CALIFORNIA URBAN WOODY GREEN WASTE UTILIZATION

By

Tim R. Plumb [1]

Marianne M. Wolf [2]

John Shelly [3]

Urban Forests Ecosystems Institute
California Polytechnic State University
San Luis Obispo

In Cooperation with

California Department of Forestry and Fire Protection
Riverside, CA

May, 1999

Technical Report No. 8

---

[1]Professor Emeritus, Natural Resources Management Dept., California Polytechnic State University, San Luis Obispo, CA.

[2]Associate Professor, Agribusiness Dept., California Polytechnic State University, San Luis Obispo, CA.

[3]Head of the Information Services Center and Research Associate, U. of California Forest Products Laboratory, Richmond, CA.

ACKNOWLEDGMENTS

Financial backing for this project was provided by an Urban Forestry Grant from the California Department of Forestry and Fire Protection with technical support from the Natural Resources Management Department, Urban Forest Ecosystems Institute, and Cal Poly Foundation, Cal Poly State University, San Luis Obispo, California. We especially thank the following individuals:

Eric Oldar, Uban Forester, Calif. Dept. of For. & Fire Protection, Riverside, Calif.
Will Senerchia, Past Mill Manager, Institute for Sustainable Forestry, Piercy, Calif.
Tom Larsen, President, Integrated Urban Forestry, Inc. Laguna Hills, Calif.
Craig Linquist, Service Line Mgr., Arbor Care, San Jose, Calif
Guy Hall, Owner (Retired), Cal Oak Lumber Co., Oroville, Calif.
Cindy McCall, Parks & Urban Forester, Lompoc, Calif.
Martin Fitch, Parks Superintendent, Sacramento, Calif.

Mill Owners

George Hessenthaler, Urban Forest Woodworks, Inc. Logan, Utah
Dave Faison (Deceased), Into the Woods, Peteluma, Calif.
Warren Wise, The Woodsman, Stockton, Calif.
Peter Lang, the Peter Lang Co., Santa Rosa Calif.
Dave Parmenter, California Hardwood Producers, Aurburn, Calif.
Don Seawater, Pacific Coast Lumber, San Luis Obispo, Calif.
Paul Mueller, Native Woods, Covina, Calif.

Cal Poly State University

Richard Thompson, Ph.D., NRM Dept.
Tim O'Keefe, Ph.D., NRM Dept.
David Yun, Student Assist. NRM Dept.
Jeff Reimer, Technician, NRM Dept.
Joyce McAlexander, Grants Analyst
Sharon Ledbetter, Sec., College of Business

Cal Poly Students

Daren Cliff, Agribusiness Dept.
Janna Swanson, Agribusiness Dept.
Jeromy Lowney, NRM Dept.
David Snakenborg, Agribusiness Dept.
Paul Benedix, Agribusiness Dept.

Assistance was also provided by many individuals and organizations via telephone and personal interviews who are too many to acknowledge individually. Thank you all.

PREFACE

When urban trees are damaged or dead, their disposal can be a big financial burden for a homeowner or responsible governmental agency. Traditionally viewed as waste, much of this material has been historically dumped in landfills. Some of the larger material has been used for firewood, and some has been chipped or ground for mulch. More recently, there has been a growing awareness of the tremendous potential value of the larger woody material (sawlogs) for lumber production.

Although concern about reducing the amount of solid green waste going to landfills was the major catalyst for conducting this study, identifying the size and potential value of this urban tree resource for solid wood production may be even more important.

This study is to be accomplished in three phases. This report deals with Phase I which involves: 1. determining the volume of sawlog-size material currently being removed from urban sites, 2 determining the amount of woody green waste going to landfills, 3. identifying key milling operations currently using urban saw logs, and 4. presenting the costs and methods of milling urban sawlogs. Phases two and three involve the identification of new and existing niche products and the marketing of these products, respectively. Although effective marketing of this material is an important key to successful economic utilization of urban sawlogs, the production of value-added products is equally important.

Two conclusions from this study are that: 1. It’s very difficult to get quantitative information about the volume of sawlogs being harvested because neither arborists nor governmental agencies track woody green waste as sawlogs per se, nor are they familiar with sawlog requirements and/or specifications; and 2. A high proportion of the large woody green waste never gets to a dump or landfill, consequently it’s disposal is little impacted by AB 939, the 1989 Waste Management Law that mandates a 50% reduction of waste going to landfills by 2000.

Finally, it is hoped that the information in this report will: 1. Encourage municipalities to establish a program to use sawlog-size woody green waste for solid wood production, and 2. Encourage new entrepreneurs to get into the business of milling urban sawlogs.

DISCLAIMER

Trade names, commercial brands, and equipment sources and costs mentioned in this report are solely for information. No endorsement by the authors or any sponsoring agency is implied. Indicated equipment sources and costs may no longer be available.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

SUMMARY

I.O. Introduction. This report deals with one of California's important "natural" resources, namely, urban trees that are removed for a wide variety of reasons and end-up clogging landfills, or at best are used for firewood or other low value commodities. Historically, productive utilization of this "waste material" for valuable lumber has been minimal; but in recent years, it's potential use has been recognized by a few resource managers and mill operators. The size of this potential resource, who is currently milling it, its physical characteristics, and how to get into the urban lumber producing business are the subjects of this report.

2.0. Background. The production of green and non-green solid waste has grown dramatically in California in recent years. In 1989, the California State Legislature passed Assembly Bill 939, the Integrated Waste Management Bill, because of the increasing volume of solid waste, increasing disposal costs, and decreasing landfill space. A.B. 939 mandated a number of solid waste and landfill related surveys including county-wide surveys to determine the amount of waste being deposited annually, the amount of landfill space left and projections for the future, and a possible disposal fee added to the sales price of certain items. Also, A.B. 939 required a 25% reduction in solid waste deposited in landfills by 1995, and 50% by 2000. The most desirable management option was the maximum reduction of waste generation.

A second, best management option, to recycle or compost as much of the waste as possible, is the focus of this report. It would not only satisfy the solid waste disposal goals of A.B. 939, it could also reduce tree removal costs, produce valuable, unique lumber not normally available, generate income from the sale of lumber and value-added products, and help conserve forest land resources. Although some street trees have no doubt been used for lumber production in the past, the idea of their routine commercial use for lumber production is relatively new. And, the following basic questions have to be answered before the urban lumber potential can be evaluated: 1. How much woody green waste is suitable for lumber production? 2. Who will process it? 3. What will the products be? And, 4. Who will buy them? The proposed solutions to these questions is part of a three-phase study. This report deals with Phase I which includes the first two questions above plus the impact of woody green waste on A.B. 939, and how to setup an urban sawmill business.

Some of the difficulties encountered in reviewing the literature on woody green waste were that there were many conflicting and overlapping definitions of waste in general and woody green waste in particular. And, no reports specifically quantified sawlog-size woody green waste. We've defined woody green waste to be: discarded plant material with woody characteristics, namely trunks and large branches. Quantifying units are also imprecise and inconsistent from one report to another. We have assumed that there are approximately 3 T. of green waste/yd^3, that 1 yd^3 of hardwood logs equals ca. 80 bd. ft. of lumber, and that 1 T. of hardwood logs contains 160 bd. ft. of lumber.

3.0. Past Work. An early estimate by the Tellus Institute (1991) of the volume of California solid waste by general waste categories indicated that ca. 50 mil. T. of solid waste were produced in California in 1990. Of this amount, 16% was classified as yard waste and 4% as wood waste. Apparently, log-sized material was a component of the wood waste category, but its proportion was not reported. At any rate, about 95% of this material was disposed in landfills and less than 1% was recycled. Between 1990 and 1994, there was a 14% decline in solid waste disposed in California landfills (Environmental Science Associates and Pryde Roberts Carr, 1995). Wood waste updates have been published by the California Integrated Waste Management Board since 1994, but they did not track sawlog-size material. Consequently, the annual volume of California sawlog-size urban woody green waste could not be determined from any of the official reports generated by the state.

However, the NEOS Corp. (1994) published a comprehensive report about the amount of urban tree residues produced in the U.S. that was directly applicable to our work because they tracked log-size material. They defined a log as “unchipped wood residue greater that 12 in. in diameter.” They reported that 200.5 million yd^3 of urban tree waste were produced annually in the U.S. and 15% or 30 million yd^3 were composed of log-size material. In California, commercial tree care companies were reported to produce 48% of the urban tree waste or about 8.6 million yd^3 of which 16% was in the log-size category.

Perhaps even more basic than log volume is information about are how many urban trees there are in California, and how many are removed each year. Bernhardt and Swieke (1993) reported that there were 7.5 to 8.8 million managed street trees in California. Larsen (1995) estimated that there were about 10 million publicly managed urban trees, but he estimated that there were also 60 million privately owned urban trees. On a county-wide basis, McPhearson (1998) reported that there are ca. 6.0 million trees in Sacramento County of which 1.7 million were considered to be “urban”. Of this number, only one in fourteen were classified as publicly managed trees; however, they tended to be larger in size than privately owned urban trees.

Most urban trees are removed because they are dead or dying (25%) or because of hardscape damage (24%), i.e. trees that damage sidewalks, buildings, etc. (Bernhardt and Swiecki, 1993). They also reported that 70% of California’s urban communities removed less than 1% of their urban trees each year. Out of 150,000 street trees in Sacramento, around 825 (or 0.6%) are removed annually (Fitch, 1997).

On a state-wide basis, Larsen (1995) estimated that if the annual removal rate of urban trees was 1.5%, this amounted to 262,000 trees (0.015 X 70 mil.). If 1/4 of these trees had an average lumber volume of 75 bd. ft., then the volume of street trees removed annually would be almost 20 mil. bd. ft. On the other hand, the NEOS Corp. (1994) estimated that 968 tree care firms in California each removed 8,900 yd^3 of tree residue per year of which 1,400 yd^3 were log-size material. Assuming a conversion rate of 80 bd. ft./yd^3, this amounted to 110.4 mil. bd. ft. of log-size urban woody tree residue removed each year in California by tree care companies. This is about half the amount of urban tree residue removed by all sources.

Waste tree disposal is expensive and costs around $28/T. at California landfills. On the other hand, a large, healthy urban landscape valley oak 24 in. in DBH (diameter breast height) might be worth as much as $14,000 using the International Society of Aboriculture’s tree valuation criteria (i.e. $31/$in^2$ DBH). While the same tree, if dead, would have zero value and could be a liability. On the other hand, it might be worth $600 if milled into kiln-dried lumber and almost $5,300 if cut into specialty pencil stock. Milling urban street trees into lumber and value-added products can also have community and environmental benefits.

4.0. Size of the Urban Woody Green Waste Resource (Arborist and Landfill Surveys). In this section, two surveys are described that determine: 1. The amount of sawlog-size urban woody green waste being disposed at California landfills, and 2. The amount of sawlog material produced by commercial tree care companies. Data entry and analysis were done via SPPS® for Windows™.

For the landfill survey, a 27% response was obtained from the 101 landfills in the survey sampling frame. The amount of green waste estimated to be disposed at landfills in 1996 was 3.2 mil. T. Only 1.3% of the total waste was categorized as woody tree waste of which only 6.1% was greater that 12 in. in diameter and 4 ft. or greater in length. This was less than 0.1% of the total solid waste stream in 1996 (equal to about 4 mil bd. ft.). The highest proportion of green waste (i.e. 30%) was disposed at landfills in the summer and least (17%) in the winter. Monterey pine was the species most often identified in the waste stream. Over 55% of the landfills disposed green waste directly into the landfill while less than 0.1% directed sawlog-size material to lumber production.

The objective of the arborist's survey was to determine the amount of urban sawlog-size material that could be available each year from this source for lumber production. Recall that the NEOS Corp (1994) reported that 48% of California's urban tree residue was produced by commercial tree care companies. Our sample frame consisted of 310 California arborists certified by the ISA, and the response rate was about 20%.

Each tree care firm produced approximately 9,600 yd^3 of green waste per year. Of this amount, about 50% was greater than 6 in. in diameter and 2,400 yd^3 (about 25%) was greater than 12 in. in diameter. Assuming that 1/2 of the 12 in. plus diameter green waste was suitable for lumber production, each tree care firm potentially generated about 97,000 bd. ft./yr. On a state-wide basis, using our sample frame of 310 arborists, this amounts about 30 mil bd. ft/yr. Only about 23% of the arborist's time was involved in tree removal while trimming accounted for 70% of the other work. Somewhat surprisingly, there was only a slight seasonal variation in work load with slightly more work in the fall. About 29% of the unchipped woody green waste was left on site, and only 2.3% was used for lumber production. In regard to species, Monterey pine and various eucalyptus species were the most common trees processed.

5.0. Milling Operations Using Urban Sawlogs. This section includes a brief description of California's logging history. It itemizes thirteen factors that have historically limited the state's commercial hardwood industry (Huber and McDonald, 1994) and indicates how these factors relate to urban sawmill enterprises. However, most of this section involves a description of six California custom sawmills and one in Utah that get some or most of their sawlogs from urban sources. A new program called "Trees to Furniture" that is sponsored by Wood-Mizer Products, Inc. and Popular Woodworking Magazine got started 1997. It encourages individuals and small groups to "rescue" fallen or removed urban trees that are suitable for processing into salable lumber. Finally, there is reference to eighteen other small, custom sawmills operating in California.

6.0. Utilization potential for Wood from California Urban Trees. A brief description of the hardwood industry and some of the potential markets for urban wood products are noted in this section. This is followed by a description of several factors that affect or limit urban sawlog utilization such as species, log size and quality, wood characteristics, and embedded metal - a particular problem with urban trees. There are also tables listing physical and wood working properties of twenty-nine native and exotic urban street and landscape trees including their specific gravity, density, hardness, percent of tangential shrinkage, warp index, machinability, texture, color, and brief comments about workability. There is also a list of potential products that can be obtained from sawmill residues.

7.0. Setting up an Urban Sawmill Business. The focus of this section is to provide the pertinent information needed to establish an urban sawmill business, ranging from the basic components of an appropriate business plan to the specific equipment needed and its cost for two types of urban sawmills. The information for a business plan and various aspects of financial management are mostly derived from “A Management Plan for Hardwood Sawmills” produced by the Sierra Resource Group (1997) for the High Sierra Conservation and Development Area. Of special note, is the RMDZ (Recycling Market Development Zone) Loan Program wherein low interest loans are available for financing waste recycling enterprises including those that utilize urban sawlogs. Many of the factors that affect lumber value such as species, grade, green vs. kiln-dried, etc. are described. There is a complete list of sawmill equipment requirements and sources by the various “cost centers” involved in a lumber production. Finally, there are complete descriptions of equipment needs, costs, and annual profit and loss estimates for two types of urban sawmills.

8.0. Manufacturing Techniques and Quality Control. The final section of this report covers a variety of factors that deal with manufacturing techniques and quality control. A few basic guidelines relating to “Tree Selection, Harvesting, and Log Production” are provided along with some comments about log storage. Excessive cracking can develop as logs dry that can completely ruin their value for lumber production (Hall, 1998). Embedded metal and other objects are a major problem with urban sawlogs; dealing with embedded material is described in Appendix N which was copied from “Recycling Urban Trees” by Cesa et al. (1994). There is also a brief discussion about and the advantages of flat-sawn vs. quarter-sawn lumber.

Perhaps even more relevant to this report is the discussion about lumber drying. Basically, the value of green lumber can be more than doubled by careful drying and at a cost that is less than it took to mill it. Generalized drying schedules for “typical” western hardwood and softwood species are provided along with basic information about different drying methods and kiln sources. Drying defects are a major source of reduced lumber value and above all, “Slow drying during the critical stage minimizes defects”.

An elementary understanding of lumber grades and grading systems is essential for anyone in the sawmill business. A brief description of the grading systems is provided plus references to more in-depth coverage and where professional grading services can be obtained.

11.0. Appendices. Finally, the Appendix includes seventeen items that provide a variety of different types of specific useful information. The first two appendices, Appendix A (Abbreviations) and B (Definitions), are provided to facilitate reading the report. Appendices C through H are practical tables that can be used to determine log and lumber volumes, weight, density, etc. Material related to the Landfill and Arborist surveys are covered in Appendices I through K. The final group of appendices include financial information (Appendices O and P), how to deal with logs and embedded material (Appendices N and Q), and a list of the other small, custom sawmills in California (Appendix M).

1.0. INTRODUCTION.

Disposal of waste material (trash) is a major financial and ecological problem for urban areas of California. A growing population and the production of disposable commodities have greatly increased the problem of economically and environmentally sound waste disposal. It's been estimated that 15-30% of urban waste is classified as "Green Waste". Green waste is defined as any plant material that has been removed and traditionally discarded including logs, branches, fruit, etc. Concerned California legislators recognized the seriousness of the disposal problem and passed the California Waste Management Act (AB 939) in 1989. It requires cities to reduce the waste shipped to dumps and landfills by 25% in 1995, and by 50% by 2000.

Reducing the amount of woody green waste that goes to landfills is only part of the reason for interest in this potentially valuable urban "natural" resource. There are a number of economic and environmental benefits that can be realized by utilizing larger woody green waste (sawlogs) for lumber and other solid wood products. Cesa et al. (1994) note that: "Merchandising sawlogs from street tree removals is an alternate recycling strategy that municipalities can use to generate income for tree management and maintenance programs." Indeed, tree removals alone may amount to more than 50% of a municipality's tree management budget.

It's estimated that as much as 20 to over 200 million board feet (bd. ft. -- see **Apprendix A** for abbreviations) of woody green waste is removed from urban areas in California each year (Larsen, 1995; NEOS Corp., 1994). However, only a fraction of this material actually ends up at a landfill; most of it is used for firewood, chips, or mulch and only a very small amount is currently being milled into lumber. In addition to potential economic return from producing high value wood products, milling urban sawlogs could reduce the demand for lumber from commercial (even tropical) forests.

Summary of Advantages of Utilizing Urban Sawlogs

- Reduction in the amount of woody green waste going to landfills.
- Reduction in landfill costs for disposal of materials and conservation of landfill space.
- Reduction in labor cost by reducing the amount of crew time needed to process logs into firewood or pieces small enough to handle.
- Reduced cost of tree removal to homeowners and/or organizations responsible for tree maintenance.
- Generation of income from selling and/or processing logs into lumber and value-added products.
- Production of valuable, unique lumber not normally available from other sources.
- Conservation of forest land resources by producing sawlogs from urban trees that must be removed anyway.

2.0. BACKGROUND.

The production of green and non-green waste (cans, bottles, paper, used oil, etc.) has grown dramatically in California in the last decade (Tellus Institute, 1991). Having reached capacity or for other reasons, many of the older dumps and landfills have closed. This greatly increases the amount of waste going to those facilities still open and thus quickly reducing their life expectancy. In addition to that, disposing waste material is an expensive proposition that can cost $20-$50 or more per ton (called a tipping fee) just to dump (CIWMB, 1994). And, collecting and transporting waste may cost an additional $25 or more per ton.

In 1989, with a huge mountain of solid waste growing bigger each year, landfills reaching maximum capacity, increasing environmental concerns, and with the increasing cost of waste disposal and rising land values, the Legislature passed AB 939 which mandated a complete change in the management of solid waste in California (Tellus Institute, 1991). AB 939 provided the following hierarchy of waste management options in reduced order of preference, with a trip to a landfill the least desirable option (Comments in parenthesis refer to sawlog-size urban material.):

Hierarchy of AB 939 waste management options

1. **Maximum reduction of waste material generation.**
   (Probably not much potential for urban woody green waste as long as there are urban forests, although better species selection and management could reduce green waste production.)

2. **Recycling and composting as much as possible.**
   (Growing in importance for non-woody green waste.)

3. **The remainder to be processed in transformation facilities, i.e. incineration.**
   (Appropriate for all woody material, but closure of biomass-fueled electricity generating plants strongly limits it's current potential.)

4. **Last and least desirable, the landfill.**
   (It appears that not much sawlog-size material currently ends up in a landfill.)

Obvious solutions to the woody green waste disposal problem are: 1. reduce the amount of green waste being produced, 2. utilize as much of that being produced as possible, and 3. burn it for energy production. Recycling non-green waste is well established throughout California; many communities have programs for recycling glass, paper, aluminum, plastic and other solid waste. There are fewer programs that utilize green waste, and most of these don't involve sawlog-size material. Those that do, usually process it into firewood and only a few mill it into lumber.

One outstanding example of recycling green waste is by the southern California community of Leisure World in Laguna Hills whose program was developed by Tom Larsen of Integrated Urban Forestry (1997). Laguna Hills, a community with 60,000 trees, may produce up to 2,600 T. of green waste per year. About 33% of this waste is processed into compost or mulch valued at \$8-\$10/yd^3 or about \$40-\$50/T. Overall benefits of the program include better tree management, reduced production of green waste, healthier trees, reduced water and maintenance requirements, and a valuable end product that helps pay for their urban forest's upkeep.

Utilization of large branches and bolewood from urban sites for solid wood products is currently being done by only a few wood processing plants in California. Several of these custom sawmilling businesses are described in Section 5.3. Most of these operations mill urban sawlogs into solid wood that can be used for furniture, flooring, cabinetry, and other specialty or niche market products. Some of California's native tree species such as madrone (*Arbutus menziesii*), walnut (*Juglans* spp.), and laurel, (*Umbellularia californica*) as well as many non-native urban species have unique physical characteristics that make them highly valuable for both traditional and specialty products. Because of the "recycling" aspect of utilizing urban woody green waste, potential wood products have an "environmentally friendly" character that is becoming increasingly important to many buyers of wood products.

Although use of California hardwoods dates back more than 140 years, it, like urban sawlogs, is still mostly an under-utilized resource even after many unproductive attempts to produce a viable industry. This is especially true in regard to a "commodity" market for which a large, continuous supply of lumber is required. Currently, however, many of both the native and non-native tree species are well suited for local markets that are more flexible and cater to individual customers and specialty products. This approach and the establishment of wood "cooperatives" where small producers pool their resources for milling, drying, and marketing of their products may be the solution to a viable hardwood industry in California. Dave Parmenter's California Hardwood Producers, Inc. was the only major attempt to operate a wood cooperative in California in recent years. And notably, about 60% of its wood resource comes from the urban woody green waste of Sacramento and other local communities.

2.1. PROBLEM STATEMENT.

The California Waste Management Act of 1989 (AB 939) mandated a reduction of urban waste of 25% by 1995 and a 50% reduction by 2000. Fifteen to 20% of urban waste is classified as green waste that includes grass cuttings, leaves, twigs, and trunks. Utilizing the larger limbs and trunks for valuable wood products would not only reduce the amount of green waste that goes to landfills, it would also provide an economic return for this material. In order to achieve this goal, the volume of green waste must be quantified, sawmills identified and markets for the wood products defined or developed.

2.2. PROJECT SOLUTION AND PLAN.

A three phase approach was proposed to estimate the volume of the urban sawlog resource, to describe current milling operations, and to estimate the current and future market potential for urban waste green wood. Each phase of the study will produce a formal report that will be available via the internet to the general public with a hard copy of the report submitted to the California Department of Forestry and Fire Protection (CDF), the project sponsor.

- ***Phase 1*** Estimates the size of the urban sawlog resource, documents milling operations using urban sawlogs for at least part of their wood supply, and documents the equipment and cost of setting up a small sawmill. In addition, an evaluation is made of the economic impact of AB 939 on the disposal of sawlog-size urban woody green waste and economic feasibility of utilizing urban sawlogs.

- ***Phase 2*** Identifies existing and new niche products that would increase consumers demand for "environmentally correct" wood products. A new brand or certification of such products similar to "organic" and "recycled" may be developed. Consumer exposure to the new concept will yield a demand estimate.

- ***Phase 3*** Examines the business interest in harvesting urban waste wood and potential users of the product. Economies of scale that may be achieved through cooperative efforts will be examined.

Please note that only Phase 1 of this project is covered in this report.

2.3. GENERAL DESCRIPTION OF PHASE 1 METHODOLOGY.

The following three sections describe the specific type of information that was collected, indicate which objectives in the grant proposal were attained, and describe how the final report was disseminated.

2.3.1. Estimate of Resource Size.

The potential for growth in urban milling operations was determined by estimating the size of the of the urban sawlog resource. Primary and secondary data were used to quantify the supply of woody green waste that was removed from urban sources, including species, sawlog size, and seasonal availability. Information was obtained from:

- Landfills
- Commercial tree service companies
- Other sources, i.e. published reports and personal communications.

Primary data were collected from the above sources through the use of mail, fax, internet, and phone interviews.

2.3.2. Estimate of Economic Feasibility of Utilizing Urban Sawlog-size Green Waste.

Existing custom saw mills were examined to provide a model of an urban sawmill operation. Most of these businesses were operating at a break-even point. Their business practices were used as a general baseline for defining the costs and profitability of utilizing urban sawlogs. Information was obtained through personal visits and telephone interviews.

