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Lumber Processing in Selected Sawmills in Durango and Oaxaca, Mexico

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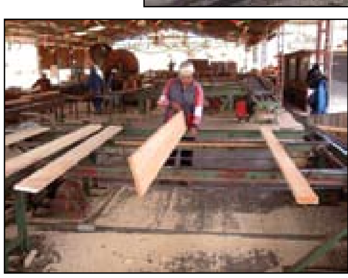

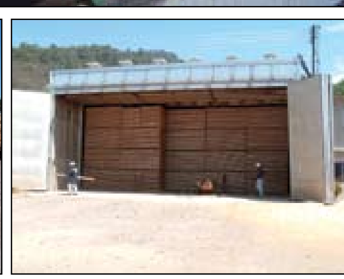

Abstract

This report documents a technical assistance trip to four community-owned forests and associated sawmill and secondary processing operations in the vicinities of Durango and Oaxaca, Mexico. The products and processes of these enterprises are described, and recommendations for improvement are provided.

Keywords: Ejido, bosque comunal, sawmill, Durango, Oaxaca, Mexico, *Pinus*, *Quercus*

Contents

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Lumber Processing in Selected Sawmills in Durango and Oaxaca, Mexico

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Introduction

The Forest Products Laboratory (FPL) was contacted by the USDA Forest Service International Programs to provide technical assistance to sawmills in Durango and Oaxaca, Mexico. A technical visit was coordinated with members of the Rainforest Alliance.

In Mexico, forests (bosques) are primarily community-owned. There are two categories of community-owned forests, “bosques ejidales” (also known as “ejidos”) and “bosques comunales.” The main difference between these two systems is in land tenure. Ejidos may be subdivided into parcels with individual owners, although a family may not own more than one parcel. Bosques comunales, on the other hand, may not be subdivided, although the total number of owners can increase.

Communities use their collective forest holdings to supply timber industries. Much of the production supplies local markets, but there is increasing interest in export markets as a source of foreign exchange. Foreign markets are demanding, and high quality is required by importers of timber and timber products. We visited timber production industries associated with community forests to familiarize ourselves with their current operations and lumber grading methods, and to survey the various species that are harvested. The forests that we visited produce mostly pine, with small quantities of oak. The regions we visited are shown in Figure 1.

Figure 1—Durango and Oaxaca regions in Mexico. www.TrailMonkey.com

Description of Sawmills

We visited four sawmills approximately 2 to 4 h driving time from the metropolitan areas of Durango and Oaxaca, Mexico. The two sawmills near Durango are ejidos, and the two sawmills near Oaxaca are comunales. All sawmills are members of the Forest Stewardship Council (FSC), a third-party organization that certifies sawmills that follow sustainable forestry practices.

Logs

Private trucking companies are contracted to haul harvested logs from the forest to the sawmills. Typical log lengths in the Durango area are 16 to 24 ft (4.9 to 7.3 m), which requires the use of logging trucks and trailers (Fig. 2). At the Oaxaca sawmills, logs are typically cut to a uniform 8-ft (2.4-m) length, which allows the use of flat-bed trucks (Fig. 3).

Figure 2—Specialized log-hauling semi-truck and trailer for carrying logs up to 24 ft (7.3 m) long.

The raw material processed and the facilities at the four sawmills are summarized in Table 1. The majority of the

