Remilling of salvaged wood siding coated with lead-based paint. Part 2. Wood product yield

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Abstract

Many U.S. military buildings being targeted for removal contain large quantities of potentially reusable wood materials. In this study, we evaluated approximately 2180 m (7,152 ft) of painted Douglas-fir siding salvaged from U.S. Army barracks. Utilizing a conventional woodworking molder, we evaluated the feasibility of producing several standardized wood product profiles, including flooring, bevel siding, and paneling. Evaluation of visual quality followed by remanufacture of siding coated with lead-based paint indicated that valuable wood products could be produced from the salvaged siding; however, this value is dependent on several factors, including the original quality (grade) as well as the extent of damage (e.g., nail holes, splits, discoloration, decay, weathering). We conclude that wood siding salvaged from military buildings can be successfully remanufactured into value-added products. Tongue & groove (T&G) flooring is a promising product in particular since short pieces of siding can be utilized. As much as 50 percent of the weight of salvaged siding can be diverted from landfill disposal by remanufacturing into T&G flooring. In addition, the market value of T&G flooring may be less affected by nail holes in the salvaged siding. We estimate that T&G flooring has a potential sale value of $3 to $6 per square foot and remanufactured Douglas-fir millwork has a potential producer sale value of about $1.20 to $1.90 per board foot.

Significant numbers of U.S. military buildings are of wood-frame construction. Many of these structures were built before or during World War II, when steel and masonry building materials were being redirected to other parts of the war effort. With the passing of the Cold War era, many military facilities have been classified as excess to contemporary defense requirements. Often, the buildings targeted for removal have been well maintained, are structurally sound, and contain large quantities of potentially reusable wood materials. Many military facilities contain millions of board feet of lumber representing millions of dollars in potential resale value. Coupling this recovered value with cost avoidance (landfill fees), there are potentially significant savings in salvaging these wood materials for reuse (Falk 2002).

A large percentage of World War II U.S. Army buildings were constructed with siding materials manufactured from solid wood. This wood siding has the potential to be reused through remanufacture into other valuable building products. However, the presence of lead-based paint (LBP) on the exterior face creates a challenge in processing this siding without exposing both processors and reusers of the wood to the harmful effects of lead.

The objectives of this research project were to examine the viability of using conventional woodworking equipment to remove LBP coatings from wood siding salvaged from military buildings and to produce a marketable wood product from the salvaged wood. This paper focuses on efforts to investigate the recovery of millwork processed from LBP siding

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Figure 1. — Single-story barrack in Fort Ord from which LBP siding was obtained.

from deconstructed buildings. Worker and workplace exposure to lead during wood remilling operations is evaluated in a companion paper (Falk et al. 2005).

Background

Fort Ord in Marina, California, provided the primary source of LBP siding. The siding was salvaged from two single-story 7.3- by 25-m (24- by 82-ft) barracks. **Figure 1** shows one barrack before deconstruction. This building is representative of approximately 1,200 one- and two-story barracks built to house the Fort Ord garrison (Denfield 2000). The opportunities to reclaim wood from these buildings through deconstruction (dismantlement) rather than demolition are immense. The Fort Ord Reuse Authority (FORA) has responsibility for base property transfer to the local municipality and has been looking for economic and environmentally responsible approaches for removing buildings.

The installed siding was thoroughly inspected and photographed to document external building conditions prior to deconstruction. This on-site inspection showed heavy paint accumulations after 50 or more years of active service life. Siding pieces from each building were given a unique identification number, which indicated exposure – north (N), east (E), south (S), or west (W) – as well as vertical location on each wall. Some siding pieces with failed paint were noticeably checked and had photo-oxidative surface erosion. Removal of siding was coordinated by FORA and the U.S. Army Construction Engineering Research Laboratory (CERL). Siding was bundled and transported full length to the Forest Products Laboratory (FPL).

All siding was 13 cm (5-1/4 in) in width and had been double-nailed to the barrack wall studs 61 cm (24 in) on center. Nail holes in salvaged wood are a significant factor in evaluating recovery and can devalue and/or limit reuse in certain ready-to-finish millwork products. Most pieces of salvaged siding appeared reasonably sound and free from decay and/or insect infestation. However, advanced decay was detected on some pieces, most often at the ends of the installed siding. Long-term exposure to sun and ocean weather affected wood quality on the south and west sides of the buildings more frequently than on the other sides.