Seasonality of the supply and the species utilized by these businesses were identified as well as differences in their operations. The size and proximity of the urban wood resource used were examined for one of the mills. The anticipated penalties incurred by municipalities not complying with AB 939 in 2000 were briefly evaluated to estimate the impact on the profitability of utilizing urban waste trees. The numbers and types of users of urban waste wood and the economic impact of AB 939 were not examined as proposed. Neither time nor funds were adequate to obtain this information which is more appropriately evaluated in Phase 3.

2.3.3. Dissemination of Final Report.

The final version of this report is available for viewing and/or downloading from Cal Poly's Urban Forest Ecosystems Institute website at: www.ufei.calpoly.edu. There is no current plan to provide published copies of this report.

2.4. Factors that Make it Difficult to Quantify Urban Sawlog Volume.

Estimating the size of the urban woody green waste resource that is suitable for milling into lumber is difficult for several reasons. This is even a major problem for the California Integrated Waste Management Board (CIWMB) who are responsible for carrying out the various mandates of AB 939 that require determination of the amount of solid waste generated in California each year. This has been especially true for the various types of wood waste that are produced, and no California surveys specifically identify the urban sawlog-size material. The overall problem is stated in one of the conclusions in the 1994 CIWMB report on non-yard wood waste, namely: "The data needed to quantify the amount of non-yard wood waste is incomplete, conflicting, or non-existent." The same conclusion was noted in their 1995 report. Non-yard waste includes all types of wood waste, both green and manufactured; but excludes smaller green waste such as tree trimmings, grass clippings, brush, leaves, and weeds.

Several of the factors that make it difficult to accurately quantify the amount of sawlog-size green waste are listed below and are briefly described as follows:

- **No record of data.** Information about sawlog-size material is either not recorded at all, or this material is mixed in with other wood waste where it can't be identified, e.g. non-yard wood waste information collected by CIWMB includes all types of wood waste. Keeping track of wood waste by type and quantity of component would be expensive, and there has been no mandate or incentive to do so.

- **Unfamiliarity with sawlog and lumber standards.** Most workers who deal with urban tree removal, disposal, and landfilling have little or no familiarity with log and lumber grading and standards. This is not surprising because there has been no financial or other reason for them to know this type of information.

- **Confusing terminology.** There has been no standardization of terms to describe the different components of green and wood waste. Different reports use different and/or overlapping terms that make it difficult to compare waste volume estimates.

- **Inadequate information.** Evaluating the potential urban sawlog resource based on tree number or volume alone, has some inherent limitations. Essential information about tree species, log size and quality, and other pertinent qualifying factors can not be determined from tree numbers and volumes. Consequently assumptions and/or conversion factors used to make resource estimates may not truly reflect the type and quality of lumber that can be obtained.

- **Inaccurate conversion factors.** The use of several conversion factors may be needed to estimate expected board foot production from cubic yards or tons of woody green waste. Moisture content, density, and other factors vary with species and over time, making weight conversion to board foot volume extremely inconsistent. Likewise, wood volume will depend on the level of compaction, crookedness, and amount of branching. Under controlled conditions, variability can be minimized, but this is not possible with normal tree removal and disposal activities. Consequently, state-wide board foot estimates will never be very accurate.

- **Inadequate tree removal records.** Even today, many municipalities don't have adequate inventories of their street trees and don't keep accurate track of how many street trees are removed. Information about the removal of private residential trees is even less available, even when a permit is required for removing a tree above a certain diameter. Often there is no follow-up after a permit is issued. Also, trees are removed by homeowners, woodcutters, tree service companies, and others that never get reported. Were there a well identified market for sawlog-size material, some of these logs would probably make their way to a mill.

- **Variation in size of landfills and tree service companies.** Reports that deal with urban tree residue and landfill solid waste flow note the wide variation in their sample populations. For example, on a U.S.-wide basis, three tree service companies dominate in the amount of trees removed versus the small and even one-man operations. The county landfill operations in California are likewise highly variable in size with Los Angles County receiving up to 36% of California's solid waste compared to less than 0.1 % for Mono County. Such variations in scale can greatly confound the interpretation of urban sawlog volume data.

- **Extrapolation to state-wide totals.** The last problem to be identified deals with the determination of state-wide urban sawlog statistics. For example, determining the maximum volume of urban sawlog-size green waste generated by sample tree care companies is straight forward for a given company and the sample population at a given confidence level. Here the problem begins. Just how many companies are there? How many trees are removed by uncertified or unadvertised companies and individuals? How accurately can the mean sawlog values per sample be extrapolated to state-wide totals? Our survey results are discussed in Section 4.3.3.1.

Finally, with all of these and other complicating factors and uncertainties, how can an accurate estimate of California's urban waste sawlog resource ever be determined? Well, it probably won't be, and it probably won't be too important anyway. What can be done is to estimate reasonable values for less than maximum state-wide production. And, it's probably more important to have local resource estimates where it can be determined whether or not there is an adequate sawlog supply for a given-size small custom sawmill. For the low production mills described in this report, knowing the volume of the local sawlog supply is far more important than knowing state-wide volume estimates.

2.5. DEFINITIONS.

The problem of different, overlapping, or no specific definitions to describe the various categories of urban green waste were briefly referred to in Section 2.4. The following is a list of key definitions from references that are relevant to this survey, and there are a few terms defined specifically for this report. Also, there is a general list of forestry and wood related definitions in **Appendix B**.

2.5.1. Published Definitions.

The following definitions are used in other reports:

TELLUS INSTITUTE (1991)

- **Yard waste** -- usually organic waste resulting from the maintenance or alteration of landscapes including but not limited to grass clippings, leaves, prunings, brush, and weeds.

- **Wood waste** -- waste materials consisting of wood pieces or particles (This is a subheading under "Other Organic Categories"). Presumably this includes all types of wood such as demolition wood, manufacturing waste wood, furniture, etc. and probably urban logs. There is no way to determine what proportion of this category represents urban sawlog-size material.

CIWMB (1994)

- **Biomass** -- Any organic matter which is available on a renewable basis including but not limited to forest residues, agricultural crops and wastes, wood and wood wastes, animal wastes, livestock operation residue, aquatic plants, and municipal wastes. CIWMB's reference to biomass resources in California from a report by the California Energy Commission includes four categories of wood residue that could include sawlog-size material. Included in this group is "urban wood waste" which is probably the same as "wood waste" from the Tellus report noted above. Urban yard waste is included with eight additional biomass categories in this report, and urban yard waste is presumably comparable to "yard waste" above. Again, there is no way to identify an urban sawlog component. The other two categories that contain sawlog-size material are logging and mill waste, and they are not relevant to this study.

- **Non-yard wood waste** -- includes pieces of wood generated during the manufacture or processing of wood products, the harvesting or processing of raw woody crops, as well as the wood debris from construction and demolition activities. It excludes green waste such as tree trimmings, grass clippings, brush, leaves, and weeds. Presumably "non-yard wood waste" is comparable to "wood waste" above. Again there is no way to identify sawlog-size material.

- **Urban wood waste** -- includes pruned branches, stumps, whole trees from street and park maintenance, used lumber from shipping pallets, and other debris from demolition and construction activities. This category seems to be very similar to "non-yard wood waste" above, but presumably it is generated from urban sources which would likely exclude forest slash and most sawmill waste.

NEOS REPORT (1994)

- **Urban tree residue** -- includes green material such as tree limbs, leaves, tops, brush, stumps, and, grass clippings. Because this report deals specifically with tree residues it includes two categories with sawlog-size material, namely: **"Logs"** : unchipped wood, usually with a diameter greater than 12 in.; and **"Mixed wood"** : combinations of logs, whole tops and brush. Other urban tree residue components are referred to later in Section 3.1.2. This is similar to "urban wood waste" noted above, but includes only green waste material and excludes construction debris, sawmill residue, etc.

O'KEEFE (1995)

- **Green waste** -- includes any plant material that has been removed and traditionally discarded including leaves, wood, stems, flowers, fruit, etc. This is approximately the same as "urban tree residue" above.

2.5.2. Other Definitions.

The next four definitions were defined specifically for this report, while "recycling" and "reuse" refer to alternate methods of waste disposal associated with AB 939.

- **Woody green waste** -- any plant material resulting from tree maintenance or removal with wood-like characteristics.
- **Sawlog** -- a tree that has been harvested and is greater than 12 in. in diameter at the small end and more than 4 ft. long.
- **Small sawlog** -- a tree that has been harvested and is between 6 to 12 in. in diameter at the small end and more than 4 ft. long.
- **Utilization** -- to convert (mill) sawlogs into lumber or other wood products.
- **Recycling** -- the process of collecting, sorting, cleansing, treating, and reconstituting materials that would otherwise become solid waste, and returned to the economic mainstream in the form of raw material for new, used, or reconstructed products that meet quality standards necessary to be used in the marketplace (CIWMB, 1994).
- **Reuse** -- to reuse processed wood as a building material with or without remilling. If reused graded lumber remains intact, it must be recertified for use in construction. Reuse does not apply to milling lumber from sawlogs.

SUMMARY OF WOOD WASTE DEFINITIONS

Category	Types of materials
Yard waste = Urban yard waste clippings, leaves, prunings, etc.	Non-woody material; includes grass
Wood waste = Urban wood waste = Non-yard wood waste	All types of woody material; used lumber, logs, demolition wood, etc.
Urban tree residue = Green waste	Discarded plant material; leaves, wood, stems, branches, grass clippings, etc.
Woody green waste	Discarded plant material with woody characteristics; branches, trunks, etc.

2.6. CONVERSION FACTORS.

To estimate potential board foot volume from urban sawlogs, it is necessary to use conversion factors to transform volume, weight, or other measurements from one set of units to another. Some of the problems associated with some of the conversion factors were briefly noted in Section 2.4. Because of the variation in weight, moisture content, compactness, species, and other factors, it would be difficult to obtain very accurate and/or consistent board foot volumes. Even the weight for a given species is highly variable. For example, the weight of 100 ft^3 of solid wood volume for Monterey pine is about 6,000 lbs. green, but only 4,000 lbs. when partially dry (50% M.C.). For a dense hardwood like valley oak, the green weight is about 8,000 lbs./100 ft^3. Consequently, state-wide estimates should be viewed as only “ball-park” estimates when converting from one unit to another. The key conversion factors used in this report are noted below plus reference to a number of standard forestry conversion tables that are in the Appendices.

2.6.1. Tons to Pounds per Cubic Yard.

Solid waste including wood is commonly measured in cubic yards or in tons. Weight per ton for waste will obviously depend on the various components and the degree of compactness. Some of the weight to volume ratios reported in the literature are as follows:

- ***Tellus Report (1991).***
  - Mixed solid waste -- (All types of waste) = 572 lb/yd^3
  - In-truck density -- Yard waste = 780 lb/yd^3
    -- Wood waste = 462 lb/yd^3
- ***NEOS Report (1994)***.
  - Tree and landscape residue -- = 667 lb/yd^3
    (Based on the approximate ratio of 3yd^3/T)

2.6.2. Cubic Yards to Board Feet.

Converting cubic yards of woody material (logs) to board feet is a common volume conversion. Its accuracy depends on how tightly the material is stacked, crookedness, branchiness, and species. The ratio of board feet to cubic feet can vary from 3 to 8 with 6 as an average value, i.e. 6 bd. ft./ft^3 of logs or a 50% recovery rate (Nunns, 1949). This works reasonably well for soft woods which tend to have straight trunks. Hardwoods because of their greater tendency to be crooked, are assumed to have a 25% recovery rate ratio 3 bd. ft. to 1 ft^3 (Pillsbury, personal communication, 1997). Therefore:

- Mixed hardwood logs -- 1 yd^3 = 81 bd. ft. (or ca. 80 bd. ft./yd^3)
- Softwood logs -- 1 yd^3 = 162 bd. ft. (or ca. 160 bd. ft./yd^3)

How well the above conversion factors will work when converting cubic yards to urban logs to board feet is not known, but they should fall within the wide range of other logs noted above.

2.6.3. Tons of Logs to Board Feet.

The following is a rule-of-thumb from Guy Hall (1998) who ran Cal Oak Lumber Co. for more than 20 years. This is an important relationship because it ties log weight to board feet of green lumber that is produced from an assortment of irregular shaped logs. Logs that are similar to those that might available from an urban environment.

- Tons of green hardwood logs to board feet = 6.0 to 6.5 T./1,000 bd. ft. or, approximately 160 bd. ft./T.

Another rule-of-thumb that Guy Hall had for lumber production was based on percent overrun and defect loss. He found that loss to defect was about 25% of log volume. Likewise, overrun was also about 25% greater than the scaled log volume. Therefore, the scaled log volume was approximately equal to milled board foot volume.

2.6.4. Cubic Feet of Wood per Cord.

Based on information referred to in Section 2.6.2. above, a cord contains 128 ft^3 of space. Actual wood volume per cord ranges from 75 to 115 ft^3. Nunns et al. (1949) assume an average of 90 ft^3 of wood/cord. Based on these assumptions, the expected board foot lumber recovery/cord for softwoods and hardwoods is:

- Board feet per cord for softwoods = 540 bd. ft./cord
- Board feet per cord for hardwoods = 270 bd. ft./cord

2.6.5. Conversion Tables.

There are several tables in the Appendices that can be used to calculate a variety of different kinds of tree and wood values. Some of these are as follows:

- **Appendix C** . Log volume -- International 1/4 in. log scale (bd. ft.)
- **Appendix D.** Solid cubic contents of logs (ft^3)

- **Appendix E.** Lumber volume for different end dimensions and lengths (bd. ft.)
- **Appendix F.** Wood density as a function of specific gravity and moisture content (lb/ft^3)
- **Appendix G.** Wood weight and specific gravity for various tree species (lb/ft^3, lb/MBF)
- **Appendix H.** Log weight as a function of DBH, log length, and density (lb./ft^3)

3.0. PAST WORK.

Several of the factors that make it difficult to quantify the amount of sawlog-size urban tree waste were described in Section 2.4., e.g. unfamiliarity with sawlog and lumber standards, confusing terminology, inaccurate conversion factors, etc. These should be kept in mind when reading the following descriptions of some of the past work with solid waste in general and woody green waste in particular. The first section (3.1.) documents work done after the passage of AB 939 to determine the amount and type of solid waste in California. Section 3.2. deals with the volume and disposal of woody green waste, and especially the nation-wide report by NEOS Corp. (1994) on urban tree residues. The third section (3.3.) covers some of the potential benefits that are associated with the utilization of sawlog-size woody green waste.

3.1. SOLID WASTE VOLUME IN CALIFORNIA.

To accomplish the ambitious goal of reducing the amount of solid waste reaching California landfills of 25% by 1995 and 50% by 2000, AB 939 established a number of new requirements and initiatives. Documenting the size and makeup of the solid waste stream was one of the initial requirements. Some of these reports that relate to the determination of the potential volume of lumber that can be produced from urban sawlogs are briefly described below.

3.1.1. Source Reduction and Recycling Elements (SRRE).

The SRRE is part of the county-wide integrated waste management plans that are developed by local jurisdictions to outline how they are going to achieve the disposal reduction goals noted above (CIWMB, 1994). They list estimates of the solid waste stream components and existing or planned diversion programs within each jurisdiction. There is some uncertainty associated with this information because the data generated are only estimates, and wood waste may be defined differently by a different jurisdiction (CIWMB, 1994). In spite of the limitations just noted, the SRRE data are some of the best information available, and they have been used as a basic source of information for other reports including the two noted below.

3.1.2. Disposal Cost Fee Study Final Report.

This is a report of a study mandated by AB 939 to develop a proposal for a “disposal cost fee” on goods sold in California (Tellus Institute, 1991). The fees were to be based: “on the cost of disposal and potential for environmental degradation of all goods sold in California and normally disposed in landfills or transformation facilities, with the exception of beverage containers subject to redemption.” The data for this report were drawn from many sources and in particular from SRREs or County Solid Waste Management Plans (Tellus Institute, 1991). The report included usable data from twenty-three counties and for the city of Los Angles, but not Los Angles County.

Eight general categories of solid waste were defined for the study including yard waste and wood waste. They are sub-categories of "organic waste"; both are defined in Section 2.5.1. Results of the study regarding disposal paths for yard waste, wood waste, and total solid waste in proportions of the material landfilled, recycled, and incinerated are shown in **Table 3.1** .

Table 3.1 . California landfill facility waste composition data[1]

Material	Tons Landfilled	Percent Landfilled	Tons Recycled	Percent Recycled	Tons Incinerated	Percent Incinerated	Total Waste (T)
Yard waste	7,396,483	94.2	219,916	2.8	239,827	3.0	7,855,926
Wood waste	1,963,779	96.9	20,854	1.0	41,763	2.1	2,026,396
Other	34,237,914	85.3	5,246,097	13.1	651,079	1.6	40,135,091
Total waste	43,598,176	87.2	5,486,867	11.0	932,669	1.8	50,017,713

[1]Source: Tellus Institute (1991), *Disposal Cost Free Study Final Report.*

It was estimated that slightly over 50 million T. of solid waste were generated in California in 1990. Of this total, about 87% was landfilled, 11%, was recycled, and 2 % incinerated. For wood waste (all kinds of solid wood including logs), almost 97% was landfilled with about 2% incinerated. As noted earlier, there is no way to determine what proportion of the wood waste is sawlog-size tree trunks. At any rate, not much of this potentially valuable resource was being reused, recycled, or even used for energy production. There were over three times as much yard waste as wood waste; presumably sawlog-size material was not part of this waste category. In 1990, yard waste had about the same track record for reuse/recycling as wood waste, Basically, the yard and wood waste resources were both lost.

3.1.3. Toward Securing Adequate Landfill Capacity.

AB 939 requires each county to prepare a "Siting Element" that shall include: "-- an estimate of the total transformation and disposal capacity in cubic yards that will be needed for a 15-year period to safely handle solid wastes generated within the county that cannot be reduced, recycled, or "composted" (Environmental Sciences Associates & Pryde Roberts Carr, 1995). This report provided the California Integrated Waste Management Board (CIWMB) with information on the remaining landfill capacity in California and suggested ways for local governments to achieve the mandated 15 years of disposal capacity. It focuses on ways to facilitate the landfill siting process. Information was obtained from a variety of reports by CIWMB and others, and surveys sent to all state landfills. Information obtained form this report included the total solid waste disposed at landfills from 1990 to 1994 (**Table 3.2.**). However, data were not obtained by category of waste.

Table 3.2. Total tons of solid waste disposed in California landfills 1990-1994[1]

Year	Tons of Solid Waste
1990	39,387,365
1991	36,517,206
1992	35,864,574
1993	33,980,273
1994	33,954,008

[1] Source: Environmental Science Associates and Pryde Roberts Carr (1995), *Toward Ensuring Adequate Landfill Capacity.*

The total solid waste reported for 1990 was about 40 million T., almost 10 million T. less than reported in the Tellus Institute report. However, this total only dealt with waste disposed at landfills, and it didn't include waste from five counties including San Francisco. By 1994, the total amount of waste had declined somewhat each year to about 34 million T. in 1994. This trend is expected as recycling programs developed after 1990.

3.1.4. Non-yard Wood Waste Report.

The CIWMB is required to : 1. assess the amount of non-yard wood waste diverted from permitted disposal facilities in California, and 2. assess environmental and economic impacts of promoting or discouraging diversion of non-yard wood waste from disposal facilities (CIWMB, 1994). One of the first tasks that was done was to define "non-yard" waste (see Section 2.4.). The report also addresses the relationship between biomass facilities and permitted solid waste facilities in regard to wood waste diversion and AB 939 mandated requirements by 2000. The three primary sources of information that were used by CIWMB (1994) to assess the amount of wood waste were the SRREs, the Disposal Cost Fee Study noted above, and the Biomass Facilities Survey and Biomass Resource Assessment Reports developed by the California Energy Commission (CEC). The Nonyard Wood Waste Report was updated in 1995, and CIWMB provided information for a 1997 update (**Table 3 .3**.).

Table 3.3. Revised wood waste estimates from CIWMB reports based on updated SRRE 1990 waste stream estimates[1]

Year	Tons generated	Tons disposed	Percent of total	Tons diverted	Percent of total
1994	3,854,254	3,400,116	88.2	454,139	11.8
1995	3,797,655	3,350,185	88.2	447,470	11.8
1997	3,850,177	3,371,910	87.6	476,267	12.4

[1]Information based on CWIMB's Nonyard Wood Waste Report (1994) and Update (1995), information supplied by CIWMB on their Interim Data Project (1998).

Approximately 3.8 million tons of wood waste were reported by CIWMB for 1994, 1995, and 1997, essentially no change over these 4 years with only about 12 % being diverted from landfills during this time. This is almost double the amount of wood waste reported by the Tellus Institute (1991) and ten times the amount recycled in 1991. Unfortunately, this information is of little help for estimating the amount of potential sawlog-size material, because, as the authors note, there is no certainty what the constituents of the waste stream are. And, the data don't include wood waste used in biomass conversion or disposed in wood waste landfills.

What is of note in this report is that the authors state that the most desirable way to reduce the waste stream is by "reusing" non-yard wood waste as a building material. And, in their definition of reuse, they include milling both trees (sawlogs) and waste wood and they also refer to "Into the Woods", an urban sawmilling enterprise that was successful in doing this. Its the highest order of use of high quality wood that for the most part is disposed in landfills, chipped, or burned. Into the Woods is one of the mills featured in Section 5.3, Small Sawmill Cutting Urban Sawlogs.

The problem of obtaining accurate data was noted earlier along with some of the reasons. The data reported by CEC (**Table 3.4.**) are an example of part of the problem of getting accurate waste wood assessment (CIWMB, 1994). The twenty types of biomass reported by CEC are from different data bases whose origin ranges from 1985 (two sources) to 1990 (five sources). It's not easy to get accurate, reliable, and comparable wood waste information.

Table 3.4. Annual biomass reported as available by the California Energy Commission[1]

Biomass material	Potential generated (T.)	Percent of total biomass
Forest & mill residue	10,702,257	23.0
Urban wood waste	1,621,118	3.5
Urban yard waste	3,054,441	6.5
Other waste	32,247,311	67.0
Total biomass	46,624,097	100.0

[1]Information abridged from CWIMB (1994) Nonyard Wood Waste Report.

Only 3.5 % of the potential biomass that could be used for energy production is projected to come from urban wood waste. This volume is almost the same as the 1.96 million tons in the Tellus Institute Report (1991).

3.2. VOLUME AND DISPOSAL OF URBAN WOODY GREEN WASTE .

One of the requisites for a meaningful evaluation of a potential urban-oriented lumber "industry" in California is knowing with some accuracy the size of the urban sawlog resource. Unfortunately, the solid waste stream information just reviewed in Section 3.1. doesn't provide any specific information about sawlog-size woody green waste. However, whatever its size, it appears that only a small proportion of this material actually gets disposed in landfills. Where it goes will be discussed later in this section. Although the following discussion focuses on an urban-oriented sawlog resource, obviously a mill would not be expected to limit its log acquisition to only urban logs. For example, Dave Parmenter's California Hardwood Producers, Inc. only gets 60% of its logs from Sacramento and other urban areas of Sacramento County; the rest come from rural and forest land. Ultimately, the size of the urban sawlog resource depends on the number of urban trees, how big they get, and when they are removed. The following sections review these topics plus what happens to woody green waste.

3.2.1. Number of Trees.

The volume of lumber that could be produced annually from urban sources in California depends on the size, number, and condition of trees growing on urban sites. Obviously the number trees removed will vary from year to year and will depend on a number of factors. So, how many urban trees are there?

Well, the number of urban trees in California will probably never be precisely known because: 1. the tree population is constantly changing with new plantings and removals and; 2. urban trees can come from such a wide variety of sources including street trees, private trees, park trees, "open space" trees, county trees, and roadside trees under Caltrans jurisdiction. Consequently, there probably will never be an exact account of the urban tree resource. As of 1992, only about half of the 468 incorporated cities in California had a tree inventory for at least some of their trees (Bernhardt & Swiecke, 1993). Without complete information about the resource, it's size and annual turnover can only be roughly estimated.

However, as more cities develop tree inventories and urban tree management becomes more formalized, information about tree numbers (trees present, planted, and removed), tree condition, growth, etc. will be known more precisely. With suitable information stored and transmitted electronically, such as on the internet, it may someday be possible to track the expected volume of trees removed by size and species. Tree removal because of storms, fire, insects and disease, and other accidental causes will likely remain unpredictable.

Bernhardt and Swiecke (1993) estimated that there were approximately 5.2 to 6.3 million street trees and 1.3 to 1.5 million park trees under municipal care. They also included another 1.0 million trees maintained along roadways by Caltrans for a total of 7.5 to 8.8 million urban trees. What Bernhardt and Swiecke did not include, was an estimate of the number of privately owned and maintained trees in urban areas. Larsen (1995) figured that there were about 10 million publicly managed urban trees plus another 60 million privately managed trees for a grand total of 70 million urban trees.