Table 1—Summary of sawmill characteristics

Sawmill	Species[a]	Length	De-barking	Primary sawing	Re-sawing	Lumber grades	Air drying	Kiln drying	Finished products
Durango #1[b]	*P. durangensis* Martínez *P. ponderosa* Dougl. *P. michoacana* Martínez *P. arizonica* Engelm.	20–24 ft (6.1–7.3 m)	No	Band saw; 8, 16, 20 ft (2.4, 4.9, 6.1 m) lumber; short stock	Wane removal; pallet stock; 1×1×48 in. (2.5×2.5×122 cm) stock; slats for fruit boxes	No. 1 No. 2 No. 3 No. 4 No. 5	No	Oil-based; wood-fired kiln	None
Durango #2	*P. durangensis* Martínez *P. cooperi* Blanco *P. engelmannii* Carr. *P. ayacahuite* Ehrenb. *Quercus sideroxyla* Humb. & Bonpl. *Quercus rugosa* Née	16 ft (4.9 m)	Yes	Band saw; 8, 16 ft (2, 4.9 m) lumber; short stock	Wane removal; pallet stock; 1×1×48 in. (2.5×2.5×122 cm) stock; slats for fruit boxes	No. 1 No. 2 No. 3 No. 4 No. 5	Yes	No kiln	None
Oaxaca #1	*P. pseudostrobus* Lindl. *P. patula* Schlecht. & Cham. *P. oaxacana* Mirov *P. lumholtzii* Robins. & Fern. *P. tenuifolia* Benth. *P. teocote* Schlecht. & Cham. *P. leiophylla* Schlecht. & Cham. *P. oocarpa* Schiede *P. montezumae* Lambert *P. pringlei* Shaw *P. douglasiana* Martínez *P. ayacahuite* Ehrenb. *Abies oaxacana* Martínez *Quercus laurina* Humb. & Bonpl.	8 ft (2.4 m)	No	Band saw; 8 ft (2.4 m) lumber; short stock	Wane removal; pallet stock; 1×1×48 in. (2.5×2.5×122 cm) stock	No. 1 No. 2 No. 3 No. 4 No. 5	Yes (short term)	Modern	None
Oaxaca #2	*P. patula* Schlecht. & Cham. *P. pseudostrobus* Lindl.	8 ft (2.4 m)	No	Band saw; 8 ft (2.4 m) lumber; short stock	Wane removal; pallet stock; 1×1×48 in. (2.5×2.5×122 cm) stock	No. 1 No. 2 No. 3 No. 4 No. 5	Yes (short term)	Modern	Doors; finger-jointing; modern

[a] *P.* designates *Pinus*.
[b] A total of seven species are processed; representative species are listed here.

Figure 3—Typical heavy-duty truck for transporting logs cut to nominal length of 8 ft (2.4 m).

Figure 4—Example of log unloading at sawmill.

Figure 5—Logs stacked in sawmill yard.

Figure 6—Example of sorting logs for specialty products; in this case, utility poles.

logs are pine species, with a small percentage of oak. We saw no effort to separate the various species of pines at the log yards or during lumber processing. *Pinus durangensis* is the primary species processed at the Durango sawmills. About 60% of total production at Oaxaca sawmill #1 utilizes *P. pseudostrobus* and *P. patula*; 60% of production at Oaxaca sawmill #2 utilizes *P. patula*, with the rest consisting of *P. pseudostrobus*.

Log Sorting

Log shipments are unloaded in the log yard (Fig. 4); the logs are stacked into more orderly stockpiles by front-end loaders (Fig. 5). All sawmills conduct some degree of log sorting, primarily by diameter. Durango sawmill #1 separates out all small-diameter, long, straight logs for utility poles, but does no additional sorting of the remaining logs (Fig. 6). Durango sawmill #2 separates all logs by diameter classes, so that more uniform diameters are processed in sawing. Small-diameter short logs are accumulated at all sawmills (Fig. 7) because no profitable markets currently exist for this resource. Neither of the Oaxaca mills sorts logs, and none of the sawmills sorts pine logs by species (Fig. 8).

Log Breakdown

Durango sawmill #2 debarks logs prior to sawing (Fig. 9) so that the slab wood and edgings are bark-free. All four sawmills utilize large band saws (Fig. 10), and saw filers are in charge of daily maintenance of the blades. During the production of sawn lumber, all the sawmills try to maximize the production of wide lumber (Fig. 11), which is dictated by strong market demands in Mexico, although the widths attainable are limited by the log diameters. Production at all four sawmills is similar to the appearance-grade processing common in the United States for hardwood lumber, which typically processes random-width dimensions. In the United States, the majority of pine species are sawn into dimension lumber for structural and utility applications, although some mills make an attempt to produce appearance-grade material. After the primary processing of full-width lumber,

Figure 7—Accumulation of small-diameter logs at log yards resulting from lack of markets for small-dimension lumber.

