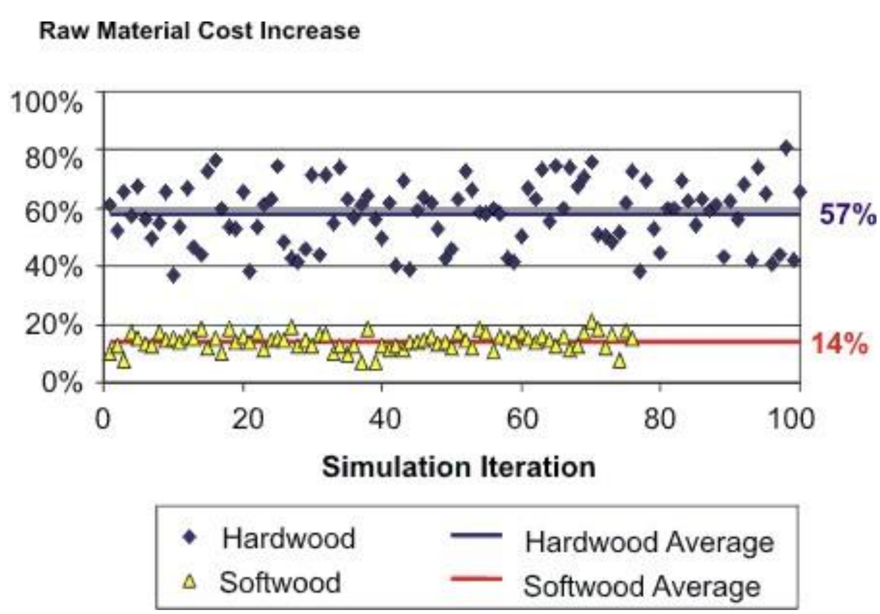


Figure 7 simulations represent the potential raw material cost impact of yield loss and estimated lumber price increase on a typical lumber pallet of 20 board feet under Scenario 2. No raw material cost impact is assumed for Scenario 1 since the sorted-out pallets or components can be used in domestic shipments.

Labor and Administration Costs

A second area of modeling required the labor and administration costs to be estimated for each of the scenarios. Higher capital investment results in lower labor costs per pallet, since capital effectively replaces labor. In this analysis, the labor factor was used to represent decreased productivity in scenarios requiring additional manual sortation. For example, companies that invested $0 in capital investment for sortation were charged with six additional employees. It is possible that the required sortation could be accomplished with fewer than six additional employees, but this would come at the cost of productivity, producing a similar net result. The resulting labor and administration cost calculations for Scenario 1 are shown in **Table 4**, based on the labor cost data contained in **Table 1**. Similar methodology was followed to calculate these costs for Scenario 2. Administrative costs relative to carrying an additional pallet category inventory (in this case, bark-free pallets for export) were estimated by Ray et al. (2006) as $0.50 per pallet and applied uniformly across all levels of Scenario 1 and Scenario 2.

Table 4. Scenario 1 (EU-Only) labor and administration (L&A) costs associated with bark-free requirements on pallets for export of goods to the European Union.

	Level 1	Level 2	Level 3	Level 4	10-year totals
# of additional employees per mill	1	2	3	6	4,668
# of mills	147	344	491	393	1,375
Additional labor cost	$26.6 million	$124.2 million	$266.1 million	$425.7 million	$842.5 million
Labor/pallet	$0.16	$1.00	$3.22	$10.32	
Administration cost (export only scenario)	$0.50/pallet	$0.50/pallet	$0.50/pallet	$0.50/pallet	$206.3 million
# export pallets produced	165 million	124 million	83 million	41 million	413 million
L&A/pallet	$0.66	$1.50	$3.72	$10.82	$2.54
Total 10-year labor and admin. cost	$109.1 million	$186.0 million	$307.3 million	$446.3 million	$1.05 billion

Environmental Cost

Finally, it was determined that an examination of the potential environmental cost of the bark-free pallet proposition was in order. Many proponents of the proposed rule are more concerned with the environmental outcomes of phytosanitary efforts than associated economic costs. In previous sections of this paper, the calculation methodology of estimating the potential economic cost of the bark-free requirement were demonstrated, based on the yield loss incurred by the higher lumber grade specifications required to fulfill the bark-free requirement. In that discussion, the "environmental" impact incurred under these same requirements was ignored. That is, the resulting yield loss would result in many more trees being harvested to produce the same number of wood pallets and containers.

But, the intrinsic value (or loss of value) from the action of harvesting more trees is open to debate and can be calculated many ways depending on the analyst's objectives. To remain conservative, the environmental cost was calculated based on a "flesh-value" calculation as explained by Dasgupta (1996).