On a local basis, Sacramento's Tree Services Department manages about 92,000 trees along Sacramento's streets, parks, and greenbelts plus another 58,000 trees where they share management responsibility with private owners (Martin Fitch, 1997 personal communication). Overall, there are approximately 6 million trees in Sacramento County, with 1.7 million urban trees, 2.4 million suburban trees, and 1.9 million rural trees (McPherson, 1998).

Of the 1.7 million urban trees, over 90% are off-street, privately owned and managed trees; there is about a 14 to 1 ratio of off-street trees to publicly managed street trees (McPherson, 1998). This is twice as many private trees as that estimated by Larson. If Sacramento is representative of the rest of California, then there is even a larger potential sawlog resource than he estimated. However, tree size is an important variable that may greatly affect the size of the sawlog contribution from off-street trees. Although McPerson (1998) didn't compare the size of street trees versus off-street trees, photo evidence would indicate that in Sacramento **(Fig. 3.1.)** street trees are generally bigger than off-street trees. The size difference is even more obvious in Glendale **(Fig. 3.2.)** where the street trees are distinctly larger.

In summary, there seems to be many more urban trees in California than estimated by Bernhardt and Swiecke (1993) and Larsen (1995). However, many of these additional trees are off-street trees that are too small to produce sawlogs. Assuming that Larsen's estimated 60 million off-street trees are smaller in size than he figured, but there are actually more of them than he figured, then his estimated 70 million urban trees might still be an appropriate number to use to estimate the total urban sawlog resource.

3.2.2. Reasons for Tree Removal.

Trees are removed from urban areas for a wide variety of reasons. Most trees that are removed are in poor condition, but healthy ones are also removed for construction projects and other reasons. In Sacramento, 61% of the homeowners that were contacted reported that they had trees removed because the trees were dead or dying. Other reasons reported included root problems, messiness, insect attraction, and other reasons (Summit and McPherson, 1998). Bernhardt and Swiecki (1993), based on their state survey of urban forestry in California, reported nine general reasons why urban trees were removed (See box).

Why trees are removed from California Urban Areas

Trees dead/dying	25%	Trees hazardous	11%	Development	4%
Hardscape damage	24%	Disease/insects	9%	Other	4%
Storm damage	13%	Homeowner request	7%	Age rotation	2%

(Bernhardt and Swiecki, 1993)

Forty-seven percent of the trees were unhealthy or were damaged by storms, insects, and disease. The California drought during the late 1980's and early 1990's had a major impact on tree death. The current "epidemic" of pine pitch canker in Monterey pine has already killed thousands of trees. So far, most have been landscape trees, but the disease is now spreading to native stands. Many of these trees are well-suited for lumber production. On a nationwide basis, 82% of tree deaths are associated with natural disasters involving wind related storms including hurricanes, and tornadoes and another 16% with ice and freezing (NEOS Corp., 1994). However, the NEOS group did not include insect and disease-related death in their mortality estimates, nor did they include tree removal because of hardscape damage, development, and other non disaster-oriented reasons.

"Other" causes reported by Bernhardt and Swiecki (1993) accounted for 4% of the trees removed and included damage from vandalism and vehicular accidents. They do not mention

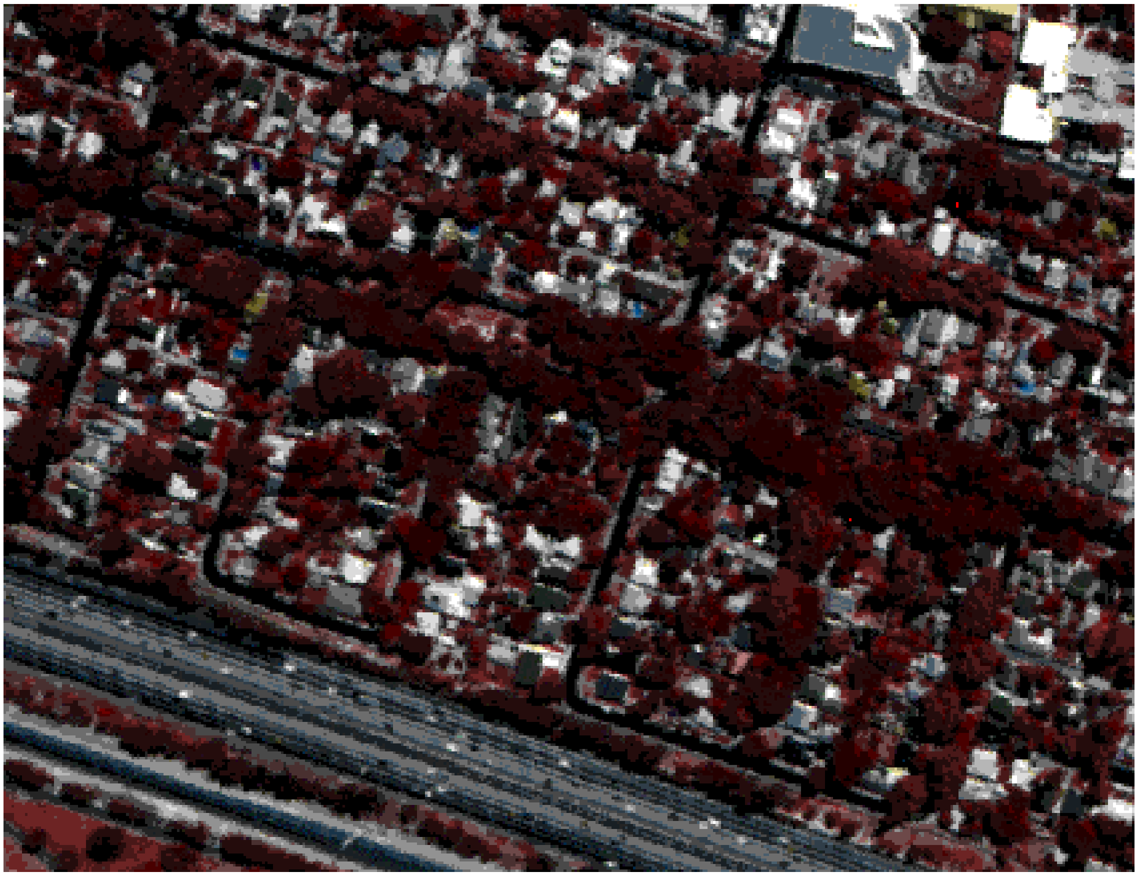


Fig. 3.1. Aerial view of Sacramento's urban forest. Urban trees are found along streets, in private yards, along freeways, in parks and on commercial, educational, and industrial sites. Street trees are generally larger than off-street trees; however, there are almost fourteen times as many off-street trees as street trees in Sacramento. (Photo credit: G. McPherson)

Fig. 3.2. The differential size between street and off-street trees is even more obvious in this photo of Glendale than it was for Sacramento (see fig. 3.1. above). (Photo credit: N. Pillsbury)

losses due to fire or air pollution. Occasionally, there are major losses of urban trees to fire, such as the Tunnel Fire in 1991 when 4,320 street trees were killed and removed in Oakland (Personal communication, Mitch Thompson, 1999). Smaller, but notable losses probably occur in most years. Fire losses are usually going to be associated with more rustic communities that historically have been affected by wildfire or those with large parks or greenbelts (e.g. Girffith Park in Los Angles). Air pollution also affects tree health and probably is responsible for some mortality. Some species are much more sensitive to air pollution than others, especially some of the pine species. On the other hand, there is concern about some tree species, e.g. sweet gum (*Liquidambar styraciflua*), that produce undesirable hydrocarbons (Miller, 1998). Deliberately removing such species for this reason does not seem reasonable, but it may limit their future planting.

Removing healthy undamaged or hazardous trees accounts for up to 37% of annual tree removal (Bernhardt and Swiecki, 1993). Most, 24%, are removed because of the damage (hardscape damage) they cause to sidewalks, sewers, etc. This figure should decline as undesirable tree species are replaced with species that cause less damage. Only 4% of the urban trees are removed because of construction, but this number will vary greatly by community. Those areas with the largest numbers of natural trees usually have the greatest number of trees removed for construction.

Trees removed because they have reached a scheduled “rotation age” was only 2% (Bernhardt and Swiecki, 1993). However, the proportion of trees removed for this reason should increase dramatically in the future as more urban forestry programs recognize the life expectancy of various species and plan for their removal before they become an hazard. Then, with a well established market for urban tree residue and sawlogs, tree removal which is now mostly an expensive burden for most urban forest programs, can actually help subsidize the maintenance of a healthy, productive urban forest.

3.2.3. When Trees Are Removed.

Seasonal variation in tree removal depends heavily on geographic location in the United States as it is affected by local storm patterns. NEOS Corp., (1994) reported that there was fairly equal seasonal tree removal throughout the United States with the following seasonal removal percentages: fall 28%, winter 19%, spring 23%, and summer 30%. Seasonal variation is probably less important in California where storm-associated removal is usually less important. But even here, violent wind-accompanied storms have occasionally downed many trees in localized areas, e.g. Golden Gate park in San Francisco in January 1995 when hundreds of trees were blown down.

3.2.4. Number of Trees Removed.

In any given year, one or more of the reasons just noted can greatly affect the number of trees that are removed, especially for a specific community. Consequently, the supply of sawlogs can vary tremendously from one year to another making it difficult to effectively use all of the resource that‘s available in a “bonus” year, i.e. from the log supply stand point. As noted earlier, Monterey pine death from pitch pine canker related mortality is going to soar in the Central Coast Region for the next few years. And, currently, there is very little lumber being produced from this resource. Don Seawater, a custom mill operator in San Luis Obispo, is overwhelmed with logs. Shipping Monterey pine logs out of the coastal region to other mills is currently restricted.

A number of studies and individual urban reports give a range of expected tree removal rates. In their comprehensive state-wide survey, Bernhardt and Swiecki (1989) found that 70% of the city and county programs removed fewer than 1% of their tree inventory per year, while 17% of the programs removed more than 2% of their trees. In a nation-wide study, Tschantz and Sacamano (1994) reported an average annual removal rate of only 0.4% of the urban tree inventory. They also found that annual tree removal is directly related to population size in cities with less than 1/2 million residents, but removal declined somewhat in cities with larger populations. Annual tree removal ranged from 16 trees for populations of around 5,000 residents to a maximum average of 831 trees for populations between 1/4 to 1/2 million residents. The mean number of trees removed in 1993 was 183 per city.

For individual California cities, Monterey with a street tree population of 14,000 trees, removed 241 trees in 1997 or about 1.7%. This percent will most likely increase as more pine trees are affected by pine pitch canker. Monterey also has 300 a. of Monterey pine green belt with an unknown number of trees in a forest type of stand structure. There is no estimate of the number of trees that are removed from this area. The City of Lompoc has an active solid waste management program that includes an effort to mill urban sawlogs with a portable band mill owned by CDF. With a street tree inventory of 13,061 trees, they removed 350 (2.6%) of the trees in 1996 and 228 trees (1.8%) in 1997. Their removal rate is somewhat high because of the poor condition of their urban forest. Cindy McCall, their Urban Forester, estimated in 1994 that about 65% of the urban forest would have to be removed in the next five years for various reasons with lack of tree diversity the main reason (Thompson et al., 1994).

The City of Sacramento removes around 0.6% of their street trees each year (Fitch, 1998). An epidemic of Dutch elm disease (Ceratostomella ulmi) has accelerated their tree removal rate in recent years. Current work by Summit and McPherson (1998) also gives some insight into residential tree removal in Sacramento, but not to the rate of removal. They found that 66% of the residents had removed at least one tree from their property and often within their first five years of tenure. In regard to tree removal by residents versus tree care companies, both removed about the same proportion of trees, but tree size "significantly" determined who removed which trees. The ratio of tree removal for resident/tree care company was about 69/31% for trees less than 20 ft. tall, and it was exactly the opposite for trees greater than 20 ft. in height. The larger the trees, not too surprisingly, the greater the proportion removed by commercial tree care companies, and they removed all trees greater than 50 ft. tall (Summit and McPherson, 1998).

The relationship of tree size to who removes the trees is of major importance in the later determination of volume of urban woody green waste that's generated from urban areas. The assumption is made that almost 50% of the urban woody green waste is generated by commercial tree care companies (NEOS Corporation, 1994). The size versus who-removes-the-tree relationship substantiates this assumption in that sawlog-size urban trees are most likely to be removed by commercial companies and not residents, thus removing some of the uncertainty about the size of the sawlog resource.

3.2.5. Volume of Sawlog-size Urban Green Wood.

It was noted earlier, that 15 to 20% of urban California waste is classified as yard waste or green waste. For 1990, this was estimated to be approximately 29 million tons (Tellus Institute, 1991). How much of this was large, woody green waste suitable for lumber production was not determined, but it was known that it varied greatly from one community to another. The potential board foot volume from urban woody green waste is covered in the next three subsections based on previous work. The estimates range wildly from a low of about 20 million bd. ft. to a high of 230 million bd. ft. pointing out the need for better inventory methods to identify urban woody green waste. What is missing from all of their surveys is an accurate estimate of the number of urban trees removed per year that have sawlog potential.

3.2.5.1. Larsen estimate. Larsen (1995) reasoned, if there are a total of 70 million urban trees in California and the annual removal rate is 1.5%, that 1.05 million trees would be removed annually. Of that number, he assumed that 25%, or 262,000 trees, would produce an average wood volume of 75 bd. ft. of wood per tree. Total estimated volume of urban wood removed per year would amount to 19.7 million bd. ft. (i.e. 75 bd. ft. X 262,000). The average board foot volume/tree for all trees removed would be about 18.8 bd. ft. per tree.

3.2.5.2. Sacramento estimate. Sacramento currently offers the best opportunity to estimate lumber production from urban green wood waste because it stockpiles its sawlog-size tree trunks that are then milled into lumber by California Hardwood Producers, Inc., Aurburn, California. Sacramento removes approximately 0.6% of its 150,000 street trees annually which amounts to about 15 - 20 tons logs per month (Fitch, 1997). Assuming an average wood density of 50 lb./ft^3, and a cubic-yard to board-foot conversion rate of 80 bd. ft./yd^3 (ca. 25% rate of recovery), the total annual board foot production is estimated to be 28,800 bd. ft./year. (See calculations in the following box.) For comparison purposes, this is an average volume of about 36 bd. ft. per tree, or about two times the 19 bd. ft./tree estimated by Larsen. Total board foot volume removed annually on a state-wide basis using Larsen's estimated annual tree removal figure of 1,050,000 trees equals 37.8 million bd. ft./year.

ESTIMATED LUMBER PRODUCTION FROM SACRAMENTO WOODY GREEN WASTE

Assumptions:

Average green wood density: 50 lb/ft^3

Cubic yard conversion factor to bd. ft.: 80 bd. ft./yd^3

Number of Sacramento urban trees: 150,000

Percent trees removed per year: 0.6%

City stockpiles 15-20 tons of logs per month

Calculations:

Number of trees removed/yr. = 150,000 X 0.006 = 800 trees

Weight of logs = 20 T X 2,000 lb. = 40,000 lb/mo.

Volume of wood = 40,000 lb/50 lb/ft^3 = 800 ft^3/mo.

Cubic yards of wood/mo. = 800 ft^3/27 ft^3/yd^3 = 29.6 yd^3 (or ca 30 yd^3/ mo)

Board foot volume of wood/mo. = 30 yd^3 X 80 = 2,400 bd. ft./mo.

Yearly board foot volume = 2,400 bd. ft. X 12 mo. = 28,800 bd. ft./yr.

Average bd. ft. volume/tree = 28,800 bd. ft./800 trees = 36 bd. ft./tree

(This is approximately equal to a 12 in. diameter log 6 ft. long.)

3.2.5.3. NEOS Corporation estimate. A comprehensive survey of the amount of urban tree residues produced in the United States was sponsored by the Allegheny Power System and published in 1994 (NEOS Corp.). The following paragraphs outline some of the results of this report as they relate to urban tree utilization in California. The overall survey results are based on over 1,300 reports from the 3,878 private and governmental organizations that were contacted throughout the United States.

These organizations were classified into six categories of tree residue generators. The total national production of urban tree residue by generator type is shown in **Table 3.5.** and amounted to 200.5 million cubic yards per year. Data for California tree residue are included in Table 3.5.; it amounted to 17.8 million cubic yards per year. Commercial tree care firms (CTCF) accounted for 48.3% of California's woody urban green waste, somewhat higher than the national average of 36.4% for that group.

The CTCF generator group was based on the four digit Standard Industrial Code number 0783. This code included firms that conducted the following: **1.** arborist services; **2.** ornamental bush planting, pruning, removal, and surgery; **3.** ornamental tree planting, pruning, removal, surgery; and **4.** tree trimming for public utility lines. A total of 968 commercial tree care firms were estimated to be operating in California. The accuracy of this number is very important because the state total tree residue for this generator group is directly related to the number of firms. California is included in a "Western" Section of the U.S. with twelve other states, and the mean amount of residue per CTCF generator is 8,884 yd^3 for a total of 8.6 million yd^3 (**Table 3.5.**).

Table 3.5. Estimate of urban tree residue produced by generator type for the United States and California[1]

Generator group	National estimate		California estimate	
	Volume (1,000's yd^3)	Percent	Volume (1,000's yd^3)	Percent
Commercial tree care	72,937		8,602.5	48.3
Utilities	9,334	4.7	149.8	0.8
Municipalities	15,527	7.7	813.0	4.6
Park & Recreation Dept.	22,382	11.1	1,781.1	10.0
Landscape clearance Co.	5,565	2.8	21.3	0.1
Lawn/garden/landscapers	74,780	37.3	6,434.6	36.2
Total	200,525	100.0	17,802.3	100.0

[1]Adapted from the 1994 NEOS Corporation Report -- from their Appendix H: State Residue and Generator Totals.

Only tree residue was inventoried, and it was classified into seven categories. (See the following box for a definition of these waste categories.) Although the "mixed wood" category included logs, there was no way to determine what the log proportion was; consequently, mixed wood was not included in estimates of potential board foot volume.

TREE RESIDUE (GREEN WASTE) CATEGORIES [1]

Chips: all wood chips. **Logs:** unchipped wood greater than 12 inches in diameter. **Tops** and **brush**: unchipped wood residue other than logs. **Mixed wood**: a combination of logs, whole tops, and brush. **Leaves**: seasonally produced leaves. **Stumps**: only those pulled.

[1]NEOS, Corporation Report (1994).

The estimated national total amount of urban tree green waste by residue category is shown in **Table 3.6.** plus the amount produced by western commercial tree care firms. Wood chips by far make up the greatest proportion of green waste at 67% overall and somewhat less at 46.9% by western CTCFs.

Table 3.6. Estimate of the volume of urban tree waste by residue type for the United States and amount produced by western commercial tree care firms[1].

Residue type	National estimate		Western tree care firms	
	Volume (1,000's yd^3)	Percent	Volume (1,000's yd^3)	Percent
Chips	134,352	66.2	510.9	46.9
Logs	30,078	15.0	174.6	16.0
Tops and brush	16,042	7.9	260.5	23.9
Mixed wood	12,031	5.9	123.2	11.3
Fall Leaves	4,010	2.0	3.3	0.3
Grass and clippings	4,010	2.0	6.7	0.6
Whole stumps	2,005	1.0	11.1	1.0
Total	202,528	100.0	1,090.3	100.0

[1]Adapted from the 1994 NEOS Corporation Report.

The proportion of green waste produced as logs was 15% overall for the U.S. and 16% by western tree care companies. The proportion of waste produced by commercial tree care companies and the proportion of the waste they produce in logs are important because these values can be used to estimate the potential volume of lumber generated from urban tree residue annually in California. (See the following box.)

POTENTIAL ANNUAL LUMBER PRODUCTION FROM CALIFORNIA URBAN TREE RESIDUE [1]

Average annual tree residue per western commercial tree care firm (CTCF): 8,884 $yd.^3$/yr. (Rounded to 8,900 yd^3/year).

Percent of tree residue in logs/CTCF: 16.0%.

Volume of logs/CTCF = 8,900 yd^3 X 0.16 = 1,424 yd^3/yr.

Assume: conversion of yd^3 to bd. ft. is ca. 25% of cubic volume: 80 bd. ft./yd^3.

Therefore, annual bd. ft. of logs/CTCF = 1,424 yd^3/yr. X 80 bd. ft./yd^3 = 114,000 bd. ft.

Assume: number of CTCF in Calif. = 968 firms.

Therefore: Calif. total annual bd. ft. volume from urban logs = 968 X 114,000 bd. ft. = 110,352,000 bd. ft./year (or ca 110.4 million bd. ft./year).

Assume: that CTFCs generate 48.3% of tree residue/yr in Calif. (Table 3.5.).

Therefore, total bd. ft. volume in Calif/yr = 110.4 mil. bd. ft./0.483 = 228,571,000 bd. ft./yr (or ca 228.6 million bd. ft./year).

[1]Based on information from the 1994 NEOS Corp. Report (1994).

Based on available information and the multitude of assumptions and calculations noted above, the potential annual board foot volume of lumber from urban woody green waste from three different sources is as follows:

Source	Annual volume (bd. ft.)
Larsen	19,700,000
Sacramento	37,800,000[1]
NEOS Report	229,200,000

[1]Assumes Larsen's 1.05 mil. trees removed annually at 36 bd. ft./tree

There is almost a twelve-fold difference between the lowest and highest estimate of potential annual board foot volume from urban tree removals. So, which is the best estimate of lumber that could be produced? At this time, the Sacramento estimate seems to be the best of the three because it's based on the fewest assumptions and it deals with real logs from a specific community. The NEOS value seems to be too high and assumes that all of the 968 tree care companies identified actually remove almost 8,300 bd. ft./company/year. This is discussed further in Section 4.3.3.1.

However, a word of caution, keep in mind that these are estimates of potential gross wood volume. The actual amount of lumber that is produced will depend on a number of factors including log size, shape, condition, presence of metal in the log, and available milling facilities.

3.2.6. Disposal of Tree Waste.

An implicit goal of this study is to promote the economic utilization of urban woody green waste, thus reducing the amount going to landfills. How much of the urban tree residue actually gets dumped? Overall, only a relatively small proportion of the sawlog-size material gets to a landfill (**Table 3.7**). In the NEOS Corp. Report (1994) it is estimated that about 17% of all tree waste gets dumped and only 13% of the unchipped logs. The majority of the other unchipped logs, about 76%, are either left on-site, given away, or sold. Of the unchipped logs that are sold, 72% is utilized for firewood. Many communities simply leave the wood on-site or haul it to a central location where it's free for the public to take.

The amount of tree waste that gets dumped in California has declined in recent years (Bernhardt and Swiecki, 1993) while the number of programs that chip tree waste have increased from 46% in 1988 to 76% in 1994. By far, most of the urban tree waste in the United States is chipped or about 67% (**Table 3.6.**). Bernhardt and Swiecki (1993) also reported that the utilization of green waste has increased in recent years because of:

- High landfill costs.
- Public awareness of waste related issues.
- State goal to reduce solid waste going to landfills by 50% by 2000.
- Landfill prohibition because of limited space.

Utilization bolewood from urban sawlogs for the production of solid wood products is being done by only a few small mills in California. Some of the more notable milling operations are Dave Faison's

Into the Woods in Peteluma (Note: Dave Faison passed away in 1998 and his company has since been dismantled.); Dave Parmenter's California Hardwood Producers, Inc. in Auburn; Warren Wise's Woodsman in Stockton; and Don Seawater's Pacific Coast Lumber in San Luis Obispo. Probably one of the best established urban wood milling operation in the United States is John Hessenthaller's Urban Forest Wood Works in Logan, Utah. All of these businesses mill urban sawlogs into solid wood that can be used for furniture, flooring, cabinetry, or other specialty or niche market products. An expanded description of these milling businesses and others currently operating in California is presented later in Section 5.3. titled "Small Sawmills Cutting Urban Sawlogs"

Table 3.7. Methods of disposing urban tree wood waste in general and unchipped logs specifically[1]

Disposal method	All tree residue (%)	Unchipped logs (%)
Give away	42	30
Landfill	17	13
Sold	12	17
Leave on site	11	29
Send to recycle	6	4
Burn for energy	3	2
Open burn	<1	1
Stockpile/use on site	4	3
Incinerate	<1	<1
Other	3	1
Total	100 ±	100 ±

[1]Based on information from the 1994 NEOS Corp. Report.