Figure 8—Mixture of species and diameters of logs queued for sawing. Large-diameter log on right with heavy bark structure is *Pinus pseudostrobus*; other logs are *P. patula*.

Figure 9—De-barked logs.

Figure 10—Large band saw used at sawmills.

Figure 11—Sawmill processing in Mexico targets production of wide lumber because of strong market demands.

Figure 12—Example of slabs accumulated at sawmills.

Figure 13—Bucking long logs into short lengths in log yard.

Figure 14—Large quantity of log shorts resulting from poor log bucking practices.

Figure 15—Lumber recovered from slabs is sawn into slats, pallet stock, and blanks for broom handles.

lumber with wane is edged through a gang-rip saw, resulting in narrower-width lumber. Slabs are accumulated and stockpiled (Fig. 12) for further reprocessing into smaller stock, such as slats.

Durango sawmill #2 and both Oaxaca sawmills process log-length lumber from logs that are harvested and cut to a specific length in the forest. Durango sawmill #2 primarily processes 16-ft (4.9-m) logs, and both Oaxaca sawmills primarily process 8-ft (2.4-m) logs. Durango sawmill #1 acquires the majority of their logs in 20- to 24-ft (6.1- to 7.3-m) lengths; a large percentage of these logs are later cut to 16-ft (4.9-m) lengths in the yard (Fig. 13). Only the highest quality logs are processed full-length into lumber longer than 16 ft (4.9 m). This process results in an abundance of short log cut-offs (Fig. 14).

Slab Recovery

A common problem among all four sawmills is to find methods to utilize the sawmill waste. All sawmills have a re-saw production line (Fig. 15), where lumber is recovered from slabs. Three products are commonly processed on these re-saw lines (Fig. 16):

(a) Thin slats for fruit boxes
(b) 1- by 1- by 48-in. (2.5- by 2.5- by 122-cm) clear stock for broom handles
(c) Components for pallet stock

All four sawmills named these three products as outlets for lumber recovered from slabs. No other primary products are made from slabs.

Grading

All sawmills have similar grading methods and grading systems. Green lumber is visually graded and categorized into one of five lumber grades, No. 1 through No. 5. The No. 1 and No. 2 lumber grades are commonly combined into a single high grade, referred to as “Firsts.” Table 2

Table 2—Summary of lumber grade specifications, based on interviews with lumber graders

Grade	Knot size	Frequency and characteristics of knots and other defects
No. 1	No knots	Clear both faces
No. 2	Smaller than 1 in. (2.5 cm)	Clear one face; 4 or fewer knots permitted on back
No. 3	Smaller than 2 in. (5 cm)	4 or fewer knots permitted on both faces
No. 4	Smaller than 2 in. (5 cm)	5 to 8 knots permitted on both faces
No. 5	Larger than 2 in. (5 cm)	More than 4 knots on both faces; checks, splits, and centered pith

Figure 16—Byproducts made from slabs: (a) slats for fruit boxes; (b) blanks for broom handles; (c) pallet components.

Figure 17—Representative boards from lumber grades: (a) "Firsts": combination of No. 1 and No. 2 grade lumber; (b) No. 3 grade; (c) No. 4 grade; (d) No. 5 grade. See Table 2 for description of grades.

summarizes the specifications of the lumber grades, based on our discussions with the graders. This grading system is applied only to full-length lumber, and no grading manual was available at any of the sawmills. Figure 17 shows representative boards from each of these lumber grades.