Dasgupta points out that even though environmental resources are often cited as having intrinsic value above their actual use-value, the use-value methodology provides us with biased estimates of accounting prices, and this bias is sometimes useful in analysis of the resulting model coefficients. He noted that Spence (1974) took the accounting price of blue whales to be the market value of their flesh, and showed that under a wide range of plausible parametric conditions, it would be most profitable commercially for the international whaling industry to agree to a moratorium until the desired long-run population size were reached, and for the industry to subsequently harvest the creatures at a rate equal to the population's (optimal) sustainable yield. Likewise, if bark-free pallet requirements can be justified after the extra wood-value is taken into account, any specific recommendation would, obviously, be reinforced if the intrinsic worth of the phytosanitary risk reduction or the increased level of forest harvesting were added, even if unknown.

The calculation of this environmental cost, in terms of extra lumber consumption, is relatively straightforward. For Scenario 1, it is unrealistic to assume any environmental costs, under the expectation that the "barky" pallets will be utilized in domestic trade. Thus, no environmental cost is (theoretically) incurred in the case that bark-free pallets are required in trade solely with the European Union.

The "Universal" Scenario 2, however, requires that all pallets are eventually manufactured bark-free; thus, the "barky" wood is lost to the global trade system, and the resulting yield loss is replaced by defect-free wood from additional lumber production. Using an assumed future 10-year U.S. production total of 4.5 billion pallets, at 20 board feet per pallet, at the average yield loss rates of **Table 1**, and at the 2:1 ratio of hardwood to softwood pallets, it can be calculated that an additional 14.4 billion board feet of hardwood lumber, and an additional 1.95 billion board feet of softwood lumber, for a total of approximately 16 billion board feet, will be consumed to achieve bark-free pallet production under Scenario 2. Using the assumption of 160 board feet of lumber per 15-inch diameter at breast height (dbh) tree containing two 16-foot logs (Wenger 1984), an estimated 100 million additional trees would be harvested in the United States over 10 years in meeting the bark-free requirements of the proposed regulation. The cost of this additional lumber consumption is then used in the final calculation of the expected value of Scenario 2. Following the logic of Dasgupta (1996) and Spence (1974), the actual "economic" cost is based strictly on the calculated value of the additional lumber and its impact on the market. Thus, the "environmental cost" used in the analysis is merely stated in terms of this additional footage of lumber, and the intrinsic value of the additional harvesting of 100 million trees as required for this option is left out of the economic calculations.

Likewise, the environmental cost is assigned monetary value in Scenario 3, the "Replacement" scenario, only through the raw material costs incurred (for alternative raw material) and saved (for elimination of wood use). Under this scenario, wood is phased out of pallet and container use for alternative raw materials, thus producing a theoretical environmental "gain" in the amount of the lumber not used for pallet production. A comprehensive valuation of environmental cost of this scenario, however, would necessarily include a calculation of the environmental "costs" of the alternative material used in the replacement of the wood, whether it be engineered wood, paper, steel, or plastic. These calculations, while beyond the scope of the current study, are ripe ground for future research.

Results and Discussion

Scenario 1 – EU-Only

Figure 8 illustrates the expected annual costs of Scenario 1 for each year over a 10-year transition period. As demonstrated, labor and administration costs far outweigh the capital costs of producing bark-free pallets. The accumulated total of these costs for the 10-year period is $1.08 billion, comprised of

$1.05 billion in labor and administration costs, and $36.85 million in capital costs. After this period, the additional cost of bark-free pallet production to maintain a steady-state annual cost is expected to be around $200 million per year. These numbers result in an average per-pallet cost increase of $2.69 for each of the 412.5 million bark-free export pallets produced over the 10-year transition period.

Figure 8. Scenario 1 annual costs of U.S. bark-free pallet production.