3.2.7. Cost of Disposing of Green Waste.

The cost for waste disposal is expensive. The national, average fee for dumping a ton of waste at a landfill is about $27 or $9/yd^3 (NEOS Corp., 1994); they assumed that 3 yd^3 equaled approximately 1 T. of waste. Nationwide, landfill disposal costs varied both by region and by the type of organization generating the waste (NEOS Corp., 1994). The average disposal cost was $9.12/yd^3 and ranged from a low of $7.65 in the Southeast to a high of $15.98/yd^3 (about $48/T.) in the Northeast. There was a "significant" difference in landfill disposal cost between the different types of wood waste generators, with commercial tree care companies lowest at $6.25/yd^3 to a high of $45.39/yd^3 for municipal park and recreation organizations. According to the CIWMB, tipping fees in California ranged from $0.0 to $82.62/T., with an average cost of $28.85/T. Tipping fees are only part of the cost of waste disposal. The CIWMB (1994) also noted that the cost of collecting waste wood in California was $26.76/T. for residential collection compared to slightly more for commercial collection at $28.01/T.

Disposing of wood waste at a wood processing facility may only cost $8 to $10 per ton, and some processors may even pay for clean wood. Nationally, 60% of the tree waste generators spent money to dispose of their waste, 30% broke even, and 10% actually made money on their waste (NEOS Corp., 1994). During 1992-1993, Hayward, California reduced the cost of dealing with tree waste by $75,000 (Bernhardt and Swiecki, 1993). They recycled over 551 T. of wood chips for landscape mulch, dump site cover, and fiber. Reference was made to the effective and income producing recycling of green waste by Laguna Hills which recycled about 850 T. of waste per year for $40-50/T.

3.3. BENEFITS OF UTILIZING SAWLOG-SIZE URBAN WOODY GREEN WASTE.

Traditional uses of woody green waste, e.g. firewood, chips, and mulch are only referred to briefly in this report. Rather, the focus is on the conversion of sawlog-size tree trunks into lumber and other solid wood products. Obviously, the economic return for the lumber can be a direct benefit for both the log (tree) owner and log miller. And, a number of additional important values can result when urban logs are milled into lumber. The following sections deal with the value of a tree under different conditions plus a brief discussion of the community, environmental, and woodworker's benefits that can result from the proficient and economical utilization of urban sawlogs.

3.3.1. What Is a Tree Worth?

This section describes the comparative economic values of a hypothetical valley oak (*Quercus lobata*) as it goes from a healthy, useful life to an untimely death due to oak root fungus (*Armillaria melia*), and the many different destinies (uses) it could have thereafter. It should be emphasized that the following analysis is based on a number of simplifying assumptions, and it should used only for a general comparison of different potential tree and product values. Also, not all of the costs for each stage of utilization are systematically identified or included. A more detailed economic analysis is definitely needed to clearly understand the cost or profitability of the following scenarios.

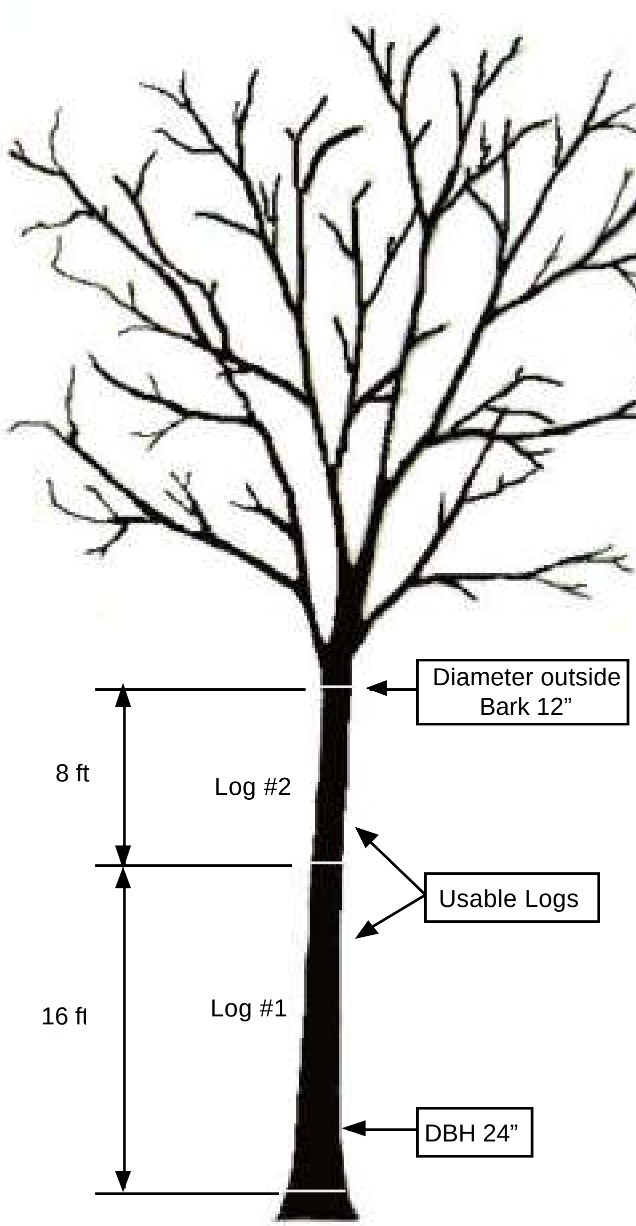
The oak tree used in this analysis is assumed to be located in the front yard of an urban dwelling. It is 24 in. at DBH with 24 ft. of usable trunk (1 1/2 sixteen-foot logs) and a total height of 50 ft. Outside trunk diameter at 25 ft. is 12 in. and the bark is 1 in. thick (**Figure 3.3**). This is a very good timber tree with no defect, and it represents the upper end of urban tree quality.

3.3.1.1. Healthy, urban landscape tree full of life. Thompson et al. (1994), based on several references, note the following potential annual economic benefits from an average urban tree with a 40-year life expectancy:

Benefit	Value per tree per year
Energy savings	$20
Soil and water conservation	$75
Air quality enhancement	$50
Property value (public & private)	$110
Average annual benefits annualized over 40 years	**$225**
(Or, a total of $10,200 for 40 years)	

There are also a number of systems used to determine urban tree value. One system involves a formula method where tree value is based on a specific value per square inch of trunk cross-

What Is A Tree Worth?



Tree Description:

24-inch DBH Valley Oak, 2 trunk logs, no rot or other defects, located in an urban setting.

Log Description:

Log #1: Basal Log, 24 inches DBH, 16 ft long, diameter outside bark at small end = 18 inches, diameter inside bark = 16 inches.

Log #2: Second Log, 8 ft long, outside diameter at small end = 12 inches, diameter inside bark = 10 inches.

Figure 3.3. Hypothetical urban valley oak used in the calculation of “what a tree is worth” under different conditions and potential stages of utilization.

section at DBH. There may be adjustments for species, location, and condition of the tree. The International Society of Arboriculture (ISA) currently uses a base value of $31 per in^2 at DBH. In the following calculations, there are no adjustments for species, location, or tree condition and the valley oak is assessed at full ISA base value:

Tree value = cross-section in in^2 at DBH X $31/ in^2
Cross-section for a 24 inch DBH = 452.4 in.
Tree value = 452.4 in^2 X $31/in^2 = **$14,024**

High values like this are sometimes claimed for deliberately or accidentally killed or severely damaged trees.

3.3.1.2. Dead tree. The valley oak died unexpectedly from oak root fungus. It is now a snag that is potentially hazardous and a liability for its owners.

Tree value: Value at this time is assumed to be **$0.00**

3.3.1.3. Felling the tree. A dead tree is an unsightly hazard in an urban setting and must be removed. Safe felling of a large tree can be very expensive and require the skill of trained arborists. It is estimated that felling the oak and leaving it in place on the ground, but bucking it to firewood-length sections (16 in. long) , and bucking and chipping the branches and foliage would cost about $320 at $40 per hour (Personal communication with Craig Linquist, 1998).

Tree value: -$320

3.3.1.4. Tree removal to a landfill. One way to deal with the dead tree trunk is to buck it into manageable lengths and transport them to a landfill for disposal. However, not all landfills will take large woody green waste; consequently, transportation cost may be greater than it is for smaller material. Estimated cost for bucking, loading, and transport to a landfill is $200. Disposal cost is based on trunk weight which is based on its volume and density.

Total trunk volume: Assume that the mid-log diameter of the 24-ft. long trunk is 18 in. with a cross-sectional area of 1.77 ft^2.
Volume: = cross-section area (ft.) X length in feet
= 1.77 ft^2 X 24 ft. = 42.4 ft^3.
Trunk weight: Assume that green density is 58 lb./ft^3 (**Appendix G**)
Weight: = trunk volume X density
= 42.4 ft^3 X 58 lb/ft^3 = 2,459.2 lb. (or 1.23 T.)
Dump fee: Assume $27/T.
Cost for dumping trunk: = $27/T. X 1.23 T. = $33.21
Total cost to dispose of the trunk :
Total cost: = Cost of Bucking + Loading + Transport + Dumping
= $200 + $33.21 = **-$233.21**

3.3.1.5. Trunk value for firewood. Another alternative is to sell the trunk for firewood. The retail value for firewood is assumed to be $150 per cord. Normally, the cost for felling, bucking, transport, equipment maintenance, and excise tax would be deducted from the retail value.

Retail firewood value: = number of cords X retail value per cord.
Number of cords: The volume of wood in a cord usually varies between 75-95 ft^3. Trunk volume was calculated in section 3.3.1.4. Assuming that 85 ft^3/cord, then 42.4 ft^3 = about 0.5 cords.

Retail firewood value : = 0.5 cords X $150/cord = **$75.**
(Note: net value = retail value - production costs.)

3.3.1.6. Trunk value for chips. Assuming that the trunk of the valley oak can be chipped, what is the expected value for this commodity? The market value for wood chips varies considerably and is currently low at about $10-20 per ton of dry chips. Net value equals the value per ton of chips minus various production costs such as chipping, transport, handling, etc.

Retail chip value: = Tons of dry chips X cost per ton
Weight of dry oak log: = log density X log volume
(Assume a dry density of 38 lb/ft^3, **Appendix G**)
= 38 lb/ft^3 X 42.4 ft^3 = 1,611.2 lb. (or 0.8 T.)

Retail chip value: = 0.8 T. X $20/T. = **$16.20**
(Note: net value = retail value - production costs.)

3.3.1.7. Trunk value for green lumber. How much lumber can be milled from the oak tree trunk and what is its estimated retail value? These calculations assume that the trunk is in sound condition, there are no volume deductions for defect, and the trunk is cut into two logs, a 16-foot basal log and an 8-foot second log. Diameter outside bark of the small ends of the basal and second log are 16 and 12 in. respectively. Volume estimates are based on the International 1/4 Inch Log Rule (**Appendix C**) which use inside bark (IB) dimensions. The bark is assumed to be 1-inch thick for both logs. Select grade, green oak lumber is assumed to $1.50/bd.ft.

(Note: Actual lumber grade recovery will usually be considerably less than the 100% select grade used in this example. Only about 30% of the lumber from the butt log would normally be expected to yield select or better, while the upper log would probably yield less than 12% select and better grades. See the box at the end of this section for an estimate of more realistic lumber yield.)

Retail green lumber value: = cost/bd. ft. X log bd. ft. volume
Trunk volume in board feet (International 1/4-inch log scale):
Basal log: = small end diameter IB @ log length
= 14 in. @16 ft. = 135 bd. ft.
Second log: = 10 in. @ 8 ft. = 30 bd. ft.
Trunk volume in board feet: 135 bd. ft. + 30 bd. ft. = 165 bd. ft.

Retail green lumber value: = $1.50 X 165 bd. ft. = **$247.50**

The net value for green lumber can be estimated by subtracting the production costs from the retail value. Sherrill et al. (1997) estimate direct lumber production costs in eastern United States to be between $0.50-$0.75 per bd. ft. In California, a rough estimate of direct production costs is about $1.00/bd. ft. or $165 in this example
Therefore:

Net green lumber value: = retail value - production costs
= $247.50 - $165.00 = **$82.50**

Table 3.8. Realistic lumber recovery rates by grade for the hypothetical tree example and a typical urban street tree[1]

Tree type	Log section	Percent estimated lumber recovery by grade				
		FAS	Select	#1 Common	#2 Common	#3 Common
Example tree	Basal log	20	10	35	20	15
	Second log	8	4	32	24	32
Typical urban tree	Basal log	10	4	35	18	33
	Second log	8	4	32	25	32

[1]Lumber recovery rates estimated by John Shelly, U.C. Forest Products Lab, Richmond, CA.

3.3.1.8. Trunk value for kiln-dried lumber (7% M.C.). The value for lumber can be significantly increased if it is dried to 6-8% moisture content which will require the use of a kiln. Details about kiln drying are covered in Section 8.5. The direct costs to dry lumber to 7% M.C. are estimated to be about $0.05 to $0.10 per bd. ft. (Anonymous, 1997). Lumber volume from the trunk was calculated in Section 3.3.1.7. above and is 165 bd. ft. However, a reduction in lumber volume due to drying is estimated to be about 10% for shrinkage and 5% for degrade, or about 15% overall. Therefore, kiln-dried volume is: 165 bd. ft. X 0.85 = 140 bd. ft. Assume that the lumber is dry, select oak valued at $3.75/bd. ft.

Retail kiln-dried lumber value: = cost/bd. ft. X log bd. ft. volume
= $3.75/bd. ft. X 140 bd. ft. = **$525.00**

Net lumber kiln-dried value: = retail value - production and drying costs
Drying cost at $0.05/bd. ft. = $0.05/bd. ft. X 165 bd. ft. = $8.25

Net lumber kiln-dried value: = $525.00 - $165.00 - $8.25 = **$351.75**

3.3.1.9. Trunk value for bookmatch billets. Bookmatch billets are consecutive pieces of lumber from the same log that laid side by side form an almost symmetrical pattern from the common center line of each pair of boards. The value of a matched pair of boards can be about three times the value of unmatched boards. Obviously, not all of the boards from a log can be cut into bookmatch billets. However, it is assumed possible for these calculations and will result in an overestimated retail value. Assume that the value for oak bookmatch billets is three times that for select, kiln-dried lumber or 3 X $3.75/bd. ft. or $11.25/bd. ft.

Retail bookmatch billets value: = cost/bd. ft. X log bd. ft. volume
= $11.25/bd. ft. X 140 bd. ft. = **$1,575.00**

Net bookmatch billets value: = retail value - productions costs
= $1,575.00- $165.00 - $8.25 = **$1,401.75**

3.3.1.10. Trunk value for pen/pencil stock. The final potential wood product being evaluated is wood stock for specialty pens and pencils. In this example, the stock material is 0.75 in. in cross-section and 6 in. long. About twenty-five such pieces can be produced per board foot of lumber, and each piece is assumed to have a retail value of $1.50. As in the previous calculations, it is assumed that all of the lumber produced from the oak trunk is suitable for the purpose being evaluated.

Retail pen/pencil stock value: = cost/piece X number of pieces
Number of pen/pencil stock pieces: = pieces/bd. ft. X bd. ft. volume
= 25/bd. ft. X 140 bd. ft. = 3,500 pieces

Retail pen/pencil stock value: = $1.50/piece X 3,500 pieces
= **$5,250.00**

Net pen/pencil stock value: = retail value - production costs
Estimated production costs: = $1.25/ bd. ft. for milling and drying.
= $1.25/bd. ft. x 165 bd. ft. = $ 206.25

Net pen/pencil stock value: = $5,250.00 - $206.25 = **$5,043.75**

In summary, enormous economic benefits can come from the positive utilization of a resource that has been poorly or not utilized at all and has been disposed at considerable cost to the landowner, community, and environment. A landowner should be rewarded by reduced tree removal costs, at least for logs that have lumber value because of species, size, or condition. Benefits to the community and environment are described in the next sections. (See a "Summary of What a Tree is Worth" in the following box.)

3.3.2. Community Benefits.

A variety of community benefits can result from productive utilization of woody green waste (Sherrill et al., 1997). Local milling of urban sawlogs provides greater community prosperity by providing more jobs and a greater economic base even though it might be relatively minor in scope. Money or wood products generated from milling and selling sawlogs and/or reduced disposal costs could be used to enhance a communities' urban forest management program. Better and more tree projects could be supported. Although urban forests shouldn't be managed for commodity production, advantage can be taken by using species with both desirable landscape qualities and high wood value. Urban trees would be planted, grown, and eventually removed on a regulated basis. Profitable urban sawlog utilization should benefit both a community and its urban forest program.

Summary: WHAT IS A TREE WORTH?

This is a summary of the retail value of a 24-inch DBH valley oak as it goes from a healthy, urban, landscape tree to various potential products that could be derived from it. It assumes that the entire trunk could be used for the purpose stipulated, thus producing the maximum expected value. See **Figure 3.3.** for a description of the tree. Production costs have not been deducted from "retail value"; e.g., production cost for kiln-dry lumber is estimated to be $1.05/bd. ft. and when deducted, a $3.75 retail "board foot value" drops to $2.70/bd. ft. Keep in mind that although it is possible to produce usable wood from any size tree, even branch material, the production costs rise rapidly as tree size decreases.

Tree or trunk use	Condition	Retail: Tree value (165 BF)	Retail: Bd. ft. value ($/BF)
Healthy, landscape tree	Base tree value @ $31/in^2	$14,024	$85.00
Dead tree	No landscape/commodity value	$0	$0.00
Felling tree in place	Felling, bucking, chipping[1/]	-$320	-$1.94
Trunk removal to landfill	Loading, transport, dump fee	-$233	-$1.41
" into firewood	Retail value @ $150/cord	$75	$0.46
" into chips	Retail value @ $20/T.	$16	$0.10
" into green lumber	Retail value, @ $1.50/bd. ft.[2/]	$248	$1.50
" into kiln-dry lumber	Retail value, @ $3.75/bd. ft.[3/]	$525	$3.75
" into bookmatch billets	Retail value, @ $11.25/bd. ft.	$1,575	$11.25
" into pen/pencil stock	Vol.: 165 Bd. ft., @ $1.50/item	$5,250	$32.00

1/ Includes chipping of limbs, leaves, & other tree parts @ $40/hour.
2/ Trunk (sawlog) volume is 165 bd. ft.
3/ Assume a 15% loss in kiln-dried lumber volume due to shrinkage and drying degrade.

3.3.3. Environmental Benefits.

Productive utilization of urban woody green waste can benefit the environment on both the local and higher levels. Locally, keeping trees out of a dump saves critical landfill space and eliminates any associated pollution that might occur as the material breaks down. It makes it easier to comply with the reduced dumping mandated by AB 939. Greater utilization of woody green waste for lumber and solid wood products reduces the amount used for firewood or burned at dumps and thus less air pollution and CO^2 production. Fortunately, not much woody material is burned at landfills these days (NEOS Corp., 1994).

Another important environmental benefit of utilizing urban woody green waste is the reduction of the amount of lumber needed from commercial forest land (Sherrill et al., 1997). It was noted earlier that this could amount to over 20 million bd. ft. per year in California. The concern about the negative effects of logging on the environment have been well documented. Reduced logging would mean less soil erosion, stream pollution and disturbance, loss of wildlife habitat and especially reduced loss of threatened and endangered species.

3.3.4. Benefits to the Woodworking Community.

The program "Trees to Furniture" (see Section 5.4.), sponsored by Wood-Mizer Products, Inc. and Popular Woodworking Magazine, emphasizes benefits that a woodworker and the woodworking community can derive from milling lumber from urban woody green waste (Sherrill et al., 1997). In this program, woodworkers are encouraged to become involved in "moving trees from the (growing) site to the sawmill and then to the shop". For many, working with wood is not only profitable, but also extremely enjoyable. Using wood that you have tracked from a log to a piece of furniture or some other wood project is very satisfying. There is also the opportunity to get species, quality, or grain of wood that might not be otherwise available. For some, using "green" or "environmentally friendly" wood has a significant appeal in itself. Basically, everyone and the environment "wins" when urban sawlogs are used productively.

4.0. SIZE OF URBAN WOODY GREEN WASTE RESOURCE (ARBORIST & LANDFILL SURVEYS).

The amount of woody green waste produced in California each year that is disposed in landfills has been estimated in a variety of reports since the passage of AB 939. Data from several of these reports were summarized earlier in Section 3.1;. Unfortunately, none of these studies identify sawlog-size green waste; and, for a variety of reasons, the accuracy of much of the data that are presented are questioned by the authors of these reports. Even if reliable, the reports usually deal with waste going to landfills and not the total size of the resource. An important exception is the U.S.-wide report on urban tree residue by the NEOS Corp. in 1994 that does estimate the amount of sawlog-size material generated by tree service companies and others who produce green waste. We were not aware of the NEOS Report when the study began, but we have since found it to be an extremely important point of reference for our work.

A brief overview of the goals for this section was given earlier in Section 2.3.1. (Estimate of Resource Size) that involves the use of resource surveys to document woody green waste production and the amount reaching county and municipal landfills. In addition, a telephone survey was used to learn the number of trees removed by the thirteen Caltrans Districts. However, these results were too unspecific to be useful. Caltrans does not routinely keep track of tree removals by tree number or size.

4.1. OVERVIEW OF SURVEY METHODOLOGY.

Methodology that was the same for both the landfill and arborist surveys is presented in the next three subsections, while information specific to a given survey is found later with each survey description.

4.1.1. General Comments.

One of the primary objectives of this study was to quantity the amount of woody green waste that is available for recycling into wood products. Existing data do not identify woody green waste by size or amount. The primary data that were needed to make these estimates were collected though the use of surveys to licensed arborists for an estimate of total woody green waste production and to county and city landfills for information about the amount of this material being dumped in public facilities.

4.1.2. Survey Administration.

The way a survey is administered is determined by the complexity of the questions, timing of expected response, length of the questionnaire, sampling frame (population), and the survey budget (Churchill, 1991). Surveys are administered several ways including mail, fax, internet, telephone, and by personal interview. Telephone questionnaires are generally used for simple questions. Because the types of questions needed to estimate woody green waste by size were complex and the respondents needed to research their answers, a telephone questionnaire was not feasible. E-mail addresses were also not available; therefore, the internet was not a feasible way to administer the survey. Feasible methods for administering the survey were by fax and by mail. Sending the surveys by fax was preferred because it has a faster response time than mail. It was the method used for the landfill survey. However, surveys were mailed to the arborists because we didn't have their fax numbers.

4.1.3. Data Management and Analysis.

The software package, SPPS® for Windows™, was used for data entry and analysis for both surveys. After the data were entered, they were checked to ensure that the responses were entered correctly. For example, percentages that add to 100 were checked. The individual questions were measurements using means and frequencies. Means were used to analyze responses that were measured, i.e. using ratio or numerical data. Frequencies are counts that were used to analyze responses that were measured using nominal data, e.g. number of landfills or arborists dealing with Monterey pine.

The statistics presented in this report are subject to sampling error because they do not represent the total population. Because sampling errors exist for the means of the data examined in these surveys, a 90% confidence interval is included to show the range that includes the population mean 90% of the time. The confidence interval was calculated as follows:

$$X = \mu \pm t_{90\%} S_X$$

where:

X = the confidence interval.

μ = the sample mean.

$t_{90\%}$ = the value of t, the standardized normal variable at the 90% confidence level.

S_X = the standard error.

4.2. LANDFILL SURVEY

One of the initial objectives of this study was to determine how much sawlog-size woody green waste was being dumped at active landfills in California. What role, if any, did this type of material have in landfill obsolescence? Would it be seriously impacted by the 50% waste reduction requirements of AB 939? The NEOS Corporation Report (1994) indicated that nation-wide, less than 3% of log-size urban tree residue was disposed of at landfills. If this were likewise true for California, then this size material represents only a very small fraction of the total solid waste going to landfills, and only a relatively small amount of urban saw-log size material is being dumped.

4.2.1. Landfill Sampling Frame.

A sampling frame lists the elements of the population from which the survey sample is derived (Churchill, 1991). The sampling frame examined in this survey was all of the active landfills in California listed in the 1995 CIWMB publication Active and Interactive Landfills (Publication no. 251-95-016). A census of all landfills was attempted. However, the 1991 Disposal Cost Fee Study (Tellus Institute, 1991) received usable data from only 23 counties, and showed that it is very difficult to generate an 100% return rate from landfills. A list of the landfills and phone numbers is included in **Appendix I** .

4.2.2. Landfill Questionnaire Development.

The accuracy of the data provided by a survey is based on the type of questions and order of questions in the survey instrument. A funnel approach to question sequencing is the approach recommended by Churchill (1991). This approach begins with broad questions and then progressively narrows the scope of the questions. This was the approach used for the questionnaire sent to the landfill operators that commences with a general question about waste (See **Appendix J-1** for the questionnaire and questionnaire cover letter.). Next, the questionnaire asks about the proportion of total waste that is green waste and how it is utilized at the landfill. The remaining questions ask for specific information about the volume of woody green waste, the composition of woody green waste by size and species, and the source of woody green waste. The final question asks about the likelihood that a landfill would develop a woody green waste diversion program if a business existed that utilized woody green waste in the production of recycled wood products.