Evaluation of the siding by wood anatomists at the FPL confirmed the wood species as Douglas-fir (*Pseudotsuga menziesii*). Particles of windblown sand were frequently embedded in the siding where the paint film had failed. This condition raised some concern about whether the siding could be machined without causing excessive wear on cutting tool edges. Also, the abrasive characteristics of heavily pigmented paint and metal objects (e.g., nails, screws, and staples) caused further concern. If the wear to the knife cutting-edge was found to be too rapid or excessive, the costs of resharpening and the loss of wood surface quality could make remanufacture impractical. This was especially true for the conventional woodworking equipment evaluated here. Compared to other woodworking machines, the knife blades of wood planers and molders are sensitive to declines in cutting performance from abrasive wear and damage from foreign objects. Another practical limitation in remanufacturing the reclaimed siding was piece length. A substantial number of the pieces of siding were under 1 m (3 ft) in length, limiting the product types that could be made from such material.

Experimental approach

Remanufacture of salvaged siding

For laboratory processing, a four-head molder in the FPL carpentry shop was used to remill the experimental supply of salvaged siding. The molder was retrofitted with a new Hydro-loc cylinder with a diameter of 150 mm (5.9 in); surface cutterheads with body height of 150 mm (5.9 in) and 54-mm (2-1/8-in) bore; and side cutterheads with body height of 60 mm (2.4 in) and 46-mm (1-13/16-in) bore (Hermance Machinery, Inc., Williamsport, PA). The heads were designed with a dual chamber that utilizes hydraulic pressure for attaching to the molder arbors to optimize cutting uniformity and concentricity. Specifications included a 12-degree cutting angle suitable for processing softwood material. The heads were initially set up with M-2 grade high-speed steel (HSS) flat and profile ground knives (35-degree bevel angle). Corrugated (16/60) blades were used instead of flat stock knives to allow fast replacement in case of damage by foreign objects.

Comparative trials were conducted on southern pine (*Pinus* spp.) LPB siding from another deconstruction project using carbide-bonded knives. The pine siding was of lower quality than the Douglas-fir siding; it had large knots, more weathering and paint loss, and extensive evidence of soil contamination. A total supply of 1268 m (4,159 linear feet [lf]) of southern pine feedstock was prepared for remanufacture into bevel siding.

Products selected for evaluation

On-site inspection of the wood siding suggested processing into a number of feasible valued-added wood products. The overriding constraint on the products selected for evaluation was the thickness of the siding (19 mm, 3/4-in). Only products with final dimensions less than this were possible.

Three millwork profiles were selected for study evaluation: 8.7-cm (3-5/16-in) wide square-edged tongue & groove (T&G) matched flooring, V-groove paneling, and overlap bevel siding (8.9 cm, 3-1/2 in wide). Flooring and paneling were finished to 14 mm (9/16 in) thick; bevel siding was processed to a 11-mm (7/16-in) pattern thickness. These profiles were chosen for several reasons:

- The profiles are based on West Coast Lumber Inspection Bureau (WCLIB) standard profiles for western wood species for millwork (WCLIB 2001).

• The depth of the profiles should eliminate weathering-related defects and be of adequate thickness for LBP removal.

• At least one profile should result in a final product that can be made from short lengths of siding without a significant effect on market value.

• The profiles maximize fiber recovery with a minimum of contaminated waste.

• The profiles are well recognized by builders and are used in high volumes in residential and commercial building construction.

Preparation of siding

Before millwork machining, each piece of siding was square end trimmed. This served several purposes, including the minimization of feed problems into the molder, removal of unusable wood, elimination of end-grain splitting and residual nails or shanks remaining from deconstruction, and assurance that only usable wood would be machined into finished millwork. After end trimming, the pieces of siding were edge-ripped into feedstock widths for molder processing depending on the finished millwork pattern.

Metal detection

To prevent knife damage and to maximize operator safety, all siding was scanned for nails and other metal objects. The salvaged siding was scanned twice, before edging and prior to remilling, using a hand-held detector manufactured by Lumber Wizard (Van Nuys, CA). This device proved effective with good sensitivity to locate both embedded nail fragments remaining from deconstruction and small metal staples hidden beneath the paint.

Inspection of siding

Each piece of siding was individually inspected twice – once before any machining took place and a second time after being remilled into the millwork product. The first inspection identified various visual characteristics and necessary decisions for cut-to-length trimming to eliminate unusable material and provided a basis for segregating each piece into a profile classification (selected millwork pattern). The second inspection focused on quantifying defects not previously visible through the paint of the unprocessed siding and quantifying secondary losses in length caused by either unacceptable defects or defects disallowed in the finished millwork product.