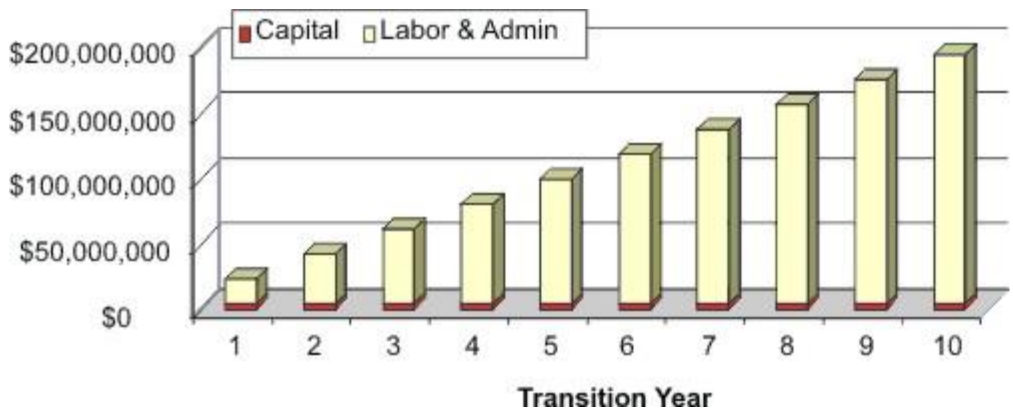
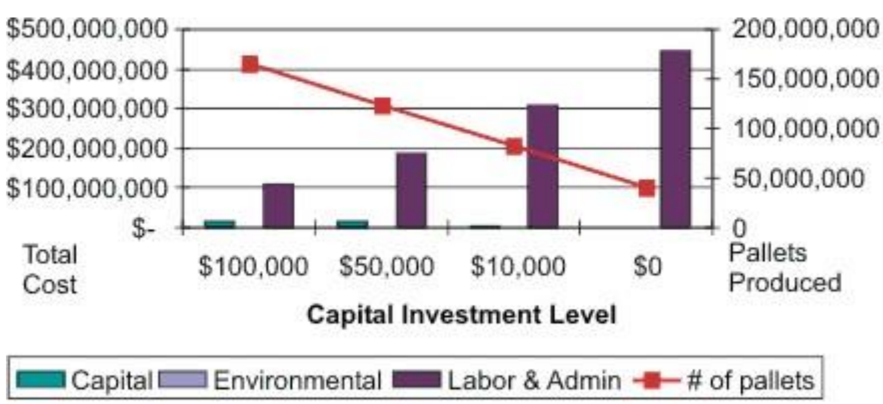


Figure 9 illustrates that these costs impact companies inversely to the amount invested in capital expenditure. Perhaps one unexpected outcome of the bark-free requirement is that smaller, less capitalized pallet companies will incur proportionately much more of the total cost of the bark-free regulation as they struggle to remove barky defects through much more manual labor and its associated costs and decreases to productivity.

Figure 9. Demonstration of the impact of investment level on individual cost variables, Scenario 1.



Scenario 2 – "Universal" requirement of bark-free pallets for all trade

Figure 10 illustrates the expected annual costs for Scenario 2 for each year over a 10-year transition period. Under this scenario, the environmental cost due to increased lumber consumption to replace all the sorted and disposed-of bark occurrences dwarfs all of the other costs. The accumulated total of these costs for the 10-year period is $14.2 billion comprised of $12.2 billion in raw material costs, $1.9 billion in labor and administration costs, and $81 million in capital costs. After this period, the cost of bark-free pallet production to maintain a steady-state annual cost is expected to be around $2.5 to $3 billion per year. These numbers result in a total per-pallet cost increase of $3.15 for each of the bark-free pallets produced, or, if allocating the total cost to the export pallets only, $20.77 per bark-free export pallet.

Figure 10. Scenario 2 annual costs of U.S. bark-free pallet production.

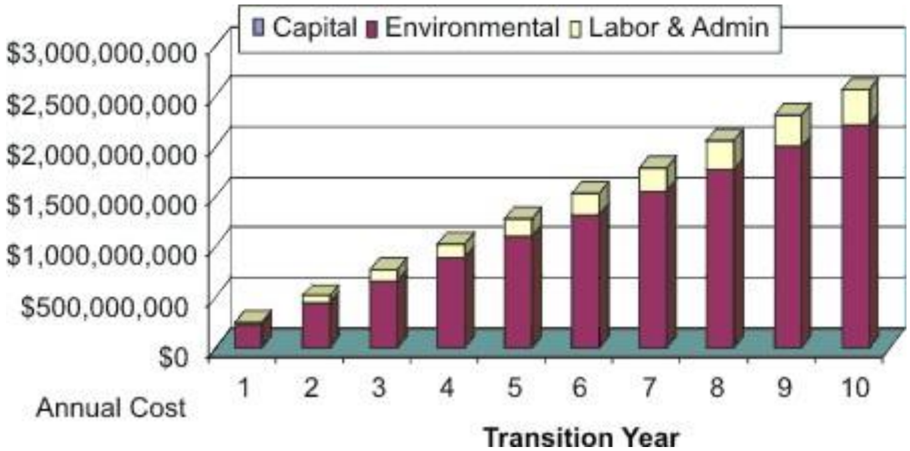
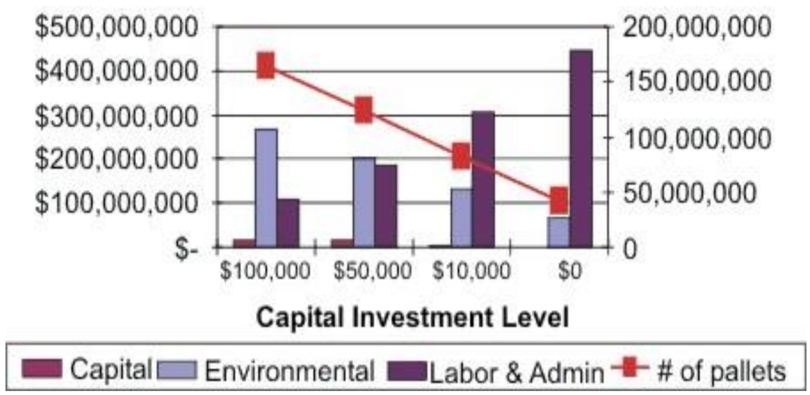