Before the questionnaire was sent to the landfills, a pre-test was administered in November 1996. Ten questionnaires were faxed to randomly chosen landfills in the sampling frame. First the recipients of the pre-test questionnaires were telephoned to explain that they would receive a questionnaire, and the purpose of the questionnaire was explained. Next, the questionnaires were faxed to the ten landfills with a letter again explaining the purpose of the survey. The letter also asked for comments concerning the questionnaire. Eight out of ten of the pre-test questionnaires were returned, and the comments indicated that the questionnaire did not need to be changed.

4.2.3. Landfill Survey Administration and Response

In January 1997, the fax questionnaire was sent to all 101 landfills in the sample frame (**Appendix I**). First, as in the pre-test, the recipients were telephoned to explain that they would receive a questionnaire and its purpose. Phone calls were made to the landfills that had not responded to the questionnaire by May. Questionnaires were re-faxed in May to those landfills

Twenty-seven responses were received from the 101 landfills that were contacted. Two of the responses accounted for multiple landfills. One response from Kern County represented 20 landfills and another was received from Riverside County that represented 12 landfills. The twenty-seven responses outlined in this survey represented approximately 27% of the operations contacted and fourteen of the State's fifty-eight counties.

Listed in **Table 4.1.,** on a per county basis, are the tons of waste disposed in 1994 by the same landfills that responded to our 1997 survey. Not all of the landfills from the individual counties returned our questionnaires. For example, only five of the eleven landfills on the Los Angles County list responded. The 1994 county waste totals in **Table 4.1.** represent only those landfills that responded to our questionnaire. These counties disposed 10,702, 296 T. of waste or 31.5% of the total waste disposed in 1994.

Table 4.1. Solid waste disposed by county in 1994 for the same landfills that responded to our 1997 survey[1]

County	Tons of Waste[2]	Percent of waste	County	Tons of Waste	Percent of waste
Alameda	1,791,647	5.28	Los Angles	5,578,486	16.43
Calaveras	25,025	0.07	Mendocino	22,255	0.07
Glenn	25,060	0.07	Monterey	280,674	0.83
Humboldt	135	0.00	Placer	35,910	0.11
Imperial	52,006	0.15	Riverside	1,520,801	4.48
Kern	954,014	2.81	San Joaquin	293,000	0.86
Kings	93,655	0.28	Lake	29,628	0.09
Total waste: of reporting landfills	10,702,296 tons (1994).		Total state waste: 33,954,007 tons (1994)[3]		

[1]Source: Environmental Science Associates & Pryde Roberts Carr (1994) *Toward ensuring Adequate Landfill Capacity*.

[2]Note: These are tons of waste disposed in each county in 1994 by landfills responding to our questionnaire.

[3]These are total tons of waste disposed in county landfills in 1994 (see **Appendix K**).

4.2.4. Landfill Survey Results

The total amount of waste generated by the twenty-four respondents who indicated the volume of waste received by their landfills in 1996 is 10,234,070 T. (Table 4.2.). This volume is 96% of the 10,702,296 T. of volume received two years before by the same landfills in 1994 (**Table 4.1.**), according to the report *Toward Ensuring Adequate Landfill Capacity* (Environmental Science Associates & Pryde Roberts Carr, 1994). The slight decline in 1996 from 1994 also mimics the trend in total solid waste reduction since 1990. We therefore assumed that the two data sources are similar.

4.2.4.1. Waste going to landfills. The total tons of solid, woody, green waste that were reported by the respondents of our 1997 survey are shown in **Table 4.2.** The survey values, scaled up to state-wide totals, are shown in **Table 4.3.** using the same 31.5% relationship of the 1994 sample landfills to total state-wide waste referred to in Section 4.2.3. and **Table 4.1.** Unfortunately, the 1994 survey did not quantify waste by components and only reported total weight. Another concern about the Environmental Science Associates & Pryde Roberts Carr (ESS&PRC) data is that they reported about 25% less total waste for 1991 than that Tellus Report (1991). Part of the difference may be because the ESS&PRC data did not include five counties in their data totals. If this relationship is still true, our data might be upscaled by another 25%. However, because of some uncertainty about the accuracy of some of the earlier information, were prudent and used the smaller, 1994 relationship in our calculations.

Table 4.2. Tons of total waste, green waste, and woody green waste received by landfills in 1996 based on our survey sample

Waste category	Tons of waste	Percent of preceding category	Tons of waste per response	Mean 90% confidence interval
Total waste (N=24)[1]	10,234,100	100.0	426,420	±272,450
Green waste (N=22)	1,017,700	10.5	48,990	±33,290
Woody green waste (N=19)	129,700	12.0	6,830	±5,080

[1]N = the number of sample responses that provided usable information.

On the average, each landfill reported that approximately 426,000 T. of solid waste were received in 1996. This amounted to a total of 10,234,100 T. for the survey and 32.5 mil. T. for the entire state (**Table 4.3.**). Green waste made up 10.5% of the total waste or about 3.2 mil. T. state-wide. And, about 12% of the green waste consisted of woody green waste or about 412 thousand T. state-wide and 1.3% of the total annual solid waste stream.

Because of the difference in terminology and waste components, it's impossible to directly compare our results to those of the Tellus Institute (1991) and CWIMB (1994, 1995) reports in which yard waste does not include tree trunks whereas wood waste includes not only tree trunks, but also all types of manufacturing and demolition wood, furniture, etc. The combined amount of yard and wood waste in the Tellus Report (**Table 3.1.**) is 9.9 million T. or about

Table 4.3. State-wide total landfill waste, green waste, and woody green waste (T.) for 1996 extrapolated from sample data

Category	Sample (T.)	State-wide (T.)	Percent of total (%)
Total waste	10,234,100	32,468,500	100.0
Green waste	1,017,700	3,228,700	10.5
Woody green waste	129,700	411,500	1.3

19.8% of the total 1991 solid waste. This is about double the 10.5% green waste reported for our survey, but the Tellus Report also included industrial wood, etc. The same combination of urban and wood waste reported by the California Energy Commission in **Table 3.3.** (CIWMB, 1994) is 4.7 mil. bone dry tons (B.D.T.). [Although not precise, a B.D.T. has almost twice the wood mass of a ton of undried material.]

Although our landfill survey didn't assess the amount of waste that was being diverted from landfills, the 1997 CIWMB data indicated that only about 12% of the non-yard wood waste was being diverted at that time.

4.2.4.2. Size of the woody green waste. Of more importance to this report than how much green waste was landfilled is the amount of the waste that is sawlog-size. The distribution of green waste by size category is shown in **Table 4.4.** Almost 60% of the woody waste is less than 6 in. in diameter, and 15.7% is 12 in. or greater in diameter of which only about 1/3 or 6.1 % is 4 ft. or longer. The minimum size that most sawmills would consider economical to cut is 12 in. in diameter and ≥ 4 ft. in length, although some sawmills usually won't deal with logs less than 18 to 20 in. in diameter. Using the smaller log size, this amounts to only 25,100 T. (i.e. 411,500 X 0.061) of sawlog-size material, about 0.08% of the total solid waste in 1996. Assuming that there are approximately 1,000 bd. ft. /6.25 T. of logs, then this amounts to slightly more than a minimum of 4 mil. bd. ft. (i.e. 25,100 T. X (1,000 bd. ft./6.25 T.) = 4,016 X 1,000 bd. ft.) of sawlog-size woody green waste that was disposed in California landfills in 1996. Eleven percent of the woody green waste is in unspecified sizes greater than 6 in. in diameter and most likely contains at least some sawlog-size material also.

Table 4.4. Percent of total woody green waste (411,500 T.) by size category going to landfills

Stem size	Mean proportion (%) (N=16)[1]	Solid wood[2] estimate (MMBF)	Mean 90% confidence interval (N=16)
Less than 6 in. in diameter	58.4	38.5	±15.2
Six to 12 in. in diameter and less than 4 ft. long	4.4	2.9	±2.5
Six to 12 in. in diameter and and 4 ft. or longer	4.0	2.6	±2.9
Twelve in. or greater in diameter and less than 4 ft. long	9.6	6.3	±9.0
Twelve in. or greater in diameter and 4 ft. or longer	6.1	4.0	±6.2
All other greater than 6 in. diameter (respondent didn't specify size)	11.3	7.4	±8.6
Unallocated green wood waste	6.3	4.1	NA[3]
Total solid wood estimate (MMBF) =		65.8	

[1]Number of sample responses that provided usable information.
[2]Assuming 160 bd. ft./T. of green logs (See Section 2.6.3. Tons of logs to board feet).
[3]NA = not available.

4.2.4.3. Seasonality of waste disposal. There was a slight but distinct trend throughout the year when woody green waste was disposed at landfills (**Table 4.5.**); if there was a change from month to month, it was usually only 1% except for a 3% drop from October to November. The season for highest waste disposal was from June to October and the lowest was in January with a minimum of only 5% of the total woody green waste. These results almost exactly mimic the seasonal results from the NEOS Corp. Report (1994) as follows:

Season	Winter	Spring	Summer	Fall
NEOS Report	19%	23%	30%	28%
This survey	17%	24%	30%	29%

The NEOS data were for the entire U.S. which has a vastly different climatic regime than California. Off hand, California green waste deposition does not appear to match adverse weather conditions or other factors that would promote natural disaster related woody tree residue. On a U.S.-wide basis, most (70%) disaster related waste is associated with strong winds and hurricanes (NEOS Report, 1994).

Table 4.5. Proportion of woody green waste disposed each month at California landfills

Month	Mean proportion (%) (N=16)[2]	Lower proportion[1] (N=16)	Upper proportion[1] (N=16)
January	5	3.9	7.1
February	6	4.8	7.9
March	7	5.2	8.4
April	8	6.2	10.0
May	9	7.9	11.0
June	10	7.7	12.0
July	10	8.0	12.9
August	10	8.3	11.7
September	12	7.2	15.8
October	10	8.0	12.7
November	7	5.2	9.8
December	6	4.2	8.2

[1]Ninety percent confidence interval.

[2]Number of sample responses that provided usable information.

4.2.4.4. Species of trees. The species of trees reaching landfills greatly affect the value of the potential lumber produced. The questionnaire listed eight prominent tree species or genera and asked the landfill operator to indicate which of them had reached the landfill. The survey responses are listed in **Table 4.6.** An obvious limitation with this question is the ability or even the need for landfill operators to keep track of this type of material much less identify it. Some of this material would be difficult to identify even by a trained forester. Not surprisingly, 33% of the time there were species that couldn't be identified (**Table 4.6.**). Monterey pine was the species noted at 18.5% of the landfills followed by redwood, cedar species, and Douglas-fir. Although the state-wide volume of Monterey pine that's being removed will probably increase considerably in the next few years because of pitch canker, the amount of sawlog-size material reaching a landfill would not be expected to increase concomitantly.

Table 4.6. Tree species received by landfills in the past 3 years

Tree species	Percent of landfills receiving a given species[1] (N=27)[2]
Monterey pine	18.5
Redwood	14.8
Cedar (spp.)	14.8
Douglas-fir	14.8
Monterey cypress	11.1
California bay	3.7
Acacia (spp.)	11.1
Walnut (spp.)	11.1
All other species	22.2
Not sure	33.3

[1]Multiple responses possible; therefore, the sum for all species is greater than 100%.
[2]Number of sample responses that provided usable information.

4.2.4.5. Utilization and diversion of green waste. What happens to all of the waste including green waste after it's disposed at a landfill is an important question as the year 2000 and the requirements of AB 939 for a 50% reduction from 1989 levels in waste deposited in landfills rapidly approach. While it's not the responsibility of landfills to reduce waste generation, they certainly have an important role in recycling, transformation, or other utilization of waste after it gets to a landfill. One of the survey questions addressed the subject of green waste utilization and the results are listed in **Table 4.7.** Overall, 56% of the landfills bury at least part of the green waste that they receive while 45% utilize it in some way. Unfortunately, the data don't indicate the amount of the waste that is utilized, but rather the proportion of landfills that use a particular method of utilization. Therefore, a landfill may use only one, or several different utilization methods.

Mulching is the second most common use for green waste (41% mulched) followed by 31% used for landfill cover. Less that 0.1% of the landfills surveyed utilize woody green waste for lumber production. Landfills that receive only a few logs a month and are distant from milling operations will probably never be able to economically process their sawlogs into lumber.

One final survey question inquired about the likelihood that a landfill would divert sawlogs to a local mill if one existed (**Table 4.8.**). The response was quite predictable. Seventy-six percent indicated that they would or probably would divert woody green waste to a wood product business and no landfill indicated that they would not do so.

Table 4.7. Methods of green waste utilization based on the 1997 landfill sample survey responses

Method of utilization	Proportion of landfills indicating method is used[1] (%) (N=27)[2]	Mean proportion of total waste (%) (N=22)	Mean 90% confidence interval (%) (N=22)
Directly to landfill	55.6	43.3	±16.3
Landfill cover	29.6	11.1	±7.6
Mulch	40.7	7.3	±5.1
Soil amendments	18.5	10.9	±8.9
Sold to co-generation plants for electricity	25.9	10.3	±6.9
Diverted to other uses without processing	3.7	0.7	±1.2
Lumber production (logs)	<0.1	<0.1	NA[3]
Incinerated	<0.1	<0.1	NA
Firewood	14.8	0.2	±0.2
Other	11.1	9.8	±10.0
Unallocated waste	NA	7.4	NA

[1]Multiple responses possible; therefore, the sum for each method of utilization is greater than 100%.
[2]Number of sample responses that provided usable information.
[3]NA = not available.

Table 4.8. Probability that a landfill would develop a wood diversion program if a business existed that utilized woody green waste in the production of wood products

Potential action	Proportion of landfill operators (%) (N=21)[1]
Certainly would divert woody green waste	47.6
Probably would divert woody green waste	28.6
Might divert woody green waste	23.8
Probably would not divert woody green waste	0.0

[1]Number of sample responses that provided usable information.

4.2.4.6. <u>Summary of landfill survey results.</u> The amount of green waste estimated to be disposed at landfills for 1996 was 3.2 mil. T., about half of that reported by the Tellus Institute (1991) and the California Energy Commission (CIWMB, 1994). This difference may be due to a number of factors including different waste components, survey accuracy, and a decline in green waste generation. Only 1.3% of the total waste was categorized as woody green waste of which only 6.1% was sawlog-size material greater than 12 in. in diameter and 4 feet or longer in length. This was only about 0.08 of the total solid waste stream in 1996, and it amounted to a potential lumber volume of slightly more then 4 mil. bd. ft.

The highest proportion of woody green waste is disposed at landfills in the summer (30%) and least in winter (17%) just like the overall U.S. disposal percentages for urban tree residue. Monterey pine was the tree species most often identified in the waste stream, followed by redwood, Douglas-fir, and cedar species. Over 55% of the landfills disposed the green waste in the landfill while less than 0.1% of the landfills diverted the sawlog-size material to lumber production. Almost half of the responding landfills indicated that they would divert woody green waste to a wood processing business if such a facility was available.

4.3. ARBORISTS SURVEY.

Another objective of this study was to determine the amount of urban sawlog-size woody green waste generated in California each year that could be available for lumber production. As already noted, one of the previous solid waste studies in California specifically identified sawlog-size material. It was either a component of urban wood waste or non-yard wood waste along with demolition and industrial wood, etc. The U.S.-wide report by NEOS Corp. (1994) on urban tree residues identified seven classes of tree residue including “logs” (i.e. unchipped wood, usually with a diameter of 12 in. or greater) produced by seven types of “generators”. However, log waste was not sampled by size. We were not aware of the NEOS Corp. Report when our study was set up, but we had already determined that arborists (tree care firms) generated a large part of the urban woody green waste and they would be the most productive sample population to survey. They were a good choice because the NEOS Corp. survey found that almost 50% of the urban tree residue in California was produced by commercial tree care firms (C.T.C.F.).

Primary data were needed to estimate woody green waste generated by C.T.C.Fs. that were available for conversion into wood products. These data were collected through the use of a survey of arborists who represented tree care companies.

4.3.1. Arborist Sampling Frame.

The sampling frame for this survey consisted of 310 California arborists certified by the International Society of Arboriculture. They were individuals who were supposed to represent different commercial tree care companies. Although all of the respondents were supposed to be from different firms or branches of large firms, the original list of names was on mailing lables obtained from ISA. We didn’t make a copy of the mailing lables and appearantly ISA couldn’t duplicate the list because of staff changes. Consequently, we were unable to confirm who was on the complete mailing list. This was an unfortunate mistake that will be discussed later in Section 4.3.3. when scaling the survey results to a state-wide level.

4.3.2. Arborist Questionnaire Development.

The approach that was used for the landfill survey was also used for this survey where the accuracy of the data obtained was based on the type of questions and their order in the questionnaire. Again, a funnel approach to question sequencing was used where the order of questions narrows in scope (Chandler, 1991). The questionnaire, shown in **Appendix J-2** commences with general questions about tree removal. The next questions are about the type and timing of work done in a typical year. The remaining questions are specific about the volume of wood waste, its composition by size and species, and its method of disposal. Finally, arborists are asked about their interest in sending their woody green waste to a sawmill if one were available.

In retrospect, a few of the questions were not precise enough and the opportunity to get some key information was lost. For example, Question 2 asked about the number of trees trimmed or removed in a typical year. Those should have been separate questions. And, Question 6. b. had to do with the size of the wood waste and classified it into three sizes one being 12 in. or greater in diameter. Unlike the landfill survey, it did not separate this size of material into less than and greater than 4 ft. in length so that usable sawlog-size material could be identified.

4.3.3. Arborist Survey Results.

The results of the arborist survey are described in the next six subsections. According to the NEOS Corp. Report, commercial tree care firms (C.T.C.F.) generate almost half (48%) of the urban tree residue in California; consequently, they were the key group to query about woody green waste generation. On a per C.T.C.F. basis, results for both this and the NEOS Corp. surveys are close in regard to the amount of woody waste that were reported for each C.T.C.F. It's important to keep in mind that these results are approximations and extrapolation to state-wide values along with converting volume of waste to potential annual board foot recovery is especially uncertain. These concerns are discussed in the next section.

4.3.3.1. Volume and size of woody green waste. The mean volume of woody green waste produced per C.T.C.F. in California in 1997 was 9,640 yd^3 (**Table 4.9.**). This is somewhat more than the 8,884 yd^3 of tree residue reported by the NEOS Corp. (1994) for western C.T.C.Fs., but less than the national average amount of 10,232 yd^3 per C.T.C.F. The total amount of woody green waste for the survey sample is listed in **Table 4.9.** at 588,000 yd^3. Extrapolated to a state-wide total, this amounts to 2,988,000 yd^3/yr. if the total population of C.T.C.Fs. consists of 310 operating companies in our sampling frame (**Table 4.10.).** The National Arbor Association lists only 176 commercial tree care firms in California and a search of the "yellow pages" on the internet for commercial tree service companies produced a list of only 174 firms and a large part of these were hauling companies. All of these numbers of firms are considerably less than the 968 C.T.C.Fs. used in the NEOS Corp. Report to scale up to the California state-wide volume of tree residue. The range of total cubic foot volumes of urban woody green waste for these different scale-up values is 1.7 to 9.3 million yd^3 (**Table 4.10.**).

So, what is the appropriate scale-up number of tree care firms? The NAA and yellow page figures seem too low. Undoubtedly, there are companies or individuals that remove urban trees that are not listed in either of these sources. On the other hand, the NEOS Corp. (1994) number of C.T.C.Fs. seems too high. The shrub maintenance and other types of firms that they included in their estimate may not be involved in much urban tree removal. Because total state-wide values have little meaning in the determination of whether or not an area has a

Table 4.9. Size and volume of woody green waste generated per commercial tree care firm (arborist) based on the survey results

Green waste size category	Percent of total waste	Mean yd^3 per tree care firm	Mean 90% confidence interval	Cubic yards per survey sample
< 6 in. in diameter (N=61)[1]	44	4,270	±2,460	260,000
6 to 12 in. in diam. (N=61)	29	2,770	±2,040	169,000
> 12 in. in diameter (N=61)	25	2,410	±1,300	147,00
No size indicated (N=2)	2	190	NA[2]	12,000
Total	100	9,640	---	588,000

[1]N = number of sample responses that provided usable information.
[2]NA = not available.

large enough supply of sawlog-size material to support a small sawmill operation, they should only be considered a general indicator of the state's total potential urban lumber production.

Table 4.10. Size and volume of woody green waste generated by commercial tree care firms (C.T.C.Fs.) scaled up to statewide totals using three different scaling values[1]

Size category	Cubic yards per tree care firm	State-wide scale-up volumes (yd^3)		
		N.A.A. (176)	Survey (310)	NEOS (968)
< 6 in. in diameter	4,270	752,000	1,324,000	4,133,000
6 to 12 in. diam.	2,770	488,000	859,000	2,682,000
> 12 in. diameter	2,410	424,000	747,000	2,333,000
No size indicated	190	33,000	59,000	184,000
Total	9,640	1,697,000	2,989,000	9,332,000
> 12 in. diameter converted to bd. ft. values[2]	193,000	33,920,000	59,760,000	186,800,000

[1]Number of California commercial tree care firms (C.T.C.Fs.) based on different sources; N.A.A. = National Arborists Assoc., Survey = this survey, NEOS = NEOS Corp. Report (1994).
[2]Based on a 25% recovery rate (80 bd. ft./yd^3 of logs).

In regard to size, slightly less than half (4,270 yd^3) of the total woody green waste was less than 6 in. in diameter, and there were almost equal amounts of the 6- to 12-in. and the greater than 12-in. material (Table 4.10.), i.e. 2,770 and 2,410 yd^3 per C.T.C.F. respectively. For the >12-in diameter material (sawlogs), this amounts to approximately 193,000 bd, ft. per C.T.C.F./yr. and assumes a 25% recovery rate/yd^3 (i.e. 80 bd. ft./yd^3). This would amount to a state-wide range of 34 to 187 million bd. ft. However, this incorrectly assumes that all of the waste >12 in. in diameter is suitable for lumber production. Unfortunately, as noted earlier, this larger material was not reported by length as in the Landfill Survey where the "logs" >4 ft. in length were separated from those <4 ft. in length, and the ratio of these two sizes was 6.1 to 9.6 (or 0.64%). Assuming that this same size relationship holds true for the material generated during tree removal, then 193,000 bd. ft./C.T.C.F. would be reduced to 123,000 bd. ft./C.T.C.F. [Note: There is no way to verify this assumption, and there may be no size relationship between what is removed and what shows up at a landfill.]

4.3.3.2. Type of work done by tree care firms. The primary work done by tree care firms is tree pruning which takes up to 70% of their time (**Table 4.11.**), although the range varies from 0 to 100% . While tree removal is next in importance at 23%, it also ranges from 0 to 100%, and less than 7% of the time is spent on other services such as planting and raking. According to Bernhardt and Swiecki (1989), urban forestry budgets reflect about the same balance between maintenance (primarily trimming) and tree removal at 55% and 13% respectively. Planting takes up a little over 16% of the budget and the rest is spent on equipment and administration. This survey didn't inquire about budgetary items; however, Thompson et. al. (1994) report that during a tree's forty-year life expectancy, $250 would be spent on trimming and $700 (±$50 depending on tree size) would be spent for removal. Tree removal is expensive and any opportunity to reduce this cost, i.e. compensation for sawlog-size material that is generated, should be a financial boost to an urban forest program or to an homeowner.

Table 4.11. Type of work done by commercial tree care firms (arborists) and number of trees trimmed and/or removed

Factor	Mean	Mean 90% confidence interval
Type of work	(%)	(%)
Tree trimming (N= 69)[1]	70.0	±4.2
Whole tree removal (N=69)	23.2	±4.0
Other services (N=69)	6.8	±2.2
Number of trees	(No.)	(%)
Trimmed or removed (N=68)	10,300	±6,800

[1]N = the number of sample responses that provided usable information.

Although an average of around 10,000 trees were trimmed and/or removed each year per C.T.C.F., again there was a tremendous range between firms, and from 0 trees to over 50,000 trees for the larger firms with multiple crews. As noted in Section 4.4.1., the question would have been more useful had it asked for separate responses regarding trimming and removal. As it is, there is no way to estimate the proportion of trees that were removed.

4.3.3.3. Methods of processing woody green waste. As with the previous survey questions, the answers varied greatly from firm to firm with some doing either 100% chipping or 100% cutting into pieces (**Table 4.12.**) But on the average, it was just about 43% for both methods of processing, or just over 4,000 yd^3 for each C.T.C.F. Fourteen percent of the woody green material was in an “other” category that included stacking and bundling, halving (splitting), and a very small amount was milled. The NEOS Corp. (1994) reported on the type of residue generated by C.T.C.Fs. (**Table 3.4.**). They did not ask quite the same questions as our survey about processing woody green waste, but the production of chips was the outcome in either case. They reported that chips make up 67% of the processed tree residue.