Kiln-Drying

Three of the four sawmills operate dry kilns. Durango sawmill #2 does not operate a kiln; 100% of their product is sold as green or air-dried lumber. Durango sawmill #1 operates an oil kiln that is heated by burning solid wood waste. Three shifts are required to manage this kiln; highly skilled operators are required to maintain proper temperature and humidity control. Both Oaxaca sawmills operate modern kilns (Fig. 18) with computer-controlled sensors and utilize sawdust waste for heat generation. At three of the four sawmills, we observed stickers that were improperly aligned (Fig. 19). Only Oaxaca sawmill #2 had perfectly aligned stickers in every lumber bundle that we inspected.

Finished Products

With the exception of thin slats, pallet lumber, and broomstick handle blanks, only Oaxaca sawmill #2 manufactures secondary products; their primary added-value product is floating-panel doors (Fig. 20). This sawmill is in the process of installing a finger-jointing system to be able to efficiently utilize the short clear lumber from mill residues (Fig. 21). Although Oaxaca sawmill #2 is using modern equipment to produce fine quality doors, we saw a few instances of splits and checks in the rails and stiles of these manufactured products (Fig. 22). We noticed that the rails and stiles in the finished doors are primarily made from flat-sawn lumber, and they are stored in the warehouse in an unfinished condition. To produce a more dimensionally stable and value-added product, we recommended that the sawmill consider

Figure 18—Example of modern drying kiln for Oaxaca sawmill.

Figure 19—Misaligned stickers during drying result in warped lumber.

Figure 20—Floating-panel, solid-wood doors manufactured in Oaxaca.

Figure 21—Modern finger-jointing system.

Figure 22—End checking on flat-sawn grain of unfinished door stiles.

quarter-sawn lumber for door rails and stiles. Because the operation is a sawmill, specially cut lumber can be selected from the production line. In addition to the use of more dimensionally stable lumber, we also recommended the application of a surface finish soon after manufacture, to reduce the amount of shrinking and swelling resulting from fluctuations in relative humidity. We recommended that lumber for the unfinished door market be immediately shrink-wrapped before storage.

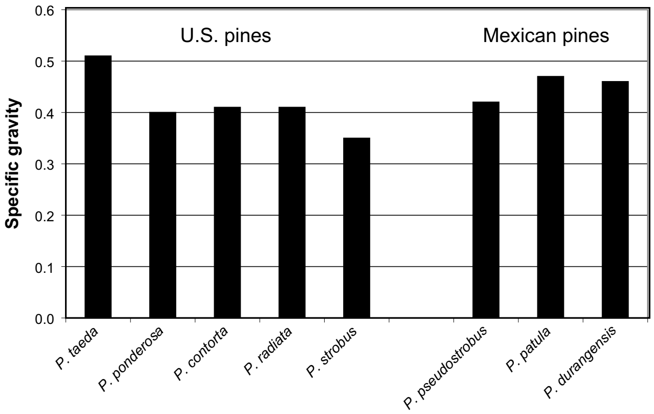

Figure 23—Specific gravity of various U.S. and Mexican pine species.

Information Gathered

With our newly gained knowledge of the pine species available in Oaxaca and Durango as well as the lumber processing and grading capabilities, we conducted a review of the literature to compare the mechanical properties of the pine species utilized in these regions in Mexico to those commonly utilized in the United States.

Comparison of Mexican and U.S. Pines

Figure 23 compares the specific gravity of several U.S. and Mexican pine species. Table 3 compares the modulus of rupture (MOR), modulus of elasticity (MOE), side hardness, and radial, tangential, and volumetric shrinkage of four native commercial pines of the United States, one species (*P. radiata*) that is native to the United States but has commercial value only as a plantation species in foreign countries, and three Mexican pines. Of the commercial U.S. species, *P. taeda* is a southern yellow pine, *P. ponderosa* and *P. contorta* are western yellow pines, and *P. strobus* is northern white pine. *Pinus radiata* is native to California and Guadalupe Island. *Pinus taeda* has the highest specific gravity of all the species shown in Figure 23 and is considered one of the strongest softwood species in the United States for structural applications. Southern yellow pine is commonly used for structural joists and planks and in engineered wood products such as glued-laminated timber members. *Pinus ponderosa* and *P. contorta* are commonly classified as Western Woods in U.S. lumber grades. These species are known to possess lesser mechanical properties compared with those of southern yellow pine. These species are commonly used for construction studs as well as nonstructural applications in molding and millwork. *Pinus strobus* is usually processed as appearance grade lumber and used in nonstructural applications such as furniture, molding, and millwork.