Figure 11 illustrates again, as did **Figure 9**, that these costs impact companies inversely to the amount invested in capital expenditure. In addition, **Figure 11** also demonstrates how those companies that are able to make capital investments generate higher raw material costs, due to higher production, but their number of bark-free pallets produced, and therefore, their total cost per pallet produced, is less than the non-investing companies.

Figure 11. Demonstration of the impact of investment level on individual cost variables, Scenario 2, including projected lumber consumption as environmental cost.



Scenario 3 – Replacement Scenario: Wood pallets suffer complete market replacement by alternative shipping platforms

Table 5 presents the logic of Scenario 3, one in which plastic pallet production displaces solid wood pallets in international trade. Considering first the potential number of pallets that will be lost to plastic pallet alternatives, the high-value product sectors will most likely be assumed to switch to the alternative system. Assuming that these product sectors consume anywhere between 25 percent and 60 percent of the export pallets gives us an expected value of 147 million pallets per year that will be lost by the wood pallet producers. This assumption has a high probability of occurrence because of the high product value to pallet cost ratio.

Table 5. Calculated cost of Scenario 3, total product replacement of wood export pallets by plastic pallets.

Variable	Units	10-year cost
Product $ impact based on potential market share loss	85% to 92% of the export business (25% to 60% of the pallets used)	Product value of $757 to $820 b 84 to 210 (147) mm pallets
Cost of replacement platform	50% one-way plastic pallets @ $12 to $35/pallet * 25% increase due to volume price pressure 50% multi-use or custom plastic @ $55 to $80/pallet * 10% increase	Average product value of $5,364 per pallet for these sectors (Plastic pallet prices are 0.3% to 1.6% of average product value)
Pallet replacement costs by high-end users (one-way)	0.12 to 0.30 * 35 million @ 15 to $43.75/pallet price	4.2 to 10.5 million pallets/yr $63 to $459.4 million $261.2 mm * 10 = $2.612 b
Pallet replacement costs by high-end users (multi-use)	0.12 to 0.30 * 35 million @ $60 to $88/pallet price	4.2 to 10.5 million pallets/yr $252 million to $924 million $588 mm * 10 = $5.88 b
Capital costs	$250,000 to $400,000 investment per mold * 2,000 molds	$500 to $800 million = $650 million
Environmental savings of lumber – export only	98 mm hw pallets * 20 bf/pallet * 0.34/bf + 49 mm sw pallets * 20 bf/pallet * 0.19/bf	$853 million
Total cost estimate: Scenario 3	$2.612 b + $5.88 b + $650 mm – $853 million over 147 million plastic replacement pallets	$8,289,000,000 $56.38/pallet

The average product value per pallet of $5,364 is calculated as the total product value (roughly $790 billion) divided by 147 million pallets. The expected cost of the plastic pallets, taking into account probable price increases of 25 percent (one-way) and 10 percent (multi-use) for increase in demand and rising cost of plastic (Stratis 2006), results in plastic pallets that range anywhere from $15 to $88 each. These apparently high pallet costs still only represent 0.3 to 1.6 percent of the average product value, which, when weighed against the cash-flow risk of potential product quarantine at ports, is a minor cost that will likely be taken by these high-end customers upon one or more reported major quarantine episodes. It should be noted that the 147 million plastic pallets under calculation leave us far short of the estimated 750 million demand for export pallets; in fact, the 412 million bark-free wood pallets will still have an export market, so the $1.12 billion additional cost to achieve these 412 million pallets under Scenario 1 could also be included. The additional cost has been left out as an inconsequential additional complexity to the demonstration under development.