Segregation into the profile classifications was mainly based on recoverable length. Because wood flooring can be manufactured from short pieces, salvaged siding that was 40.6 cm to 2.1 m (16 in to 7 ft) long was sorted for processing into T&G flooring. Wood paneling is typically sold in lengths ≥2.4 m (≥8 ft), often to 3.1 m (10 ft), to accommodate vertical placement on interior walls; therefore, siding pieces from 2.4 to 3.1 m (8 to 10 ft) were segregated for V-groove paneling remanufacture. However, pieces over 2 m (7 ft) but less than 2.4 m (8 ft) long were also included in this profile classification. Salvaged pieces more than 3.1 m (10 ft) long were segregated for remanufacture into the bevel siding pattern, since siding is most valuable in longer lengths.

Evaluation of discoloration

To evaluate the effects of potential iron discoloration on the remanufactured bevel siding, specimens were cut from the processed siding and subjected to exposure testing. Nail holes were qualitatively ranked as having a low, medium, or high level of iron (ferrous oxide) stain. Each nail hole was repaired by filling with wood plastic putty. The stained specimens (and unstained controls) were then coated with acrylic latex primer. Six specimens were prepared per test sample group. Three specimens each were painted with a single or double topcoat of exterior latex white house paint. The selected material complied with ASTM D 358; both repaired and control specimens were evaluated with ASTM D 3459 (ASTM 2002). This testing was conducted at the Forest Resources Laboratory at Penn State University using a laboratory kiln to provide test exposure conditions.

Figure 2. — Grade stamp marking observed on several pieces of salvaged Fort Ord siding.

Results and discussion

Inspection of the LBP coated wood siding yielded much information about the potential to produce value-added wood products. The first visual assessment of all pieces indicated that the Fort Ord siding was manufactured from high quality Douglas-fir. This was confirmed by the discovery of a few isolated grade stamps (**Fig. 2**). Most pieces of siding had one clear face with few knots and were finely textured (30 or more growth rings per inch). We also observed that a substantial proportion (30%) of the salvaged siding was vertical grain, which is highly desired for finished millwork markets.

Initial inspection results (before remilling)

An analysis of data from the initial inspection indicated the following:

• Total footage of siding shipped to FPL from Fort Ord: 2179.9 m (7,152 ft)

• Total number of pieces: 1,229

• Total footage lost due to deconstruction damage, decay, or other length trim: 470 m (1,542 ft)

• Total number of whole pieces judged unacceptable for remanufacture: 76

• Percentage of loss of original length due to damage, decay, or end trim: 22 percent

Table 1 summarizes the most common defects found in the salvaged siding based on the first inspection. There was appreciable variation in surface checking, and as expected it was more severe on the southern and western exposures. However, irrespective of exposure, distortion was limited, and the salvaged siding pieces were straight for the most part. Warp-

Table 1. — Frequency of observed defects in salvaged Douglas-fir siding.

Defect	Type or severity	No. of pieces[a] (observations)
Surface checking	None to very slight	1
	Slight	96
	Slight to moderate	18
	Moderate	17
	Moderate to heavy	8
	Heavy	6
Warp	Bow	1
	Cup	16
Decay	Brown rot	16
	Soft rot	4
	Combination	--
	Mildew	10
Residual fasteners	Metallic oxide/rust	292
	At least one nail	65
	Multiple nails	10
	At least one staple	8
	Multiple staples	5
	Tacks	1

[a]Numbers shown are for 584 pieces of a total of 1,229 pieces in which noticeable defects were observed during initial visual inspection.

Table 2. — Length recovery of usable material with respect to building exposure.

Building exposure	Original length	Length after end trim	Length suitable for remilling
	(m [lf])	(m [ft])	(%)
East	719.3 [2,360]	633.1 [2,077]	88.0
North	313.3 [1,028]	269.8 [885]	86.0
South	292.9 [961]	232.3 [762]	79.3
West	709.6 [2,328]	618.1 [2,028]	87.1

Table 3. — Profiles produced from salvaged Douglas-fir siding.

Profile	Avg. initial piece length	Piece count	Produced length	Percentage of total length
	(m [ft])		(m [lf])	(%)
T&G flooring	1.5 [4.8]	924	913.5 [2,997]	53.4
V-groove paneling	2.2 [7.1]	85	215.5 [707]	12.6
Bevel siding	4.4 [14.3]	148	580.3 [1,904]	34.0

ing in the form of cup was apparent but not sufficiently problematic to discount any piece from remanufacture. Brown rot and soft rot were present in relatively few pieces, which is either an indication of the local climate and/or that the buildings were well maintained. Many pieces of siding did have metallic stains due to nail and other metal hardware corrosion, likely related to the salty marine air at Fort Ord. The most common reason for designating a piece unacceptable for remanufacture was deconstruction damage.