The processing of Mexican pines that we observed at the four sawmills most closely resembles the U.S. grade sawing methods for *P. strobus*. As observed in Figure 23, the specific gravity of the Mexican pines exceeds the specific gravity of *P. ponderosa*, *P. contorta*, *P. radiata*, and *P. strobus*. Our data indicate that Mexican pines have sufficient to excellent mechanical properties for structural and semi-structural applications.

Comparison of Mexican and U.S. Oaks

Table 4 compares the MOR, MOE, side hardness, and radial, tangential, and volumetric shrinkage of three native oaks of the United States and six species of Mexican oaks. *Quercus alba* is the most valuable white oak in the United States, and *Q. rubra* is the most valuable red oak. *Quercus virginiana* is much less valuable than these two species (perhaps because of its small size, poor form on many sites, and drying difficulties), and it resembles the Mexican oaks in

Table 3—Physical properties and dry (12% moisture content) properties of pine (*Pinus*) species

Data source[a]	Basic specific gravity	Species	MOR (MPa)	MOE (GPa)	Side hardness (kN)	Shrinkage, green to ovendry (%) Radial	Tangential	Volumetric	Origin[b]
FPL	0.34	*P. strobus*	59	8.5	1.7	2.1	6.1	8.2	USA
	0.47	*P. taeda*	88	12.3	3.1	4.8	7.4	12.3	USA
	0.38	*P. contorta*	65	9.2	2.1	4.3	6.7	11.1	USA
	0.42	*P. ponderosa*	65	8.9	2.0	3.9	6.2	9.7	USA
	0.46	*P. radiata*	81	10.2	3.3	—	—	—	Asia
Cockrell	0.46	*P. radiata*	91	12.4	3.4	5.2	7.0	11.4	CA
	0.41	*P. radiata*	79	10.0	3.2	4.0	6.3	—	Australia
Lavers	0.43	*P. radiata*	85	9.0	3.8	—	—	—	Kenya
	0.39	*P. radiata*	85	8.3	2.7	—	—	—	NZ
Davalos	0.46	*P. durangensis*	102	11.9	3.4	—	—	13.1	Mexico
	0.47	*P. patula*	95	12.5	3.8	—	—	10.8	Mexico
Sachsse	0.45	*P. pseudostrobus*	—	11.1	—	—	—	11.6	Mexico

[a]FPL 1999b; Cockrell 1959; Lavers 1983; Davalos and others 1978; Sachsse and Cruz de León 1992.
[b]CA is California; NZ, New Zealand.

Table 4. Physical properties and dry (12% moisture content) properties of oak (*Quercus*) species

Data source[a]	Basic specific gravity	Species	MOR (MPa)	MOE (GPa)	Side hardness (kN)	Shrinkage, green to ovendry (%)			Origin
						Radial	Tangential	Volumetric	
FPL	0.56	*Q. alba*	99	12.5	5.7	5.6	10.5	16.3	USA
	0.60	*Q. rubra*	105	12.3	6.0	4.0	8.6	13.7	USA
	0.80	*Q. virginiana*	127	13.7	—	6.6	9.5	14.7	USA
Cruz	0.59	*Q. affinis*	—	—	—	4.6	12.9	18.5	Mexico
	0.73	*Q. rysophylla*	—	—	—	5.0	11.5	17.5	Mexico
	0.75	*Q. polymorpha*	—	—	—	5.4	11.4	17.9	Mexico
	0.74	*Q. prinopsis*	—	—	—	6.2	13.2	20.8	Mexico
Echenique	0.68	*Q. barvinervis*	—	—	—	—	—	21.2	Mexico
Kukachka	0.91	*Q. oleoides*	79	12.4	8.9	—	—	—	Tropical America

[a]FPL 1999b; Cruz de Leon 1994; Echenique Manrique and Becerra Martínez 1969; Kukachka 1970.

anatomy. *Quercus alba* and *Q. rubra* are both ring-porous species; *Q. virginiana* is diffuse-porous, as are the many of the Mexican oaks. The mechanical properties of the Mexican oaks are largely unknown, but shrinkage is high, which may partially account for the limited utilization of this wood.