The cost of these plastic replacement pallets, then, is calculated as $8.492 billion ($2.612 billion for the estimated 50% one-way pallets, and $5.88 billion for the other 50% multi-use pallets). Added to this cost is a conservative $650 million for individual pallet molds that producers will have made for their needs. Finally, to account for the difference in cost between these plastic pallets and the wood ones they will replace, the environmental savings are subtracted, in terms of wood not used, which is calculated as $853 million. (Some argue that the environmental cost of the plastic pallets is actually higher than the wood; but this is left for another investigation.) These calculations leave us with a total cost increase estimate of $8.289 billion, or $56.38 per export pallet.

Calculation of Expected Cost of All Three Scenarios

The expected cost of all three scenarios is calculated as the product of the cost of each scenario times its associated probability:

$$E(Cost) = \Sigma Cost_{(Scenarioi)} * P_{(Scenarioi)} \quad [3]$$

where:

$i = 1$ to 3.

Since the expected cost of each scenario has been calculated, what remains is the calculation of the expected probabilities of each scenario. This study remained true to economic logic; that is, the probability of something occurring is inversely related to its cost, all other things being equal (Equation [**4**]).

$$P(Scenario)_i = \text{Standardized Cost } (Scenario)_i * 1/\Sigma \text{ Standardized Costs (All Scenarios)}$$

where:

$\text{Standardized Cost } (Scenario)_i = [Cost\ (Scenario)_3/Cost(Scenario)_i]*Cost(Scenario)_3$
and
$i = 1$ to 3. [**4**]

Application of Equation [**4**] results in calculated probabilities of 0.828, 0.064, and 0.108 for Scenarios 1, 2, and 3, respectively. Substitution of these calculated probabilities into Equation [**3**] with their related costs results in an expected cost of bark-free pallet regulation of $2.697 billion over a 10-year transition period (**Table 6**).

Table 6. Summary table of key calculations in this analysis.

Variable	10-year cost by scenario			Total cost
	S1, EU-only	S2, Universal	S3, Replacement	
Capital ($)	36,850,000	51,590,000	650,000,000	--
Labor & admin ($) (S1 &S2) replacement ($)(S3)	1,048,755,000	1,937,743,000	8,492,000,000	--
Environmental ($)	0	12,164,404,000	(853,000,000)	--
Total scenario cost ($)	1,085,605,000	14,153,737,000	8,289,000,000	--
Number of U.S. mills affected	1,375	2,948	n/a	--
Cost per affected mill ($)	789,530	4,801,132	n/a	--
Probability (%)	82.8	6.4	10.8	--
Expected cost ($)	--	--	--	2,696,776,000

Limitations

Economic Transaction Costs

One potential area of cost increase for the bark-free proposition is that of economic transaction costs. Program administration, port enforcement, unintended consequences, and the cultural costs of incomplete information and economic "opportunism" are now routinely being recognized by economists as "hidden" costs that are extremely hard to quantify, yet quite real (Rao 2003). One possibility for evaluation of comparative efficiency of governing structures is based on direct assessment of costs for transaction in different organizations. Often, however, that possibility is restricted due to: difficulties measuring the absolute level of transaction costs; opposite dynamics of different items of costs in various organizations; realization of complex (and interlinked) rather than pure modes in transitional trade; and alternative forms of bureaucratic organization, eliminating the basis for fair comparison (Bachev 2004).

It is important to assess the impact of a new institutional restriction (a new EU standard giving new property rights arrangement for trading partners) – namely introduction of bark-free requirement by the EU. The assumption applied is that new institutional modernization will change the traditional costs structure in U.S. industry, increasing both production and transaction costs. If transaction cost estimates were included in this modeling, the goal would be to define the level of associated changes in levels of different costs (total costs) in the three postulated scenarios.

Based on the poorly defined definition of the proposed requirement, the demonstrable significant error rate in program inspection and enforcement, the uncertainty concerning how the programs will be administered, and the likelihood of graft occurring to circumvent the proposed rule in certain cultures, the authors believe the actual economic transaction costs will be substantial and different for each of the three scenarios. But, lack of adequate data precludes their inclusion in this study. More work is warranted in this area.

Point Estimates and Author Estimates of Baseline Data

The data cited in **Table 1** forms the foundation of this study. In all cases, it represents a best estimate for each variable from all of the sources cited in the study. Pallet industry data is scarce; individual producers rarely keep accurate production data, pallet customers do not typically share their purchasing data, and government data are usually interpolated from macro-level trade estimates. A few countries have better pallet industry data than the United States; most do not. The authors believe the sources cited in **Table 1** are the most reliable authorities and have chosen their figures accordingly.