Based on this initial inspection, the recovery of siding deemed acceptable for remanufacture is summarized in **Table 2**. Because the results for both buildings were nearly identical, the values shown are averages for the two barracks. It is apparent that directional exposure has some effect on recovery as the yield is somewhat less for siding from the southern side of the buildings. No effect on recovery based on the vertical location of the siding was found, however.

Table 3 shows the distribution of the salvaged siding to T&G flooring, V-groove paneling, and bevel siding profiles based on the length classes described earlier. Because there are many shorter pieces of siding in a building (especially around/between doors and windows), about 75 percent of all the pieces of siding were suitable for flooring and accounted for 53 percent of the length of siding evaluated. The yields for the other profiles were significantly lower.

Secondary inspection results (after remilling)

Each piece of produced T&G flooring, V-groove paneling, and bevel siding was inspected to determine further recovery adjustments after remanufacture. As shown in **Table 4**, the losses (unusable material) observed in the second inspection were low in comparison to those observed in the first inspection. In total, loss of length was 24.2 percent. In addition, over 95 percent of the individual pieces of flooring, paneling, and siding fell into the category of industrial clear or better (C & Btr) finished millwork quality, excluding consideration of nail holes or ferrous stain as grade-limiting imperfections (which are not specifically addressed in the grading rules). **Figure 3** illustrates all three profile patterns produced.

Several bevel siding and V-groove paneling pieces were rejected because of insect damage not observed until after remilling. Exposed gallery tunnels (**Fig. 4**) combined with an adult insect prothorax showed that this internal wood damage was caused by metallic wood borers (*Buprestis aurulenta*). Additional losses (**Table 4**) reflect adjustment measures to account for end-split meeting a C & Btr grade of millwork under WCLIB rules. Of the total linear footage processed, 29.7 percent of the remanufactured Douglas-fir siding material met the criteria for vertical grain millwork.

Wear of knives during machining of siding

The edges of the high-speed steel (HSS) knives dulled rapidly (**Fig. 5**), which indicates that this type of knife would need to be sharpened or replaced frequently when machining LBP surfaces. Degradation in surface quality was observed after freshly sharpened HSS knife blades had processed only about 275 m (900 ft) of painted siding. Interruptions in processing to sharpen or replace knives after such a short run would seriously hamper production.

Although only 999 m (3,277 lf) of siding remained to be processed, carbide-tipped knives were purchased to see if more material could be processed without surface degradation than with the HSS knives. All of the remaining siding was remilled without degrade in surface quality. The condition of the carbide-bonded knives (**Fig. 6**) suggests that much more material could have been processed with these knives compared with HSS knives before milled surface quality would have been discernibly affected.

Evaluation of discoloration

As a result of age and exposure, many nails used to secure the siding to the barracks had corroded, leaving an iron (ferrous oxide) stain in and around each nail hole. Because ferrous oxides are soluble and can be a source of bleed-through dis-

Table 4. — Additional loss in length.

Profile	Original loss		Loss after remilling		Total loss	
	Original trim loss	Percentage of original length	Additional loss after remilling	Percentage of original length	Total loss	Percentage of original length
	(m [lf])		(m [lf])		(m [lf])	
T&G flooring	348.7 [1,144]	27.6	19.2 [63]	1.5	367.9 [1,207]	29.1
V-groove paneling	31.7 [104]	12.8	11.0 [36]	4.4	42.7 [140]	17.2
Bevel siding	89.6 [294]	13.4	27.1 [89]	4.0	116.7 [383]	17.4
Total	470.0 [1,542]	21.6	57.3 [188]	2.6	527.3 [1,730]	24.2

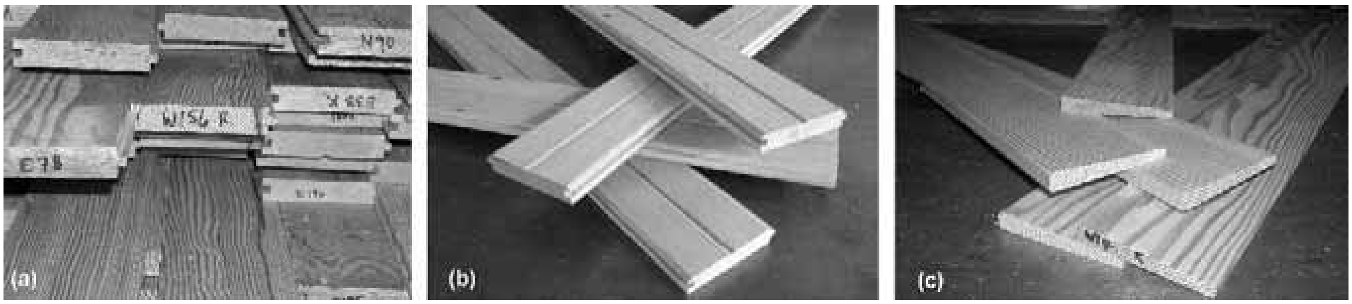

Figure 3. — Three millwork patterns remanufactured from experimental supply of Douglas-fir LPB siding material: (a) T&G flooring; (b) V-groove paneling; and (c) bevel siding.