Another related survey question asked about what method of handling was used for large wood disposal. Unfortunately, “large” was not quantified so the answers are arbitrary; however, where “large” wood was involved, 83% of it was cut into pieces and only 4% was chipped and 14% was in an “other” category. Presumably, much of this material was larger than most chippers could handle, or there was an alternate disposal method.

Table 4.12. Methods for processing urban woody green waste by California commercial tree care firms (arborists)

Method	Mean percent	Mean yd^3 per C.T.C.F.	Mean 90% confidence interval (yd^3)
Chipped (N=63)[1]	43.5	4,200	±1,980
Cut into pieces (N=62)	42.5	4,100	±4,300
Other (N=63)	14.0	1,300	±1,300

[1]N = number of samples responses that provided usable information.

4.3.3.4. Seasonality of tree work. The proportion of trees trimmed or removed each month are shown in **Figure 4.1.** There was only a 2% variation between the low and high amount of work performed with a low of 7% in April and a high of 9% from September through December.

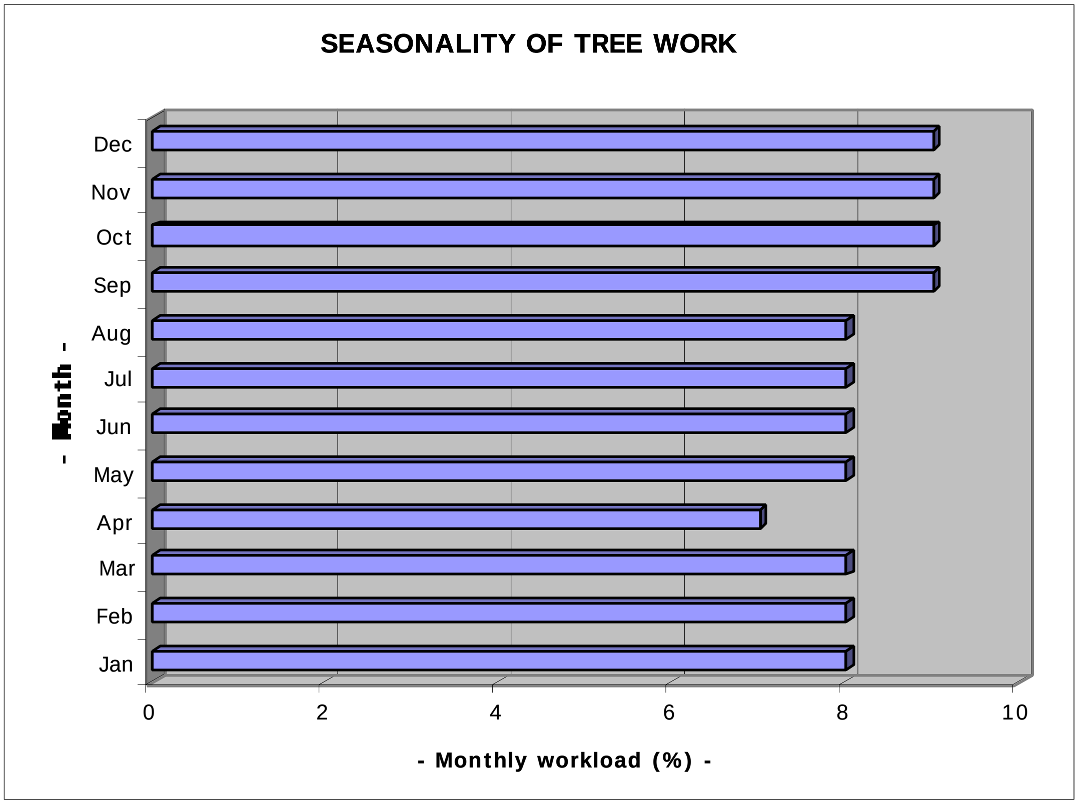


Figure 4.1. Monthly percentage of trees removed or trimmed by California commercial tree care firms (arborists).

4.3.3.5. Species of trees trimmed or removed. The proportion of C.T.C.Fs. that dealt with different tree species are listed in **Table 4.13.** This is the same list of eight species listed in the Landfill Survey (Section 4.2.3.4.), however, the magnitude of the response per species is much greater, as would be expected. Both Monterey pine and eucalyptus (spp.) were treated by 77% of the C.T.C.Fs., followed by redwood and acacia (spp.) as the next most common species. Douglas-fir was the least common species encountered by C.T.C.Fs. which is not too surprising considering its natural habitat. All of these species would definitely have an important role in lumber production from urban sawlogs. What's missing from the list are more of the non-native species that are covered in the "other" category.

4.3.3.6. Disposal of woody green waste by tree care companies. This is an important area covered by the survey that relates to lumber production from urban sawlogs. This is especially so for the disposal of unchipped woody green waste because this material is most likely to be suitable for lumber production. Results of the survey with regard to both chipped and unchipped woody green waste are shown in **Tables 4.14.** and **4.15.** respectively. Only 9% of the chipped waste was disposed at landfills. Most of the waste was used as mulch and was either left on site (16.9%) or taken to a green waste recycler (28.0%); and, mulch accounts for most of the "other" category. It usually costs a C.T.C.F. to dispose chips either at a landfill or green waste recycler (**Table 4.14.**).

Table 4.13. Proportion of different species of trees removed or trimmed each month by California commercial tree care firms

Tree species	Percent of C.T.C.Fs. dealing with a given species[1] (N=27)[2]
Monterey pine	76.8
Redwood	65.2
Cedar (spp.)	63.8
Douglas-fir	42.6
Monterey cypress	58.8
California bay	47.1
Acacia (spp.)	68.1
Walnut (spp.)	49.3
Eucalyptus (spp.)	76.8
All other species	60.9
Not sure	39.1

[1]Multiple responses possible; therefore, the sum for all species is greater than 100%.

[2]Number of sample responses that provided usable information.

Table 4.14. Percentage of **chipped** woody green waste by different disposal methods

Disposal method	Mean percentage (N=68)[2]	Mean 90% confidence (N=68)	Compensation for disposal[1] (%) Pay (N=64)	Compensation for disposal[1] (%) Receive pay (N=64)
Leave at location	17.0	±5.4	0.0	6.3
Take to a landfill	9.0	±4.7	50.0	0.0
Take to a green waste recycler	28.0	±7.8	51.3	0.0
Sell for mulch	9.0	±4.6	- - -	23.4
Other	32.0	±7.8	3.1	9.4
Unallocated chipped wood	5.7	NA[3]	NA	NA

[1]Multiple responses possible; therefore, the sum for all types of compensation is greater than 100%.

[2]Number of sample responses that provided usable information.

[3]NA = not available.

Almost 30% of the unchipped woody green waste was left on site (**Table 4.15.**). The same percentage reported in the 1994 by the NEOS Corp. for unchipped logs generated by C.T.C.Fs. (**Table 3.5.**). Most of the unchipped material is presumed to be too large or too uneconomical to chip. However, one survey responder indicated that he could chip material up to 30 in. in diameter while the average was 9 in. Another 20% of the of the unchipped material was sold for firewood, and based on unsolicited survey responses, most of the "other" category (20%) was material given away for firewood. These two percentages are almost exactly the same as that reported in the NEOS Corp. Report (**Table 3.5.**). Even the 11.3% of the unchipped taken to a landfill and the 1.6% taken to cogeneration plants are the same percentages reported by the NEOS Corp. at 13% and 2% respectively. All in all, the reported disposal of unchipped woody material from this survey of C.T.C.Fs. closely mimics that reported by the NEOS Corp. for unchipped logs generated by C.T.C.Fs.

Table 4.15. Percentage of **unchipped** woody green waste by different disposal methods

Disposal method	Mean percentage (N=68)[2]	Mean 90% confidence (N=68)	Compensation for disposal[1] (%)	
			Pay (N=64)	Receive pay (N=64)
Leave at location	29.3	±6.4	0.0	4.5
Take to a landfill	11.3	±5.2	50.7	0.0
Take to a green waste recycler	15.6	±2.3	49.3	0.0
Take to cogeneration plant	1.6	±2.3	1.5	0.0
Sell to a sawmill	2.3	±2.4	1.5	6.0
Sell for firewood	19.7	6.4	4.5	26.9
Other	20.2	±6.4	7.5	7.5

[1]Multiple responses possible; therefore, the sum for all types of compensation is greater than 100%.
[2]Number of sample responses that provided usable information.

That only 11% of the unchipped material was disposed in landfills, confirms the information obtained from the Landfill Survey that state-wide, very little large woody green waste gets dumped. Because of this, neither the landfills nor generators of large woody green waste should be greatly affected by the requirements of AB 939. What it basically comes down to is that utilizing sawlog-size, urban, woody green waste for lumber production is going to have a greater economic return and other benefits than are obtained with current disposal methods.

Paying for or receiving pay for disposing unchipped woody green waste (**Table 4.15.**) was almost exactly the same as it was for the chipped material (**Table 4.14.**). For both types, a C.T.C.F. has to pay for disposal at either a landfill or green waste recycling facility. The cost of disposal averages around $12/yd^3 at a California facility (CIWMB, 1994) and $9/yd^3 U.S.-wide for tree residue (NEOS Corp, 1994). Although most of the unchipped material was given away for firewood, some C.T.C.Fs. do sell it for this purpose. Only a few C.T.C.Fs. sold sawlog-size material to sawmills for lumber production.

4.3.3.7. Summary of commercial tree care firm (arborist) survey. Each commercial tree care firm produced about 9,600 yd^3 of green waste per year of which about

50% was greater than 6 in. in diameter. And 1/4 of this material, approximately 2,400 yd^3, was greater than 12 in. in diameter. Because this material was not categorized by length, only a crude estimate of potential board foot recovery can be made. If it's assumed that only 1/2 of the 12+ in. diameter woody green waste was suitable for lumber production, each C.T.C.F. generated a potential 97,000 bd. ft./yr. On a state-wide basis, this roughly amounts to between 17 to 93 million bd. ft. annually depending on which scale-up value is used.

Only about 23% of a C.T.C.F's. time involved tree removal with trimming accounting for most of the other work. About half of the green waste was chipped, and the other half cut into pieces. There was only a slight seasonal variation in work load with slightly more work in the fall. Monterey pine and eucalyptus were the most common species removed. About 60% of the chipped material was used for mulch on and off the removal site, and 1/3 of it was taken either to a landfill or to a green waste recycler at a cost to the C.T.C.F. Of the unchipped material, about 30% was left on site, and 40% was given away or sold for firewood. Slightly more than 10% of the unchipped material was disposed at landfills. Based on this survey, it would appear that the disposal of woody green waste will not be greatly impacted by the requirements of AB 939.

5.0. MILLING OPERATIONS USING URBAN SAWLOGS.

Harvesting California trees for lumber has been going on for over 400 years. The first recorded event occurred in 1579 when Francis Drake landed in California (Marin County) to repair his ship The Golden Hind (Clar, 1959). A very brief description of the history logging in California is presented in the following section. After that, there is a discussion about the hardwood lumbering industry in California and many of the factors that are believed to have limited it's successful development. This is appropriate because many of the same problems that faced the hardwood lumbering industry also seem to face the establishment of a successful urban sawlog industry. The next section describes current sawmill operations that have been using urban sawlogs for at least part of their lumber production. Then, there is a brief description of a new urban-oriented program sponsored by Wood-Miser and Popular Woodworking magazine called "Trees to Furniture". Finally, there is an extensive list of the major and minor sawmills in California as a source of other potential millers of urban sawlogs.

5.1. CALIFORNIA LOGGING HISTORY.

Utilizing trees from "urban" areas for lumber production has probably been going on to some extent since the first settlers arrived in California. Local trees have been cut to provide whatever domestic wood needs that there were, e.g. houses, furniture, grain mills, wagons, etc. The first known sawmill was established by Joseph Chapman at San Gabriel about 1822 (Clar, 1959). John Cooper built the first commercial sawmill in 1834 at Moline, north of the Russian River. At that time, lumber prices for redwood varied from $50 to $100 per MBF (Clar, 1957). The demand for lumber increased dramatically with the great influx of miners and others after the discovery of gold in 1848. That year, the first year that lumber production was reported in California, ten sawmills produced 5 MBF (Bolsinger, 1980). And by 1869, 251 sawmills produced 354 MBF of lumber. Lumber production of all species increased dramatically after 1946 and peaked in 1955 when over 6 billion bd. ft. (BBF) of lumber were cut by commercial sawmills. Commercial lumber production has declined steadily since then and was reported to be around 2.3 BBF in 1994 when only seventy-six mills were in operation (Anonymous, 1996).

5.2. HARDWOOD HISTORY -- BACKGROUND AND LIMITING FACTORS.

Practically all of the commercial lumber cut in California has been from coniferous species, primarily ponderosa pine (*Pinus ponderosa*), coast redwood (*Sequoia sempervirons*), Douglas-fir (*Pseudotsuga menziesii*), and sugar pine (*Pinus lambertiana*) with true firs (*Abies* spp.) and incense cedar (*Calocedrus decurrens*) becoming more important after 1946 (Bolsinger, 1980). Although the utilization of hardwood species for lumber, farming equipment, charcoal, and cooperage was also important during the initial part of the Gold Rush Era in the 1850's, a successful hardwood industry did not develop in California concurrent with that of softwoods. Probably the most extensive use of hardwoods has been tanoak for its bark. By 1911, Jepson and others estimated that as much as 400 MBF of potential hardwood lumber had been left in the woods to rot (Huber & McDonald, 1994). There have been various attempts to produce tanoak lumber since the 1990's, but only in the last few years has there been limited commercial production. Overall, the most successful hardwood milling operation in California was Guy Hall's Cal Oak Lumber Company in Oroville that produced hardwood lumber from 1965 until 1991 when sawmill operations were closed. The company is now focused on remanufacturing and distributing western hardwoods. Cal Oak processed more than 100 million bd. ft. of hardwood logs during these 25 years, mostly California black oak.

A number of factors have been identified for the unsuccessful commercial development of a California hardwood industry (Huber & McDonald, 1994). They note that more than fifty companies began to manufacture hardwood products since the end of World War II, but few have been profitable for long. They list twenty-four reasons why the hardwood industry hasn't been sustainable. It's important to know and understand these factors because many of them will likely also limit the successful utilization of urban sawlogs for lumber production. Those that seem particularly pertinent are discussed in the following sections.

5.2.1. Negative Attitudes.

The commercial lumber industry in California has essentially relied on softwoods because of their large size, high value, high volume, extensive distribution, and ease of processing. Because of this, California foresters and the forest industry have been overwhelmingly geared to softwood lumber production. Hardwoods have generally been considered weed species by most professional foresters. Many also perceived that native hardwoods were of inferior quality because of their "poor" tree form and various processing problems.

Although some of the same problems and negative factors that prevailed in the hardwood industry also apply to urban grown trees, it's not likely that the negative attitude of professional foresters will carry over to urban sawlog utilization because of where and how this resource is managed. To the contrary, there is some concern by some urban forest managers and others that urban trees will be grown for commodity purposes at the expense of esthetics and other community values. And, that there will be pressure to reduce species diversity, i.e. planting only trees with potential commercial value. This certainly need not happen if there are appropriate and properly focused management goals for urban forests.

5.2.2. Logging Logistics.

In contrast to softwoods that generally grow in dense, often continuous stands, hardwoods are scattered, usually with low volumes per acre. With a few exceptions, this will be true for both hardwoods and softwoods on urban sites. Providing ample volume of any one species or even multiple species in a given community will definitely limit the production and therefore size of an urban sawmill operation. Multiple sources of sawlogs including urban, rural, and even commercial forests would be needed to keep a large mill in continuous operation. But, a successful urban sawmill need not be a large volume operation. George Hessenthaler's business, to be described in the next section, mills only about 30,000 bd. ft. of lumber per year. This more than provides enough lumber for his jewelry box and other wood products business. Logistics can definitely be a limiting factor to an urban sawmilling operation.

5.2.3. High Logging Costs.

Hardwood logging is more expensive than it is for softwoods for the reasons noted above. Harvesting scattered trees is definitely expensive and it can be complicated by felling and removal problems. This is also true for "logging" urban trees. The cost and liability of felling trees near houses, powerlines, and other urban facilities is very high compared to that in a rural or wildland location. However, this is a cost borne by a homeowner or responsible governmental agency along with disposal costs. (Check Sections 3.2.1.3. and .4. for an analysis of felling and removal costs.)

5.2.4. Concurrent Logging Practices with Softwoods.

Historically, hardwoods and tanoak in particular, which often grows in mixed stands with coast redwood, have been managed differently than redwood or other conifers. Actually, they haven't been managed at all, and their silvicultural requirements are also generally different. This should not be a concern with an urban forest where trees are usually managed individually and in an unnatural environment.

5.2.5. Inconsistent Estimate of Inventory Base and Resource Value.

Again, because of their low value to foresters, reliable estimates of hardwoods were not made; and, they were not included in timberland inventories until the 1970's (Huber & McDonald, 1994). As noted earlier, less than 50% of the urban communities have accurate and complete information about the street trees they manage and even less information about the private urban trees they don't manage.

Hopefully, this information gap will disappear as more communities develop computerized data bases of their urban trees. In fact, this and the exchange of information over the internet could greatly benefit an urban sawmill business. Dave Parmenter (a sawmill owner referred to in Section 5.3.4) and others see the day when information about tree size, age, condition, potential removal date, and other pertinent factors will be readily available on the internet. This will allow a sawmill company to plan on log acquisition of a predicted volume of a given species in addition to the logs that become available due to unexpected causes. This is especially critical because of the scattered distribution of urban tree specie. (See Section 5.2.2. above.)

5.2.6. Low Quality of Hardwood Trees.

A long time complaint about California hardwoods is their branchy tree form and crooked nature consequently, log lengths range from 6 to 12 and possibly 16 feet long. Thirty-two- and even 40-foot-long conifer logs are common in the softwood industry. Guy Hall's Cal Oak mill was successful for many years because he set up their sawmilling operation to handle 4-foot-long logs. This significantly increased the lumber recovery, but reduced his hourly production rate from about 5 MBF/hr. to about 3 MBF/hr. Tanoak is one of the few hardwoods that has reasonably good tree form, but drying problems have seriously limited its use for lumber production.

Log quality will undoubtedly affect lumber recovery for the following reasons. First, urban sites may have a number of quality limiting conditions not found in a commercial forest.

Urban sites may be severely compacted and there may be only limited soil area with a high proportion of the root zone under or restricted by sidewalks, streets, parking lots, etc. Second, urban air pollution may limit growth or even eliminate some species. Third, metal embedded in a tree trunk, for example nails, spikes, barbed-wire, etc. may totally eliminate or greatly reduce the usable portion of an otherwise high quality log. Fourth, most urban trees are open-grown, with excessive light that promotes excessive and long-lived branches. However, the natural self-pruning that occurs in a dense forest may be compensated by normal urban tree pruning activities.

5.2.7. Log Grade and Lumber Yield Recovery Studies.

There has been no log grading system developed specifically for western hardwoods and past attempts to develop local grading systems have been expensive, losing propositions (Huber & McDonald, 1994). Forest Service log grading rules for eastern hardwoods have been used for western hardwoods. An obvious question is: “Is it necessary or even feasible to develop a log grading system for urban logs?” Because of the drastically different growing conditions of urban sites, a grading system that is applicable to logs from “natural” sites may have to be changed or at least tailored to urban conditions. It’s already been noted that Pillsbury and others (1995) have been developing tree volume tables for key urban species. Similar work may have to done for log grading rules for urban-grown trees. Using existing log grades for urban trees would not work. They would probably all grade out as No. 3’s. The existing log grading system could work if log lengths of 6 and 8 ft. were accepted. However, it may make more sense to assign value to urban logs on the basis of weight, length, or diameter.

Although log grade and associated lumber yield studies have been run for most key California hardwoods, they involved Forest Service log rules and National Hardwood Lumber Association lumber grade rules for eastern hardwoods (Huber & McDonald, 1994). In addition, the tests were based on “green” lumber adjusted for an estimated 5% loss in volume due to shrinkage. And, there was no determination of the final recovery in surfaced and dried lumber grades and volumes. Consequently, the actual amount of degrade and loss during hardwood lumber processing is not known. However, some in-house lumber recovery evaluations were recently reported by Hall (1998) relevant to tanoak, madrone, and California black oak milled at the former Cal Oak facility in Oroville, CA. According to Hall, their records clearly indicated that a minimum of 50% of #2 Common and Better grades were expected. In addition, for a business to successful, at least a third of the lumber reaching the green chain had to be #1 Common and Better. However, this does not provide a very secure basis for extrapolating western hardwood information to their urban counterparts. As might be expected, the situation is even worse for the exotic urban-grown species.

While good information about log grades and lumber yield is available for commercial western softwood species, some adjustments may also be necessary for their urban-grown counterparts. However, this is probably less of a problem with softwoods than hardwoods because of their more uniform growth habit and better information base. For either species, information about urban-grown log grades and especially lumber yield recovery will likely be slow in coming as there will probably be little incentive to invest money for this type of research. But, lumber yield and recovery are absolutely necessary to understand the economic viability of a venture.

5.2.8. Use of Softwood Processing Methods.

Early attempts to mill hardwood species were unsuccessful in part because operators tried to use the same techniques for hardwoods that they used for softwoods. Most softwood manufacturing methods are geared to high volume milling and processing, larger logs, producing lumber of thicker dimensions, and positioning knots and defects within a board face (Huber & McDonald, 1994). For hardwoods, defects should be confined to the edge of a board. Because of higher wood density, variable log shape, and shorter lengths, hardwood production rates are slower than they are for softwoods. To get straight hardwood logs, it is often necessary to buck to 6- to 8-foot lengths, whereas softwood logs are routinely 14 ft. and longer. The shorter logs reduce production rate dramatically. Hardwoods are usually cut to 1-inch (4/4) thickness in contrast to 2-inch dimensions for softwoods (Hubbell & McDonald, 1994; reference to Talcum, 1962). This means more sawing time and more loss to sawdust production for hardwoods. All of these factors and others made it difficult for hardwood sawmilling to be successful.

As just noted, hardwoods are usually cut at a slower rate than softwoods. They are also often cut to produce the most “figured” wood (i.e. pattern in wood created by abnormal growth) as possible especially for custom and niche markets that urban mills would often be seeking. This, plus the irregular shape of hardwood logs, may require that they be turned several times during sawing to produce the maximum amount of high value lumber. This may be difficult on small mills not equipped with an hydraulic log handling system. Probably only a few sawmill operators in California currently have the experience and background knowledge about hardwood log quality and lumber grades to consistently cut to such requirements. However, cutting to grade may be of secondary concern if specialty and figured wood are the major goals of an urban sawmilling business. It’s most likely, that anyone getting into the urban sawmilling business today would not be too concerned about processing differences between hardwoods and softwoods. However, you can maximize figure in hardwoods but softwoods do not have much character as a rule.

5.2.9. Lumber Drying Problems.

Probably one of the major problems that has limited the utilization of California hardwoods has been the inability to successfully dry most of the species. Compared to softwoods, hardwoods take much longer to dry. They also require much less severe drying conditions, consequently good control of the drying environment is essential. Information about the practical requirements of drying lumber is covered in Section 8.5.

Anyone who is seriously interested in getting into the urban sawmilling business will have to have their lumber kiln-dried, whether they do it themselves or have it done by a commercial drying company. This will require capital for either the equipment or for “outside” processing costs. Because hardwood drying is slow, cash flow will also be slow; consequently, to survive, a business will have to have enough reserve operating capital to keep in business while waiting for their lumber to dry before it can be sold. This is a common business dilemma that’s discussed in the next section.

5.2.10. Limited Working Capital.

Lack of adequate working capital has been a chronic problem in the California hardwood sawmilling industry, and it still seems to be a major handicap today with most of those in the custom sawmilling business. As noted later in Section 5.3., most urban sawmillers are barely breaking even. Some don't have adequate cash flow to purchase needed equipment or hire qualified employees, and paying even rent may be a problem. These factors will seriously limit the survival, much less growth of an urban sawmill business, or any other for that matter. The basic capital and equipment requirements for setting up and operating an urban sawmill business are covered in Section 6.0. The California Integrated Waste Management Board (CIWMB) has established a low interest business loan fund that can be used to set up or expand an urban sawlog utilization business. The details are described in Section 7.3.5.1.

5.2.11. Variable Product Quality.

Many of the problems just noted have resulted in hardwood products of variable size, quality, and inconsistent quantity that caused customer dissatisfaction. Lack of knowledge about lumber standardization and the inability to provide consistent quality has helped thwart all efforts to establish a major hardwood industry in California. However, this has primarily been in the context of a major commodity hardwood industry supplying lumber for major manufacturing businesses. This is not the focus of the small, urban, sawlog utilization businesses envisioned in this report. Product standardization is very important, but not as critical for a cottage industry supplying small wood users, where "non-standard" may be what many customers often want. However, even with nonstandard products consistent quality will be demanded by the customer.