Comments and Recommendations

The following comments and recommendations are based on our review of practices observed at the sawmills in Oaxaca and Durango:

- More efficient timber harvesting—specifically, bucking logs to desired lengths—should be conducted in the forest such that logs arrive at the sawmill in lengths that will be processed into lumber. Hauling 20- to 24-ft- (6.1- to 7.3-m-) long logs is not cost-effective when the final length of lumber is typically 16 ft (4.9 m) and shorter, and it results in significant waste.
- Lumber yield and sawing efficiency can be improved if logs are initially sorted by diameter in the log yard. Processing of logs with a wide range of diameters reduces efficiency because it multiplies the number of decisions the sawmill operator must make to maximize grade yield.
- Debarking of logs at the sawmill should be considered for several reasons. In the case of utility poles, the removal of bark accelerates drying and facilitates treatment with chemicals. Removal of bark has advantages for sawing: defects are visible (Koch 1985), and cutting bark-free logs extends the service life of saws. Sawmills can sell log residue to pulpmills as a value-added product if the bark is removed. De-barking of logs before storage in the log yard accelerates drying and results in a higher-valued product (Simpson and Wang 2003). Harkin and Rowe (1971) described the properties of bark and discussed its possible uses, such as for mulch.
- The structural pole market and rustic round-timber furniture market are likely outlets for small-diameter logs.
- In log breakdown, greater care to reduce non-uniformity in thickness would produce higher-valued lumber.
- Recovering material from slabs is an important process in the complete utilization of the timber resource. Products currently being recovered from slabs are fruit box slats, broomhandle blanks, and pallet stock. Although the market for these products seems to be well established, we recommend that other higher-valued uses for this resource be researched. In the United States, a wide range of products in the molding and millwork industry are produced from narrow stock, such as trim, picture frames, lattice, and finger-jointed molding. We recommend that the sawmills review the information on producing higher-valued products that is available from trade associations, such as the Wood Moulding and Millwood Producers Association (www.wmmpa.com).
- Utilization of narrow and short lumber resources could be extended by the use of finger-jointing. Finger-jointed molding and millwork products are common in the United States, and initial steps should be taken to make these products acceptable in Mexico. Establishing a finger-joint production line requires knowledge of processing and expected performance. Historical information is available from the Forest Products Laboratory (Jokerst 1981).
- Lumber drying is an important aspect of the production of wood products. For sawmills that are not currently set up to kiln dry lumber, steps should be taken to implement proper air-drying techniques. Research information is available from the Forest Products Laboratory (FPL 1999a, Peck 1956, Tschernitz and Simpson 1985).
- Quality control in lumber stacking and stickering should be implemented. The Forest Products Laboratory publishes information on the importance of proper lumber

Table 5—Mexican species approved by board of review for decking applications

Mexican pine species	Approval limited to specific area[a]	Approval obtained[a]	Product	Grade stamp nomenclature	Supporting agency[b]
P. strobiformis, ayacahuite, leiophylla, chihuahuana, lumholtzii, arizonica, engelmannii, durangensis, jeffreyi, cooperi, montezumae, douglasiana, rudis, hariwegii, michoacana, pseudostrobus, maximinoi, oaxacana, nubicola, patula, oocarpa, pringlei, teocote, lawsoni, herrerai	Michoacan and adjacent States	Radius edge decking	24-in. (608-mm) span	Mex. Pine (I) MCH	RRA/WCLIB
		Exterior decking	16-in. (406-mm) span		
	Durango and Chihuahua	Radius edge decking	24-in. (608-mm) span for 5/4 by 6/4 in. (31.8 by 38 mm)	Mex. Pine (I) DUR	RRA/WCLIB
			16-in. (406-mm) span for 5/4 by 4/4 in. (31.8 by 25.4 mm)		
		Exterior decking	24-in. (608-mm) span for 5/4 by 6/4 in. (31.8 by 38 mm)		
			16-in. (406-mm) span for 5/4 by 4/4 in. (31.8 by 25.4 mm)		

[a] Includes all species of Mexican pine except *P. strobiformis* and *P. ayacahuite*.