Figure 4. — Insect damage exposed after siding was remilled.

Figure 5. — Condition of conventional high-speed steel knife blade after processing approximately 900 lf of Douglas-fir LBP siding material.

coloration when used for exterior applications, an experiment was conducted on the remanufactured Douglas-fir bevel siding millwork to determine if bleed-through would be a problem in the reuse of this material. Despite exposure to the rather rigorous cyclic high/low humidity with elevated temperature specified in ASTM D 3459, none of the specimens showed metallic discoloration. Discoloration from iron stain did not occur even after an additional two cycles. However, most specimens yellowed as a result of extractive bleeding after only four to five cycles. We therefore conclude that extractive bleeding would be a problem long before iron bleed-through in the remanufactured siding.

Product valuation

While the focus of this project was to determine the *technical* feasibility of producing a value-added wood product from salvaged wood siding, some effort was taken to establish a "fair" market value for the remilled products. This effort proved to be a challenge given that the profiles produced in this project could not be viewed as completely "ready-to-use." This is especially true for the bevel siding, which would require repair or filling of nail holes prior to exterior installation. It is uncertain how consumers would accept iron stain discoloration on some processed millwork pieces. Only a market analysis can precisely evaluate consumer acceptance with subsequent sensitivity to market pricing. Despite fine wood appearance, some consumers might object to any discoloration, at least for natural finish paneling.

Industry trade publications were reviewed to identify the price for thin 14-mm (9/16-in) flooring and paneling and 11-mm (7/16-in) bevel siding products. Unfortunately, no information was available on these products except for finished 19-mm- (3/4-in-) thick millwork products. Mill order prices for nominal 1 by 4 (standard 25- by 89-mm) lumber served as

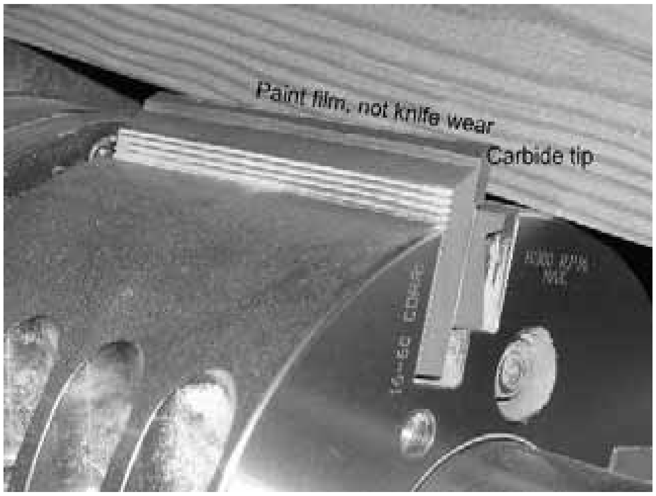

Figure 6. — Condition of carbide-bonded knife after processing more than 3,000 lf of knotty southern pine LBP siding material.

the basis to derive a dollar value estimate. FOB prices for clear mixed grain or sorted vertical grain boards were reported at $1,675 and $1,050 per thousand board feet (MBF), respectively (Crows Market Report 2003). Several western manufacturers contacted indicated an up-charge of $100 to $200 per MBF for their valued-added millwork production. Accordingly, $1.20 to $1.90 per board foot was estimated as a potential producer sale value for the remanufactured Douglas-fir material if sold as millwork. The higher expressed value corresponds to a dollar amount for more valuable vertical grain material.

Given the large piece count of salvaged LBP siding suited for flooring, additional efforts were taken to quantify the market for this particular product. Antique wood flooring from reclaimed material has become quite popular and a niche market is well established. An Internet search was conducted to identify vendors of antique Douglas-fir and southern pine flooring. Several website vendors were identified and contacted. Prices ranged from about $4 to nearly $11 per square foot (1 $ft^2 = 0.09 m^2$), which translates to a minimum of $1 per linear foot value for the salvaged wood siding. This indicates that the producer value estimate described here may be conservative for some buyer markets.

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