5.2.12. "Marketing Issues" -- Lessons from the California Hardwood Industry.

Milling lumber can be great fun and personally rewarding if it's simply a hobby. However, if it's supposed to be a successful, income-producing enterprise, then there are a number of requirements that must be met that were often missing in past hardwood milling endeavors. Huber and McDonald (1994) identified thirteen issues that repeatedly hindered hardwood sawmill's success. These and our suggestions for resolving these problems are as follows:

Past Hardwood Industry Problems	Requirements for a successful Business
• Lack of product standards.	Well-defined product standards.
• Poor product quality.	Good quality control.
• Limited range of product sizes.	Product sizes to fit customer needs.
• Lack of companion building products.	Focus on niche markets.
• Industry instability.	Financial and technical support.
• Inability to supply products in sufficient volume.	Focus on niche markets.
• Failure to keep promised delivery dates.	Realistic sales program.
• Lack of marketing information.	Customer information and service.

• Products not marketed on their own merit.	Promote unique properties of urban trees.
• Lack of promoting unique product identity.	Promote unique properties of urban trees.
• Limited consumer information of properties and uses.	Support for research and information transfer.
• Consumer prejudice to eastern species.	Promote unique properties of western urban trees.
• Procurement problems due to a limited distribution network.	Better information transfer, e.g. effecient use of the internet.

These same issues could be significant roadblocks to urban enterprises trying to break into the wood product market.

5.3. SMALL SAWMILLS CUTTING URBAN SAWLOGS.

The purpose of this section is to describe some of the key sawmilling operations currently using urban sawlogs for at least part of their log resource. Hopefully, this information will encourage others to become involved in urban sawlog utilization. With the exception of George Hessenthaler's Urban Forest Woodworks, Inc. all of the following are small businesses that involve the owner and two to four employees. George has a "big" business with around eleven employees, although several of these are primarily involved in value-added manufacturing activities. All of the owners have some traits in common. They all love milling lumber and working with wood, not too surprising. And, they all see the value of utilizing a resource that otherwise would be wasted or at best used for a lower value product. They are all small businesses and most have a problem with limited cash flow. A detailed description of seven urban sawlog milling operations is provided in the sections that follow.

5.3.1. George Hessenthaler's -- Urban Forest Woodworks, Inc.

A good example of a true urban sawlog milling business in the United States is George Hessenthaler's Urban Forest Woodworks, Inc. currently located in Logan, Utah. He recently moved his business there from Salt Lake City. Considering the arid climate in this part of Utah, neither city would seem to be a likely location for an urban forest-oriented industry. In fact, George (1997) points out that in 1847 there was only one tree, a juniper, where Salt Lake City in now located. The city fathers embarked on a vigorous shade tree planting program along with the establishment of orchards and vineyards. Although box elder (*Acer negundo*) and cottonwoods (*Populus* spp.) were some of the first trees planted, there are now over 200 species in Salt Lake City and about 75% of these are hardwoods. Unless in a tropical environment, George questions that where else will you find such a variety of trees? George routinely mills over twenty-five species of urban hardwoods, (See box below for species list.), plus all of the several different fruit trees that grow locally.

Before describing Urban Forest Woodworks, Inc. in more detail, a general description of George's company and some of his philosophy about using urban sawlogs will be highlighted. First, George and his urban wood business have been written about in several newspaper articles (Bean, 1992; Woolf, 1992) and a variety of environmentally oriented publications (Anonymous, 1993; Chapman, 1996; Herr, 1993). His advocacy for the productive use of urban waste sawlogs is clearly stated in the following quotations (Bean, 1992): "When rain forests are dwindling daily, it's criminally wasteful for expensive hardwood logs to end up in

> **TREE SPECIES MILLED BY URBAN FOREST WOODWORKS, LOGAN, UTAH**
>
> **Walnut** - black and English. **Ash** - Modesto, white, green, blue, and black.
> **Locust** - black, honey, others. **Elms** - Siberian, American. **Catalpa**.
> **Sycamore** - London plaintree, . **Nuts** - almond, pistachio, hazel.
> **Local fruit trees** - cherry, apple, nectarine, peach, apricot, and plum.

landfills and fireplaces". And: "I feel strongly that a healthy tree shouldn't be cut down. And by using discarded logs, I'm doing my part to preserve the environment, particularly in rescuing the wood from our already overcrowded landfills." The relatively small amount of lumber that George cuts each year (around 30,000 bd. ft.) will have little impact on the total amount of woody green waste going to his local landfill. And, it will have even less impact on the harvesting of either tropical or commercial United States forests. However, the cumulative effect of many such businesses throughout the United States could have a big positive effect on reducing harvesting from commercial sources.

Second, producing only lumber from urban sawlogs is not what George has in mind, rather: "It is my belief and my business practice that the wood produced from urban saw logs should not be sold as lumber. It should be sold as finished, value-added products" (Hessenthaler, 1997). And: "Anything made of wood can be made of urban forest wood." In summary, George Hessenthaler is a "crusader" for the reclamation of urban sawlogs and converting them into valuable value-added products.

5.3.1.1. <u>History.</u> In 1977, George started a small business in Salt Lake City making wooden jewelry cases. After it went broke, he then turned to making cabinets and eventually had enough business to keep ten workers occupied. During that time, he invented a line of magnetic joiner and planer knife setting jigs that allowed the blades to be set quickly and accurately. The wood he needed for his business was bought in California before he found that he could obtain lumber from local urban logs for his needs. And, the logs were basically free.

George founded the Urban Forest Woodworks in 1988 and continued collecting and storing urban hardwood logs. In five years, he sawed over 6,000 logs that otherwise would have gone to a dump. Initially, he worked with the Salt Lake City Urban Forester and gained access to the municipal log dump where the large logs were cut for firewood. George now recommends that the best way to get good logs is to pay for them at firewood prices, i.e. around $100 per cord or about 5 to 8 cents per board foot (Hessenthaler, 1997). He also recommends that you don't cut down or haul your own logs as there are professionals who have the equipment and can do it in a fast and safe manner.

During the first 5 years that Urban Forest Woodworks was in business, George invested $250,000 in wages, equipment, logs, and incidentals and essentially had a break-even business (Hessenthaler, 1992). As noted earlier in Section 5.2.10., limited operating capital seems to plague most small sawmilling businesses. Fortunately, George has been able to funnel capital earned from his various patents into his sawmill business. By 1996, the business was more than breaking-even when George moved the company to Logan, Utah where operating expenses were less.

5.3.1.2. Species. Almost any species of tree that produces logs 10 in. or more in diameter has the potential for producing valuable lumber for Urban Forest Woodworks. (See the list of species in the previous box.) George specifically seeks out some of the "worst" looking logs including crotches, knees, and limbs for conversion to high-end quality products (Chapman, 1996). These off-beat logs produce some of the best figured wood, a specialty of Urban Forest Woodworks. Most are non commercial species and are almost exclusively hardwoods with the exception of cedar, which is a favorite wood for jewelry boxes (Hessenthaler, 1997b).

5.3.1.3. Log acquisition and storage. As just noted, George can profitably saw and use logs greater than 10 in. in diameter and 3 ft. in length. This is smaller than most custom sawmills cut because of the low production-to-time ratio and other factors, but this size is suitable for George's case-making business and his bookmatch billet customers. Although George gets logs year-round, most become available between April and October. He now gets 90% of his logs from independent tree service companies. He feels that obtaining logs from governmental agencies is too complicated by "bureaucratic red tape". Hopefully, this will decrease as more agencies become aware of the many advantages of utilizing urban waste logs and there's more demand for them.

Overall, George estimates that he needs about 75,000 bd. ft. of logs to produce 35,000 bd. ft. of lumber, about what Urban Forest Woodworks uses per year. This does not include the logs or parts of logs that can't be used because of buried metal and other materials. George estimates that one out of twenty logs contain too much metal to be used. He finds most of the metal in the first 4 ft. of a tree (Chapman, 1996), which is unfortunate because some of the best lumber is found in the basal log. George and most urban sawmillers find it necessary to check their logs with a metal detector to reduce the risk of injury and damage to their saws from enclosed metal. (See Section 8.3. for a discussion about enclosed metal.)

George stockpilles excess logs. In October 1997, he had an inventory of about 5,000 logs that was comprised of almost thirty tree species. Proper stockpiling of logs is a critical step in maintaining log quality, which is complicated by the dry Utah climate. To reduce cracking, the logs are covered with a foot of straw that's saturated with dripper hoses from April to October. Unfortunately, this provides a great habit for rats that have to be controlled. (Use of water sprinklers might be a better method of applying water.)

It's taken George several years to learn the expected "yard" life of the different tree species. And, that different insects and pathogens affect species at different rates and to different degrees. He's found that some trees, like the ashes, maples, and sycamore, are especially vulnerable to horned-tail saw flies (*Ttremix* spp.). They may work in a log for as long as 3 years, riddling it to dust. Various beetles and other wood boring insects work in both wet and kiln-dried wood. To the contrary, George has also found that pathogens sometimes have beneficial effects such as spalting in maple and sycamore; but, more often they reduce or destroy log quality.

To overcome the various hazards of long term log storage, George uses underwater storage that not only protects the wood from insects, disease, and drying, but the wet wood also makes sawing easier. First the logs are cut into cants or billets and then submerged in water in special fiberglass tanks 4 X 4 X 8 feet in size that George had fabricated.

5.3.1.4. Equipment. Because Urban Forest Woodworks both mills their own wood stock and manufactures jewelry cases and other items, the business has equipment for both phases of the work. The present facility in Logan cost about $210,000. For a bare-bones start-up sawmillinig business, George estimates that it will take at least $70,000 to obtain a log truck, portable mill, kiln, and building. His basic equipment includes the following:

Milling equipment.

1. LT 30 Wood-Miser Portable Bandsaw with an 18 h.p. electric motor and no hydraulic lifts. (Next saw will have hydraulic lifts.)

2. EBAC dehumidification kiln upgraded to dry 4,000 bd. ft. per load (instead of the designed 1,500 bd. ft.) by adding two large circulating fans and a 2,500 watt digital auxiliary electric wall mounted heater. Kiln controls are external.

Remanufactuing equipment.

1. Thirty-six-inch wide dual head abrasive/planer wide-belt sander. Used for finishing thin, high-figured wood used in jewelry cases.

2. Twenty-four-inch Rockwell planer; although, it's seldom used because of better finishing obtained with the wide belt sander on thin, figured wood.

3. Other equipment includes wood shop production equipment, e.g. saws, sanders, etc. not used for the sawmilling operation.

5.3.1.5. Production. Urban Forest Woodworks, Inc. mills and dries 4,000 bd. ft. of lumber every 6 to 8 weeks or about 24,000 to 36,000 bd. ft. per year. Drying takes about 26 to 30 days per load. They've reduced lumber production since December 1996 to about 12,000 bd. ft. and have almost used up their inventory of 25,000 bd. ft. A rough estimate of production cost is $0.50 per bd. ft., which includes log purchase and transport, handling, sawing, sticking, banding, kiln drying and unloading. But, it does not include the cost of storing sawn and dried wood indoors, which can become expensive if the wood is held for a long time. Nor, does it include losses to insects or mechanical damage that can occur during handling.

George does not track lumber production by species and treats and values all hardwoods equally (Hessenthaler, 1997). He's developed his own lumber grading system that's oriented specifically to the manufacture of his jewelry cases. It allows for mineral streaks, partial rot, insect damage, bark pockets, voids, etc. He feels that these natural flaws add "character" to his cases' appearance. He has also developed a blend of epoxy resin and powdered metal to fill voids and defects that he thinks actually strengthens and beautifies the wood.

5.3.1.6. Products. As noted earlier, George does not think that wood produced from urban logs should be sold as lumber, but used in value-added products **(Fig. 5.1.)**. Urban Forest Woodworks' three value-added products are: jewelry cases, candle holders, and trophy golf ball holders **(Fig. 5.2.)**. He frequently uses up to six different wood species in a jewelry case, but does not sell them on the basis of species composition.

Figure 5.1. Candle holders and jewelry boxes produced by George Hessenthaler's Urban Forest Wood Works business in Logan, Utah.

Figure 5.2. Golf ball holders are made from scraps of wood often too small for other uses.

Rather, he classifies the cases by color, e.g. dark, medium, and light; however, the wood composition is identified in literature accompanying each box. George does not want to use a single species of wood in a case because he might use up his supply of that species, which might force him into a community to "hunt" for that species. He is dead-set against becoming an "urban forest tree predator."

George points out that probably the most important aspect of urban sawlog utilization is to sell what you make. He also notes that there is a lot of competition, perhaps 300 case-making firms in the United States plus individual hobbyists and European and Asian producers (Hessenthaler, 1997). However, instead of viewing other case makers as competitors, he sees them as potential customers for mini-bookmatch panels for case tops and for special case hardware that he's patented.

Urban Forest Woodworks, Inc. has a number of markets for their products including a standard gift market, plus customized cases to a corporate incentive market, and their own factory outlet. The latter allows them to sell "seconds" and even discontinued case models they didn't sell through normal channels. George has found that store retailers are very receptive to selling products from urban trees because of the "environmentally friendly" aspects of the product. George says that the ultimate test for an urban forest wastewood-based business to succeed in the American market place is to produce a net profit. So far, Urban Forest Woodworks, Inc., is succeeding, but they have not yet produced a net profit (Hessenthaler, 1997).

Along the way, George has been developing an economic theory that indicates that profits are indirectly proportional to size (or cost). For example, a $30 case requires "X" amount of material, skilled labor, and expensive marketing effort; while, a $4 golf ball holder requires about 0.2 "X" as much as the case. Ironically, he's found that the golf ball holders are five times more profitable than the hand-made wooden cases. Even more ironically, the golf ball holders are mostly made from scrap material; material that would otherwise be used for fuel or dumped.

In summary, George has been an avid disciple for urban green wood utilization for many years. He eagerly attends and is often a presenter at sawmilling and processing workshops, such as the Urban Wood Utilization workshop at Pierce College in Woodland Hills, California on June 13, 1997 where he was a lecturer. At that meeting, George proposed running an "hands-on" workshop at his Urban Forest Woodworks facility in Logan. He is still working on that idea and someday may have an Urban Forest Milling Conference there.

5.3.2. Dave Faison's [1]. -- Into The Woods

Dave Faison was George Hessenthaler's California counterpart in the urban sawlog milling business. However, Dave also "reclaimed" valuable timbers and beams from old buildings, factories, and other wooden structures. They both have the same philosophy about using urban sawlogs and the same concern about lumber from trees grown in tropical rain forests. Dave noted that: "I personally love working with wood, and need to feel comfortable using the product. If they have to rape the forest to get the wood I can't have that connection to it" (Herr, 1993). In regard to urban trees, Dave felt that: "We're not taking viable trees; the trees we get are either not healthy or in the wrong place. Either way, they're going to the dump. And this wood is just too beautiful to throw away" (Herr, 1993). "The point we're interested in making is that you don't have to import wood. There's beautiful wood right here" (Anonymous, 1993).

5.3.2.1. History. Dave was a custom furniture maker who was increasingly disturbed with the forestry practices that produced his raw material (Herr, 1993). He began to experiment with native and locally available non-native species. He soon found that they were not just acceptable, but they made premium furniture woods. However, there was little native lumber available for his furniture projects. In 1990, Dave co-founded Into The Woods with Wyatt Renk, also a furniture maker, and Dave Downing who owned a tree removal business and a small sawmill (Palmer, 1991). This was a perfect combination for an urban sawmill business. They set up a sawmill plus wood drying and storage facility in a converted poultry processing warehouse adjacent to the Petaluma River (Palmer, 1991). In 1996, the business expanded and rented a nearby warehouse. Dave had to restructure the business in 1996 and became the sole proprietor. He also did consulting on native woodmilling and out sourced much of the processing.

5.3.2.2. Species. As noted, Dave Faison had become an expert at milling and using native and locally grown non-native hardwoods. He found that with careful drying, difficult hardwoods like madrone (*Arbutus menziesi*), tanoak (*Lithocarpus densilforus*), and canyon live oak (*Quercus chrysolepis*) can become premium furniture woods. He has found that black locust (*Robinia pseudoacacia*) has properties similar to teak; and, chinquapin (*Chrysolepis chrysophylla*) is similar in color and workability to mahogany (Anonymous, 1993). Dave also worked with black acacia (*Acacia melanoxylon*), a wood similar to koa. Examples of this wood, produced by Into the Woods, can be seen in the Getty Art Museum. He was even successful in using blue gum (*Eucalyptus globulus*) which: "-- makes a handsome and durable

[1] Dave Faison, one of the leaders in milling urban sawlogs for lumber and specialty wood products in California, passed away in August 1998.

flooring, which should be competitive with eastern red oak" (Merwin, no date). Other species with unusual effects include pear (*Pyrus* spp.), lemon (*Citrus limonia* ssp.) , apple (*Malus* spp.), avocado (*Persea* spp.) and grapefruit (*Citrus grandis* ssp.) that produce beautiful wood.

5.3.2.3. Log acquisition. Into The Woods obtained logs and waste wood from throughout northern and central California. Dave was very selective in the type of logs they milled. He wanted trees that had interesting grain or figure like birds eye, lobster tail, flame and fiddleneck (Palmer, 1991). Dave could usually determine the grain from the outside of a log; but, it was hard to be sure about the figure. One of the exciting things about milling a log was discovering the wonderful and often surprising grain patterns and other wood features that became visible as it is cut open (Palmer, 1991). For example, from a crotch you might get "flame" or "lobster tail". But, only with these valuable wood features could Into The Woods normally afford to pay for logs, or deal with single logs. Dave figured that at $50 per hour, it would cost $150 for a boom truck to pick up a log 1.5 hours away from his mill (Herr, 1993), and this reduced the value of an urban log. He felt that the chance of finding an interesting log at a big sawmill is slim because these logs have already been excluded before they get there. Into The Woods gets most of their logs from tree-removal businesses. Dave was able to select the logs he wanted and at the same time reduce the disposal costs of the tree-removal business.

5.3.2.4. Equipment. Into the Woods used a portable Mighty-Mite bandsaw and a Mobile Dimension circular saw mill to saw their logs. They could cut logs up to 27 inches in diameter.

5.3.2.5. Products. Into The Woods specialized in hard-to-find native and exotic specialty wood, wood that can be used by custom furniture makers, woodcarvers, gun manufacturers, and others (Herr, 1993). The company processed about 50,000 bd. ft. of lumber per year. Hardwood lumber was the primary product **(Fig. 5.3.)** .

Figure. 5.3. Dave Faison's Into The woods milled and dried lumber from a variety of native and non-native hardwoods, including madrone and walnut, and specialized in "figured" wood.

The wood could be used for various nonstructural features in homes such as doors, kitchen cabinets, base boards, flooring, etc. In 1993, native hardwood lumber typically sold for about $4 per bd. ft., about the same as many imported hardwood species. Today the range is $3.50 to $6.00. In addition to lumber, they also produced value-added products such as furniture and butcher blocks (Herr, 1993). Flooring was an essential product because it allows use of the lower grades of lumber - because urban trees grow in the open, they tend to have more limbs and knots. Like most custom millers of urban sawlogs, Into The Woods was not a big money maker and it was barely breaking even in 1993 (Herr, 1993). Dave thought that certification could increase the value of his products (Faison, 1997), and Into the Woods was certified by the Rainforest Alliance.

5.3.3. Warren Wise's -- The Woodsman .

Warren Wise's custom sawmill business is located on 2.5 acres on the outskirts of Stockton, California. Like Dave Faison he specializes in finished, high value hardwoods that have been cut to maximize figured wood (Herr, 1993). Warren also imports and sells exotic hardwoods. He has been successful at drying many hard-to-dry woods and has an international clientele. Also, like George Hessenthaler and Dave Faison, Warren has a passion for milling wood. "It's always exciting to open a new log, because with hardwoods, every log is a new story" (Herr, 1993). He began his business by sawing trees from orchard clearing operations, at a time when practically all such wood was cut up for firewood or burned. Warren especially liked to help people salvage their own trees which is what he was doing when he got into the sawmilling business. The Woodsmen is a three-man operation with a sawyer and jack-of-all-trades in addition to Warren.

5.3.3.1. History. Warren taught wood shop in junior high and high school. When he retired in 1985, he bought a portable sawmill, and planned to hook it onto a motor home, and go to the woods with the intention of milling wood for other people (Wise, 1997). But, the first farmer that he contacted was pulling out fifty trees. He gave all of them to Warren with the stipulation that Warren saw all of the logs on his property so that he could be around to help. Before the job was finished, a developer gave Warren 1,100 trees that had to be removed immediately. The developer paid for delivering the logs; but, Warren's dilemma was where to store this huge pile of logs that was almost 200 ft. wide, 1,100 ft. long, and 8 ft. deep. Thus, began The Woodsman on the out skirts of Stockton.

5.3.3.2. Species. Although The Woodsman stocks over 80 species of hardwoods for sale, but not all of them are milled by Warren. The biggest volume of wood that he cuts is English walnut and California black walnut root stock (*Juglans* spp.), and he also cuts chestnut (*Aesculus* spp.), maple (*Acer* spp.), poplar (*Populus* spp.) and other species as they become available. Warren, like several other custom sawmillers, has also been successful in processing blue gum eucalyptus. He's found it best to mill freshly harvested trees, otherwise the wood gets too hard to cut efficiently. Contrary to general opinion that eucalyptus species are tough to dry successfully, Warren has found red ironbark eucalyptus (*Eucalyptus sideroxylon*) a beautiful wood that is easier to process than blue gum (Merwin, date unknown).

5.3.3.3. Log acquisition. Warren obtains his logs from about a 50-mile radius of the Stockton area, with almost 25% of the trees coming from urban sites and the rest from agricultural areas (WIse, 1997). Most of the trees are from orchards, but he also gets them from golf courses, cemeteries, parks, and residential yards. Warren, as have others working with urban trees, finds that a high proportion of them have metal and other foreign material attached to or embedded in the trunk. Orchard trees usually aren't as big of a problem as urban trees, but he has found unwanted material in logs from all sources. Like other urban sawmillers, Warren finds it necessary to screen logs with a metal detector to locate potential metal hazards. A comprehensive discussion of dealing with embedded metal is given in Section

8.1.3. Recall that George Heassenthaler has found up to one log in twenty unusable because of excessive embedded metal.

Warren has the opportunity to acquire logs all year long. He processes about 1,000 logs of various sizes in a year and stockpiles them in a deck at The Woodsmen. Good logs are separated from those with fungus diseases. To reduce checking, Warren paints the ends of the logs with latex paint.

5.3.3.4. Equipment. The Woodsman has its own 2-ton crane truck and low-bed trailer plus an all-terrain fork lift **(Fig. 5.4.)** , two items essential for an efficient sawmilling operation.
His uses an LT-30 Wood-Miser bandsaw capable of handling up to 27-inch diameter logs, or larger logs if they are first split in half with a chain saw. In fact, Warren has found that when dealing with blue gum, it's actually beneficial to use larger logs that have been split. This seems to increase that amount of stable lumber that can be obtained.

Figure 5.4. Warren Wise inspects a large walnut "crotch being moved with his all-terrain forklift.

Most lumber must be dried to be usable. This is when it's most subject to checking and warping. To reduce these problems, Warren invested in a $20,000 computer controlled vacuum kiln that dries wood rapidly and at low temperature. He's become so expert at this that he custom dries exotic hardwoods from all over the world (Herr, 1993). The kiln dries about 1,000 bd. ft. per load. Depending on species and size, it takes about 30 days for a load to dry from green moisture content to 6% compared to 20 to 60 days for other drying methods.

5.3.3.5. Products. The Woodsman mills about 24,500 bd. ft. of lumber per year. All wood is cut and then recut if necessary to produce premium grade lumber. Warren sells both air- and kiln-dried lumber, and he also does custom milling and drying. He will mill someone's favorite tree that died and can be made into "heritage" furniture for the family. As noted previously, he specializes in figured wood **(Fig. 5.5.)** and imported exotic hardwoods. Warren does not sell large units of wood or to wholesalers, but he primarily sells to fine wood craftsman who make bowls, gun stocks, toys, musical interments, furniture, etc. This is a narrow market, but one with the greatest profit while still giving the craftsman a good value (Wise, 1998). Warren also has a wide variety of specialty stock for making hand crafted pencils. Wood chips and sawdust are used for mulch and mill trims are used for firewood.

5.3.4. Peter Lang's -- The Peter Lang Company.
Peter Lang's sawmill business is located on a ranch outside of Santa Rosa, California. The

ranch is also an exotic game preserve, making probably one of the most unique environments sawmilling business in June 1990, and rather than owning his own sawmill equipment, he

Figure 5.5. Warren Wise (0n the right) mills and sells both air and kiln-dried native and non-native lumber. He also specializes in "figured" wood.

subcontracted with portable sawmill operators for his raw lumber (Merwin, date unknown). He now has his own sawmill and other processing equipment and two full-time employees plus some part time office help (Lang, 1997).