As future global trade policies with respect to pallet and container usage become more controversial, the precision of cost estimates for differing policy scenarios may become more critical. If this in fact happens, future analyses must be built on more precise data, data which does not currently exist. A framework for better pallet industry data collection and maintenance would certainly improve future global trade and environmental policy formulation.

Conclusions

Policy Implications

The *expected* economic cost to U.S. pallet producers of this proposed EU bark-free requirement is $2.7 billion in total, or $915, 875 per pallet producer on average, over the 10 years it would take to reach full implementation of the program. After the 10-year market equilibrium has been reach, the expected economic cost will total around $600 million per year, or just over $200,000 average per year for each of the 2,948 U.S. pallet producers.

The *minimum* 10-year cost of the requirement to U.S. producers, as calculated under the assumptions of an EU-only implementation, would be just under $1.1 billion, or $789,530 average per participating producer, after which the total cost to the 1,375 participating export-pallet producers will be approximately $200 million per year, an average of $145,000 per producer per year. The *maximum* 10-year cost to U.S. producers, as calculated under the assumptions of a universal implementation, would be more than $14 billion ($4.8 million average per producer) over the initial 10-year transition period and $2.5 to $3 billion ($850,000 to $1 million average per producer) for each of the 2,948 U.S. pallet producers per year thereafter.

The environmental impact of this requirement, if the bark-free standard is adopted for EU trade only, would be negligible since the pallets or pallet components sorted out due to bark could still be used in U.S. continental trade. The environmental impact of this requirement, if the bark-free standard is adopted universally, would be an additional 16 billion board feet of lumber, or approximately 100 million additional trees, consumed over these 10 years to achieve the same level of U.S. pallet production currently achieved without the bark-free restrictions. This projected environmental impact reflects only U.S. production figures and would be many times larger when the entire world production of wood packaging materials is considered.

The economic impact of a regulatory action is most accurately measured over the entire transitional period of the regulation. The transitional simulation in this study illustrates that the annual cost of the first year of the regulation is only a small fraction of the annual cost that will be realized by the tenth year, when it might be expected to attain a steady-state annual cost. It is, therefore, important for the international bodies responsible for the regulation to recognize the full cost of the regulation as it is realized at its steady-state cost, as estimated from the last year of the transition.

In all three scenarios examined, the immediate demand for bark-free pallets will far out-strip the immediate supply. In all three scenarios, the cumulative supply of bark-free pallets is not likely to catch the cumulative demand even by the end of the transition period. This situation will create conditions of instability in pallet markets, causing a likely increase in pallet prices, and creating potential problems in program administration, port enforcement, economic "opportunism", and other unintended consequences.

Management Implications

Labor and administration costs, environmental costs, and economic transaction costs to convert to a bark-free production system far outweigh any necessary capital expenditure by the wood pallet industry. Therefore, a potential outcome of the bark-free requirement is that smaller, less capitalized pallet companies will incur proportionately much more of the total cost of the bark-free regulation as they struggle to remove barky defects through a higher level of manual labor, with its associated costs and decreases to productivity. On a global scale, this might imply that small local pallet producers, both in industrialized and in developing countries, will be the most disadvantaged competitors under the requirement of bark-free pallet production.

While the advantage in the EU-only and Replacement scenarios goes to those producers who have the resources to invest significant capital, those same producers will realize lower returns on those investments in the Universal scenario, since they will capture significantly less of the market share per mill if the entire pallet industry is forced into compliance.

Finally, the biggest potential impact comes in the form of a product replacement threat to the wood packaging industry. The implication that pallets with remnant bark or barky defects, even though properly treated to ISPM standards, carry greater phytosanitary risks to the world's forests is one that can be easily exaggerated, misconstrued, and improperly enforced, while not easy to scientifically prove or disprove. This condition will most certainly be exploited by wood packaging's competitors, and the resulting accumulation of misinformation and disinformation could cost the wood packaging industry its most profitable product mix component and drive a large segment of the industry out of business. This situation, represented by Scenario 3 of this analysis, carries a transitional cost of $8.3 billion to U.S. pallet producers and pallet customers, not counting the costs related to displaced wood pallet industry workers or the environmental impact of the resulting increase in demand for petroleum-based plastic feed stocks.

Literature Cited

Araman, P.A., M.F. Winn, M.F. Kabir, X. Torcheux, and G. Loizeaud. 2003. Unsound defect volume in hardwood pallet cants. Forest Prod. J. 53(2): 45-49.