[b] RRA is Renewable Resource Associates; WCLIB, West Coast Lumber Inspection Bureau.

stickering for kiln-drying and the effects of improper stickering (Simpson 1991).

- We found no value-added outlet for No. 5 lumber, the lowest grade produced at the sawmills (Table 2). We recommend that value-added outlets be considered for the utilization of this material; one possibility is the pulp chip market. Other alternatives are (1) to re-saw the lower grade stock into short clear lumber and use finger-jointing and (2) to produce rustic end-use products, which are not downgraded by the presence of knots and other defects. Examples of rustic uses of lower-grade lumber in value-added products are shown in the Appendix. The round-timber members used in some of these structures were likely de-barked and then dried to a target moisture content.
- For sawmills that plan to implement industrial molders, oak presents a tremendous opportunity for processing flooring and other products, such as furniture and cabinets. In the few instances that we observed oak being processed, the final product was pallet stock. In the United States, oak is the predominant species used for furniture and wood flooring products. It is an excellent species for wood flooring because of its high specific gravity. We found research articles relating to utilization of oak species in a literature search of the Mexican journal *Madera y Bosques*.
- Finally, if sawmills wish to export their lumber products to the United States in the future, the operators will need a good understanding of U.S. lumber processing and grading systems. The introduction of structural lumber will require approval by U.S. grading agencies. Information about the U.S. process of acceptance of structural lumber products was reported by Green and Hernandez (2000). Some Mexican pine species have already been accepted in the United States for use as semi-structural products, such as decking. Table 5 shows Mexican pine species accepted by the Board of Review of the American Lumber Standards Committee (www.alsc.org). With proper processing equipment, Mexican sawmills can currently produce for export radius-edge decking and exterior decking to the dimensions used in the United States.

Trade Associations

Information on the process and dimensions required for producing quality oak flooring or other products is available from the following trade associations:

National Wood Flooring Association, www.woodfloors.org/consumer

Wood Flooring Manufacturers Association, www.nofma.org

Railway Tie Association,www.rta.org

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Appendix—Uses for Low-Grade Lumber

The following figures illustrate uses for low-grade lumber in value-added products. The round-timber members used in some of these structures were likely de-barked and then dried to a target moisture content.

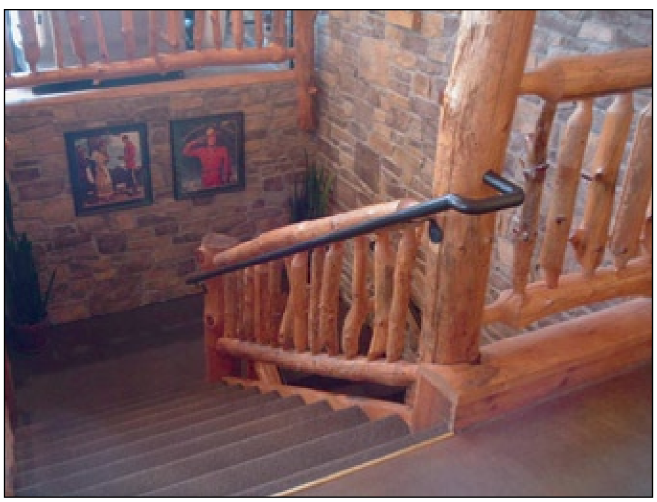
Rustic semi-structural application.

Semi-structural application.

Rustic furniture.

Non-structural application.

Structural application for round timbers.



Semi-structural application.