Bachev, H. 2004. Efficiency of agrarian organizations. *In*: Farm Management and Rural Planning. Kyushu University, Fukuoka, Japan. 5:135-150.

Brindley, E. and C. Brindley. 2004. Pallet material costs climb: Pallet prices can't hold pat for long. Pallet Profile Weekly, Special Report. Industrial Reporting, Ashland, VA. 4 pp.

Bush, R.J., R.A. Araman, and V.S. Reddy. 1997. Pallet recycling and material substitution: How will hardwood markets be affected? *In*: Proceedings Eastern Hardwoods: Resources, Technologies, and Markets. J. Wiedenbeck, Ed. Forest Products Society, Madison, WI pp. 67-73.

Christoforo, J.C., R.J. Bush, and W.G. Luppold. 1994. A profile of the U.S. pallet and container industry. Forest Prod. J. 44(2): 9-14.

Dasgupta. P. 1996. The economics of the environment. *In*: Proceedings of the British Academy, 90:165-221. www.britac.ac.uk/pubs/src/keynes95/01conten.html.

European Union (EU). 2004. Commission Directive 2004/102/EC. Official Journal of the European Union. http://europa.eu.int/comm/food/plant/organisms/imports/special_en.htm.

European Union (EU). 2006. An overview of EU rules on wood packaging material. http://europa.eu.int/comm/food/plant/organisms/imports/overview_eu_rules.pdf.

Fraser, R.F., W.W. Johnson, and P.R. Blankenhorn. 1990. A description of the 1986 pallet manufacturing industry in Pennsylvania. Forest Prod. J. 40(6): 43-47.

Haake, R.A., T.R. Petrice, P. Nzokou, and D.P. Kamdem. 2006. Do insects infest wood packing material with bark following heat treatment? 4th Meeting of the International Forestry Quarantine Research Group. Rome, IT. 3 pp.

Interim Commission on Phytosanitary Measures (ICPM). 2002. International Standards for Phytosanitary Measures Publication No. 15: Guidelines for Regulating Wood Packaging Material in International Trade. Secretariat of the International Plant Protection Convention, Food and Agriculture Organization of the United Nations, Rome, IT. 15 pp.

IFQRG. 2005. 3rd Meeting of the International Forestry Quarantine Research Group. Rome, IT. 11 pp. www.forestry-quarantine.org/Dec-2005-Report_e.pdf.

IFQRG. 2006. 4th Meeting of the International Forestry Quarantine Research Group. Rome, IT. 12 pp. www.forestry-quarantine.org/Oct06/CFIA_ACIA-IFQRG_Meeting_Report_Official.pdf.

IUFRO. 2006. Alien invasive species and international trade. International Union of Forestry Research Organizations, Working Group 7.03.12. Radom, Poland. www.forestresearch.gov.uk/fr/infd-6j7fhc.

IPPC. 2007. IPPC survey on bark of ISPM No. 15 marked wood packaging. International Plant Protection Convention. Posted on the International Phytosanitary Portal 1/26/2007. www.ippc.int/servlet/CDSServlet?status=ND0xNzE0NTEmNj1lbiYzMz0qJjM3PWtvcw~~.

Kuenzi, T. 2002. The effects of wane allowance, kerf, and target size reduction on sawmill optimization. Oregon State University, Corvallis, OR. 29 pp. www.lsize.com/ftp/literature/kuenzi_report.pdf.

Luppold, W. 1996. Structural changes in the central Appalachian hardwood sawmilling industry. Wood and Fiber Sci. 28(3): 346-355.

Luppold, W. 2003. Is the hardwood market entering a new era? Part II. Hardwood Market Report 81(42): 11-13.

Luppold, W. 2005. The number of hardwood sawmills continues to decrease – Is that bad? 2004: The Year at a Glance. Hardwood Market Report, Special Issue (Feb.). pp. 80-84.

McCurdy, D.R. and J.E. Phelps. 1996. The pallet industry in the United States: 1980, 1985, 1990, and 1995. Department of Forestry, Southern Illinois University at Carbondale, Carbondale, IL. 16 pp.

McCurdy, D.R., J.T. Ewers, F.H. Kung, and D.B. McKeever. 1988. A study of lumber use in pallets manufactured in the United States: 1982 and 1985. Forest Prod. J. 38(2): 11-15.

Michael, J.H. 1997. A characterization of the Texas pallet industry. Forest Prod. J. 47(2): 27-30.

Molina-Murillo, S., T. Smith, M. Reichenbach, and R. Smith. 2005. Impact of international phytosanitary standards on wood packaging materials end users: Pre-implementation assessment. Forest Prod. J. 55(9): 24-26.

Mumford, J.D. 2002. Economic issues related to quarantine in international trade. European Review of Agricultural Economics. 29(3): 329-348.

NWPCA. 2005a. Environmentalists are lobbying to eliminate wood packaging. Pallet Central (June). The National Wooden Pallet and Container Association, Alexandria, VA. p. 24.

NWPCA. 2005b. Wood packaging – A grassroots lobby success. Pallet Central (July-August). The National Wooden Pallet and Container Association, Alexandria, VA. p. 12.

NWPCA. 2006. NWPCA meets with top E.U. regulators to discuss next steps. Pallet Central (Feb.). The National Wooden Pallet and Container Association, Alexandria, VA. p. 1.

Parker, P.M. 2004. The world market for wood pallets, box pallets, and other load boards: A 2005 global trade perspective. INSEAD, France. The ICON Group, www.icongrouponline.com. 124 pp.

Pease, D.A., T. Blackman, and J.A. Sowle. 1996. 1996–97 North American Factbook. Miller Freeman, Inc., San Francisco, CA.

Portman, R. 2005. Official communication from the Executive Office of the President of the United States to Markos Kyprianou, Commissioner for Health and Consumer Protection, European Commission. 9/19/2005. Washington, DC. 2 pp.

Raballand, G. and E. Aldaz-Carroll. 2005. How do differing standards increase trade costs? The case of pallets. World Bank Policy Research Working Paper No. 3519. Available at SSRN: http://ssrn.com/abstract=665064.

Rao, P.K. 2003. The Economics of Transaction Costs. Palgrave-MacMillan, NY, NY. 197 pp.

Ray, C.D. 1998. Forest products industry applications of systems simulation. *In*: Proceedings of the 32nd International Particleboard/Composite Materials Symposium. Washington State University, Pullman, WA. pp. 89-93.

Ray, C.D. 2006. An examination of inspection and enforcement issues related to bark-free specifications for wood pallets and containers. IUFRO Working Party 7.03.12, "Alien Invasive Species and International Trade". Radom, Poland. http://woodpro.cas.psu.edu/IUFRO-Poland7-4re-record.ppt.

Ray, C.D. and E. Deomano. 2007. Bark occurrence in U.S. and Canadian wood pallets. Forest Prod. J. 57(3): 84-88.

Ray, C.D., J.H. Michael, and B.N. Scholnick. 2006. Supply-chain system costs of alternative grocery industry pallet systems. Forest Prod. J. 56(10): 52-57.

Reddy, V.S., R.J. Bush, M.S. Bumgardner, J.L. Chamberlain, and P.A. Araman. 1997. Wood use in the U.S. pallet and container industry: 1995. Virginia Polytechnic Institute and State University, Blacksburg, VA. 17 pp.

Scheerer, C.E., R.J. Bush, and C.D. West. 1996. The use of substitute material pallets for grocery distribution. Forest Prod. J. 46(2): 29-36.

Skog, K.E. and G. A. Nicholson. 2000. Carbon sequestration in wood and paper products. USDA Forest Service Gen. Tech. Rep. RMRS-GTR-59. pp. 79-88.

Smith, P.M. 1991. The Washington State wood pallet industry. Forest Prod. J. 41(5): 39-44.

Stratis. 2006. Estimation of plastic pallet price increases under mass replacement of wood pallets for export. Personal communication with Jay Skinner, Feb. 2006. Plastic Pallet Sales Manager, Stratis Pallets, Indianapolis, IN.

Spence, A.M. 1974. Blue whales and optimal control theory. *In*: Systems Approaches and Environmental Problems. H. Göttinger, Ed. Göttingen: Vandenhoek and Ruprecht.

Steele, P. 1984. Factors determining lumber recovery in sawmilling. USDA Forest Service, Forest Products Laboratory, Gen. Tech. Rept. FPL-39. 8 pp. www.fpl.fs.fed.us/documnts/fplgtr/fplgtr39.pdf.

Tait, P. 2005. Personal communication, 11-25-05. National Association of Pallet Distributors, UK.

USNR. 2005. Estimation of sawmills operating without debarking equipment, from USNR's database. Personal communication with Keith Fulmer, Sept. 2005. USNR Debarker Sales Manager. Hot Springs, AR.

Wenger, K.F., Ed. 1984. Forestry Handbook, 2nd ed. John Wiley & Sons, New York, NY. 1,335 pp.

White, M. and P. Hamner. 2005. Pallets move the world: The case for developing system-based designs for unit loads. Forest Prod. J. 55(3): 8-16.