5.3.4.1. Species. Walnut is by far the primary tree species that Peter mills, representing about 500,000 lb. out of the 800,000 lb. of burls that he processes annually. Other burl species include 200,000 lb. of redwood and 50,000 lb. of California bay (*Umbellularia californica*) plus another 50,000 lb. of miscellaneous species. Peter also mills lumber from walnut, bay, maple, and other native species. He is also aware of the difficulty in working with blue gum, e.g. cracking and warping, and does not foresee a big demand for blue gum lumber.

5.3.4.2. Log and burl acquisition. Peter Lang gets his logs and burls, the latter mostly from walnut groves, from throughout northern California and the Central Valleys. Unlike previously described sawmill operations, Peter's company does not generally use urban-grown sawlogs. The timing of log acquisition, species, and quality are geared to specific production needs. A good part of this need requires highly figured wood only available from tree burls. Burls are sold by the pound; last year Peter bought over 800,000 pounds plus enough logs to produce 50,000 bd. ft. of lumber (Lang, 1997). He wants only logs greater that 18 in. in diameter, with no maximum diameter limit, and at least 8 ft. long.

5.3.4.3. Equipment. The Peter Lang Company has a portable Linn lumber mill **(Fig. 5.6.)** capable of milling logs up to 47 in. in diameter, plus a chainsaw mill capable of cutting 46-inch diameter logs. Wood drying is done in a 3 H.P. NYLE dehumidification kiln with a capacity of around 4,000 bd. ft. per load**.**

5.3.4.4. Products. The Peter Lang Company produces a variety of hardwood products including kiln-dried lumber, specialty blocks for such highend items as gear shift knobs **(Fig. 5.7.)** , gun stocks, and figured wood for carvers and cabinet makers. Peter also turns bowls **(Fig. 5.8.)** and carves “life-like” animal skulls plus horns **(Fig. 5.9.)** out of wood that he mills. When asked what his company needs to become more efficient and profitable, Peter mentioned greater volume of products and more marketing effort. No doubt more products should increase profit, but more and effective marketing are essential in order to capitalize on increased production. Effective marketing is especially important for

Figure 5.6. Peter Lang’s Linn band mill is capable of cutting 46-inch diameter logs. The head rig is moved by hand.

Figure 5.7. Partially figured walnut stock, too small for cabinet and other furniture products, can be cut into small blocks for gear-shift knobs and other specialty items.

Figure 5.8. The Peter Lang Company produces turning blocks and turns some of their own bowls.

Figure 5.9. A Peter Lang specialty are “life-like” animal skulls and horns carved from wood that he mills.

sawmilling operations that are somewhat isolated in rural locations like The Peter Lang Company and The Woodsman where they are not readily accessible to “walk-in” customers.

5.3.5. Dave Parmenters’s -- California Hardwood Producers, Inc.

Because California Hardwood Producers, Inc. got about 60% of its log supply from Sacramento and other local communities, it was the best example of a small urban sawlog utilization business in California. Housed in a huge, old, wood processing plant in Aurburn, California, it had ample room for milling and storing lumber, plus milling flooring and other value-added products. Dave had built and assembled four dehumidification kilns capable of drying 1.2 million bd. ft./year that made California Hardwood Producers’ lumber drying capacity much greater than other small California custom sawmills. Combining two portable sawmills and a band resaw, Hardwood Producers Inc. had a potential milling capacity of 4,500 bd. ft. per day, and a total milling capacity of 1.8 million bd. ft./year.

5.3.5.1. History. Dave Parmenter’s sawmill business began in 1992 with a Wood-Mizer band mill and was called Parmenter Works. In 1994, Dave started a local hardwood sawmilling cooperative with four members in Auburn that was called California Hardwood Producers Cooperative, Inc. A cooperative can operate as a partnership of two members with a cooperative legal structure, but at least three members are required for cooperative status. Financial assistance was provided by a joint effort of the Sierra Economic Development District and the High Sierra Resource Conservation and Development Council to promote a local California hardwood industry. Dave changed the name of the company to California Hardwood Producers, Inc. in 1995. As a cooperative, it obtained logs, lumber, and cants from several independent portable sawmill operators plus milling its own lumber. The cooperative dissolved after a few years and Dave carried on the operation as a “sole-propriatorship”.

All in all, this would appear to be a perfect climate for a successful urban and general hardwood sawmill operation. In addition to the support from the Sierra Economic Development District and other governmental agencies, a market analysis prepared by Mater Engineering, Ltd. (1994) was tailored to identify hardwood commodity and niche markets for California Hardwood Producers, Inc. But even with all of these “pluses”, Dave like most other custom sawmill operators had a cash flow problem. For example, he was unable to hire a qualified operator to run his floor molding machine. Consequently, he had to run it himself which sidetracked his time from other important business activities. Then, a major setback occurred in July 1997 when a fire destroyed the entire sawmill except for a few small buildings. California Hardwood Producers has been slowly rebuilding since the fire, and currently has more orders than can be filled. Dave still has two Wood-Mizers operating with a crew of two mill operators and two tenders.

Prior to the July 1997 fire, California Hardwood Producers was involved in a highly promising marketing innovation with Jim Hafferty of Burls & More. Jim had developed an Internet website (www.thisoldwoodpile.com) through which he could market California Hardwood Producers’ wood products. It was an interactive website through which lumber, burls, and other wood products could be bought and sold. It also listed lumber and other product prices along with colored pictures of the different species of wood flooring and other produces. Use of the Internet for buying and selling is the wave of the future, and it should be especially beneficial for out-of-the-way operations like Lang’s and Wises’. Dave’s enthusiasm has not been burnt out by the fire. He is currently envisioning a "Wood World" or conglomerant of various wood based businesses , e.g. cabinet makers, wood carvers, etc. working together such at one location.

5.3.5.2. Species. Dave mills a variety of native and non-native hardwoods, the latter mostly coming from urban sites. Species milled include California black oak, (*Quercus kelloggii*), bigleaf maple (*Acer macrophylum*), white oak (probably *Quercus lobata*), tanoak, madrone, black walnut (*Juglans hindsii*), sycamore, ash, elm, eucalyptus (several species), English walnut (*Juglans regia*), camphor (*Cinnamonum camphora*), and black locust.

5.3.5.3. Log acquisition. California Hardwood Producers gets logs and burls from a variety of sources including 60% from Sacramento (See Section 3.2.) and other communities, plus 40% from agriculture and roadside clearings, and from commercial forests. Logs from Sacramento were valued at $7.50 per ton in 1994 (Thompson and others, 1994). As noted earlier, Dave also gets lumber and cants from other small sawmill operations throughout the state.

5.3.5.4. Equipment. It's already been noted that California Hardwood Producers was one of the biggest manufacturers of custom milled hardwood lumber (i.e. lumber cut with a portable band or circular saw) during the 1990's until the sawmill fire in July 1997. Their primary sawmilling equipment included a portable Wood-Miser band saw and a Mobile Dimension circular saw together capable of producing about 1,500 and 3,000 bd. ft. of rough lumber per day, respectively. Cants and larger material from their primary saws were resawn with a twin band resaw. Lumber was air-dried prior to kiln-drying. Their four dehumidification dry kilns had a capacity of about 45,000 bd. ft. and a 15-day drying cycle. Other lumber processing equipment included a planer, straight-line, rip saw, matcher, and cutoff saw. Dave also had a "push-feed" type of flooring molder. However, he strongly recommends that a "feed-through" type molder is a better system, but they cost around $125,000. All of his equipment was lost in the fire.

Dave currently has a new Wood-Mizer LT 40 Super Hydraulic diesel-powered saw with a computerized setworks. He has acquired a one-of-a-kind Baker twin-band resaw with automatic feed that can cut cants up to 12 X 12 in. in cross section (Cost, $82,000). He also recently bought a solar kiln, but still subcontracts for his kiln drying needs.

5.3.5.5. Products. California Hardwood Producers, Inc. manufactures both lumber and value-added products. Last year, The Burls & More website advertised lumber species, grades, and prices for Hardwood Producers' products. The list included seventeen species and three grades of lumber with prices ranging from $1.85 to $3.00 per bd. ft. for 4/4 No. 1 Common stock and to $4.95 for quartersawn English walnut. Also listed, were nine species of flooring in common and select grades plus three specialty grades. Cost ranged from $2.25 to $5.98 per sq. ft. for 2 1/4-inch wide stock.

5.3.6. Don Seawater's -- Pacific Coast Lumber.

This is one of the newest custom sawmilling business currently operating in California. It's an off-shoot from a retail building supply and lumber company called Pacific Access that was located in both San Luis Obispo, and at one time in Cambria, California.

5.3.6.1. History. Don borrowed a Wood-Miser Model LT 30 bandmill in 1995 and began milling a few logs. This was at a time when the retail business was in serious financial trouble, a partial victim of California's general recession during the early 1990's. Don was cutting both hardwoods and softwoods from any logs he could get. He was producing just enough ungraded and undried lumber to keep the retail business going. In 1997, Don bought a Model LT40 Wood-Miser bandsaw **(Figure 5.10.)** and seriously got into the sawmiling business.

Figure 5.10. Don Seawater's Wood-Mizer band mill is beginning the first cut into a 24-inch walnut log.

Don's 15 years of experience with Pacific Access, first as an employee and then owner, proved to be both beneficial and detrimental in the sawmill business. On the positive side, like others already mentioned, he had a passion for working with wood and extensive knowledge of lumber grades, lumber marketing, and an established clientele. And, on the negative side, there was the financial burden of a retail business that eventually went bankrupt. The latter has been a serious handicap to the establishment of a new enterprise that required equipment not used in the retail lumber business. However, in 1996, Don was able to get a $10,000 grant funded by the San Luis Obispo County Integrated Waste Management Authority's Technical Assistance Grant Program. The money was used to help purchase a crane truck that was essential for log acquisition.

The sawmill operation moved to a new, 1.5 acre site during the summer of 1997 where it shares office, storage, and work space with Herbert Brothers Furniture who use some of Don's wood products. Currently Pacific Coast Lumber mills and markets custom-cut, air-dried lumber from logs and demolition timbers and produces a line of Adirondack chairs as value-added products. Because the demand was treater for custom lumber than Don could cut with his bandsaw, Jerry Sprengel joined him in March 1997 with his Mobile Dimension saw Model 127 which he operates as an independent sawmill operator (**Figure 5.11** .).

Figure 5.11. Jerry Sprengel joined Don Seawater in March 1997 with his Mobil Dimension Saw Model 127 which he operates as an independent sawmill operator.

5.3.6.2. Species. Currently, Pacific Coast Lumber cuts both hardwoods and softwoods. As just noted, there is huge resource of dead and dying Monterey pine that's available. Other key coniferous species that Don mills include coast redwood, Monterey cypress (*Cupressus macocarpa*), big cone Douglas-fir (*Pseudotsuga macrocarpa*), ponderosa (*Pinus ponderosa*), Coulter (*Pinus coulteri*), and pinion (*Pinus monophylla*) pines, and incense cedar. He also mills a variety of hardwoods including acacia, American elm, walnut, sycamore, ash, oak ssp. and red gum eucalyptus (*Eucalyptus camadulensis*). Being a custom sawmilling operation, limited amounts of almost any species can be a potential resource including odd-size and uncommon species such as ironwood (*Olneya tesota*), and manzanita (*Arctostaphylos* spp.).

5.3.6.3. Log acquisition. Pacific Coast Lumber gets its logs from a wide variety of sites and sources including urban, suburban, and agricultural areas and also from forest land . It acquires logs from governmental agencies, arborists, private land owners, and occasionally from log brokers; and, it has harvested fire-killed and hazard trees from National Forest Land . Currently, because of the pitch pine canker epidemic, there is a huge supply of Monterey pine (*Pinus radiata*) logs available in the Central Coast area. This supply will continue for several years and poses a major problem for landfills and waste disposal facilities unless the logs can be profitably utilized. So far, Don has not found enclosed metal to be a big problem and currently does not scan his logs with a metal detector.

5.3.6.4. Equipment. Most of Pacific Coast Lumber's essential sawmilling equipment was noted earlier, and includes a Wood-Mizer LT40 band saw, a Model 127 Mobile Dimension saw and crane truck for loading and hauling logs. Unfortunately, the crane truck was destroyed in an accident and its loss has been a major setback to Don's business. The crane truck had a 7 ton crane capacity that was more than enough to handle most logs that would be cut with the size saws available. However, the saws will handle over-sized logs if they are split in half with a chainsaw. The crane truck could also transport up to 20,000 lbs of logs or up to around 2,500 bd. ft. of lumber. Don intended to acquire a heavy-duty trailer to double his hauling capacity. Other essential equipment includes a 9,000 lb. capacity forklift for moving logs and lumber, a Wood-Mizer bandsaw blade sharpener, a crosscut and 10-inch table saws, and a 24-inch planer.

Don had been able to get by without a drying kiln, but this was a handicap that significantly limited his potential lumber market and Adirondack chair business. The added value of kiln-dried wood and at a low processing cost per board foot have already been noted (Section 3.3.1.8.). However, like most of the custom sawmilling operations, Pacific Coast Lumber is just "making" it financially, and money for essential new equipment isn't available in the existing cash flow situation. However, a temporary solution was provided by CDF who loaned Don their experimental portable dry kiln **(Figure 5.12.)** .

Figure 5.12. Both softwood lumber, shown here, and hardwood lumber produced by Pacific Coast Lumber were dried in the CDF portable, demonstration dry kiln. Equipped with an Ebac T2000 dehumidification unit, it has the capacity of about 1,500 bd. ft. It takes about 30 to 60 days to dry softwood and hardwoods respectively.

The kiln is housed in a 30-foot trailer equipped with an Eback T2000 dehumidification unit Model 3000, and has a capacity of about 1,500 bd. ft. per load. Drying time depended on a number of factors including load size, initial wood moisture content, and wood species. All factors being equal, it takes about twice as long to dry hardwoods as it does softwoods. CDF and Pacific Coast Lumber currently have only limited experience with the kiln, and need more before the available drying schedules can be verified. With a limited number of runs, Don found that it took about 30 days to dry softwoods and 50 to 60 days to dry hardwoods. The kiln was returned to CDF, and this Winter, Don bought a Nyle Model 200 dehumidification kiln with another grant from the San Luis Obispo County Integrated Waste Management Authority. The kiln is set up in half of a 40-foot-long refrigerator trailer.

5.3.6.5. Products. In regard to lumber production, Pacific Coast Lumber's Wood-Miser bandsaw cuts about 500 bd. ft./day or about 10,000 bd. ft./month, short of an estimated maximum of about 18,000 bd. ft. per month if the sawmill was operating fully each day. Like Dave Parmenter, Don has to run the overall business plus the Wood-Mizer band mill, or hire part-time help to run it. On the other hand, Jerry can run his mobile dimension saw almost full time and cuts about 700 bd. ft./day or 14,000 bd. ft./month.

Currently, the primary product of Pacific Coast Lumber is custom-sawn, ungraded lumber **(Figure 5.13.)** for a variety of uses including corral fences, decorative non-structural uses, landscape construction, specialty items **(Figure 5.14.)** , etc.

Figure 5.13. Don Seawater often runs the bandsaw plus all other phases of Pacific Coast Lumber's operations.

Especially important from a green waste utilization perspective, small boards that would normally be scrap at most sawmills are used for Pacific Coast Lumber's Adirondack chair business whose products include chairs **(Figure 5.15.)** , ottoman, and love seats . Chairs are sold as kits that range in price from $75 for pine to $300 for walnut. Don has even developed a use for rotted-out logs, such as that sycamore round in **Figure 5.16.** that has little value for lumber, but makes an interesting planter.

Keeping in mind the main theme of this report, i.e. urban sawlog utilization, Pacific Coast Lumber can sell more custom lumber than it is currently producing, and it does so with almost no marketing program. However, its current limited lumber storage capacity and its lack of crane truck seriously limit its potential growth.

Figure 5.14. One example of specialty products made from wood milled at Pacific Coast Lumber is highly crafted bird houses made from walnut and fire-killed pinion pine.

Figure 5.15. Adirondack chairs, sold primarily as kits, are the primary value-added product made by Pacific Coast Lumber under the company mane of Pacific Adirondack Design.

Figure 5.16. Even rotted-out trunk sections can be marketable products like these sycamore "rounds" used for planters.

5.3.7. Paul Mueller's -- Native Woods .

The last custom sawmill business to be described in this report, that gets at least part of its saw logs from the "urban forest", is Paul Mueller's Native Woods which operates primarily in southern California. Paul's sawmill business was briefly described several years ago in an unidentified and undated report (Merwin, date unknown). Paul has a Model LP40 HD Wood-Mizer band mill that he moved around most of the southland and as far north as Colinga. His home base is Covina, California. Paul charged by the hour for custom, on-site sawmilling of trees removed from yards, streets, and parks. He's cut more than twenty-four species of hardwood including walnut, sycamore, silk oak (*Grevillea robusta*), cedars (*Cedrus* spp.), carob (*Ceratonia siliqua*), and cherry for decorative lumber. He's also cut blue gum, oak (which he felt must generally be 1/4-sawn), and camphor (*Cinnamomum camphora*). Camphor is highly sought for jewelry cases; oils in the wood apparently keep metals from tarnishing (Mueller, 1997).

Merwin reported that Paul was thinking about increasing his lumber inventory from about 7,000 bd. ft. to 30,000 to 50,000 bd, ft. And, Native Wood's clientele included furniture makers, crafts people, and lumber yards. Currently, however, he has significantly reduced the amount of traveling that he does and is primarily milling wood blocks for a specialty market. Paul cites at least two reasons for his change in operations. One has to do with scheduling. It's often difficult to be at a site when the trees are to be dropped, and he can't afford to wait around for it to happen. A second problem deals with the low percent of usable logs that you may get from a job. Paul notes that only about 10% of the material that he got was suitable for worthwhile lumber, but customers wanted him to take everything. So, he feels that you get stuck with a big disposal problem and/or a lot of low value wood (Mueller, 1997).

However, both of these problems could be remedied if city and private arborists were aware of the potential value of utilizing urban trees for lumber production, they knew the associated log specifications, and there was an high demand for the logs. As noted earlier, Sacramento has been stockpiling logs for California Hardwood Producers, Inc. for several years.

In regard to wood processing, when necessary, Paul contracts for kiln drying, but he is now seriously considering what type of kiln he wants to own. Because most of his current wholesale business now deals with pen blanks, 3/4 X 3/4 X 5 in. in size, he cuts and dries everything in his shop in a small home-built kiln that is thermostatically controlled with heat lamps and a fan system. He uses a conventional electric oven to drive out an additional 4 or 5% moisture still remaining in the blanks. Most of Paul's pen blanks are burl wood and therefore potentially usable for high-end products. The blocks are impregnated with acrylic resin for stabilization, durability, and longevity. They retail at about $5-7 each.

5.4. TREES TO FURNITURE PROGRAM.

This is a new program sponsored by Wood-Mizer® and Popular Woodworking Magazine to encourage individuals or small groups to "rescue" fallen or removed urban trees that are suitable for processing into salable lumber. The Trees to Furniture Program directly complements this project in regard to the profitable utilization of California urban woody green waste. The benefits touted by the Trees to Furniture sponsors are the same as those listed in this report, namely:

- Tree owner --- may reduce landowners cost for tree removal.
- Trees to Furniture participant --- opportunity to get material at greatly reduced cost and material not normally available.
- Woodworking community --- recognition for community service for helping the environment.
- Whole community --- reducing the material that goes to landfills.
- Environment --- reducing logging on commercial forest land.

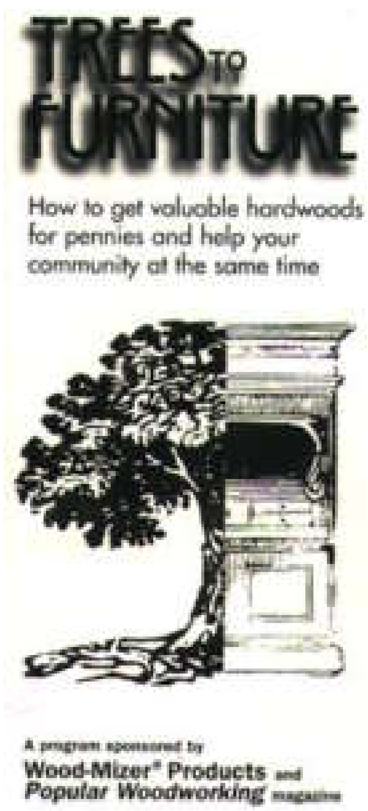


Figure 5.17. Front cover of a 20-page booklet describing the "Trees-To-Furniture" Program sponsored by Wood-Mizer Products and Popular Wood Working Magazine that encourages the utilization of discarded urban trees.

A 20-page booklet, whose cover is illustrated in **Figure 5.17.** gives an overview of how the program works in Cincinnati, Ohio (Sherrill et al., 1997). Basically, suitable logs are located and transported to a mill or the mill to the logs. Direct expenses are estimated to be between $0.50 and $0.75/bd. ft. which includes milling and transportation, but not drying. Although various types of drying are briefly discussed in the booklet, air drying seems to be the method proposed. As of May 1998, over forty people in California had indicated an interest in the program and more than 600 U.S.-wide with six to ten active working groups, according to Chris Schwarz managing Editor for Popular Woodworking. Who to contact about the Trees to Furniture Program:

Popular Woodworking
1507 Dana Ave.
Cincinnati, OH 45207
(513) 531-2690
popwood@earthlink. net

Wood-Mizer Products, Inc.
8180 west 10th Street
Indianapolis, IN 46214-2400
(800) 553-0182
w.w.w.woodmizer.com

Finally, Wood-Mizer will provide the names of portable sawmill owners in local areas who are willing to mill logs.

5.5. OTHER SAWMILL OPERATIONS IN CALIFORNIA.

A brief history of sawmilling in California was presented in Section 5.1. There has been a significant reduction in the number of high production, commercial mills in California in the last several years. However, this is not the type of mill that is appropriate for milling urban sawlogs for several reasons that have already been noted. On the other hand, small, portable mills are ideal for the small logs and low production expected from an urban sawlog resource. In addition to the small mills described in Section 5.3., John Shelly recently developed a list of the California mills that primarily saw hardwoods, these are listed in **Appendix M**. For further information, he can be contacted at the University of California Forest Products Laboratory in Richmond, CA at (510) 215-4210 or at E-mail address: jshelly@popserv.ucop.edu. Additional help should be available from Eric Oldar, State Coordinator, Urban Forestry Program, CA Dept. of Forestry & Fire Protection, 2524 Mulberry St., Riverside, CA 92501; or phone: (909) 782-4248.

6.0. UTILIZATION POTENTIAL FOR WOOD FROM CALIFORNIA URBAN TREES.

California is a leading consumer of lumber and goods manufactured from wood. This market, combined with the substantial forest resource in the State, has contributed to the development of a major, wood product manufacturing industry, including primary processing sawmills and secondary manufacturers of consumer goods. In 1990, California secondary manufacturers used an estimated $2.5 billion worth of wood (US Department of Commerce, 1993). A 1993 survey identified 860 furniture manufacturers in California (Cohen and Goudie, 1995). In 1989, West Coast furniture manufacturers (Meyer and others, 1992) used an estimated 108 million bd. ft. of hardwood lumber, or about 5 % of the national consumption. Much of the softwood used in construction is produced from California's conifer forest but less than 5 percent of the hardwood lumber used by California manufacturers for furniture, flooring and cabinets is produced in California (Shelly and Lubin, 1996). The California hardwood lumber industry is currently a fragmented industry with many sole-proprietorships and a raw material mix including trees from timberland and woodland regions, as well as native and exotic trees in the urban landscape. Based on wood properties and the experience of local artisans and woodworkers, successful markets for high value wood products made from urban trees are deemed possible, but special manufacturing techniques and innovative marketing strategies may be required to do so economically.

On the surface, the use of urban trees as a lumber resource is very appealing. It salvages wood fiber from the landfill, provides job opportunities, offers a unique wood supply for woodworkers and custom manufacturers. However, there are important barriers to success that need to be considered. Because of the wide range of species encountered in an urban environment, it is unlikely that enough volume can be produced to compete in the well-established commodity lumber markets for softwood and hardwood. The urban resource is not near any large sawmill. Operating costs are high and there is only a thin profit margin in lumber production. In combination, these factors suggest that the only reasonable venture is a small mill with low overhead costs that manufactures a high value product for a custom or niche market. This is very similar to what is happening in the California hardwood industry.

The California hardwood industry consists of producers (primary manufacturers), suppliers, and secondary manufacturers of finished goods. The producers are concentrated in northern California near the timberland hardwood resource. The current total estimated annual production of 2 million bd. ft. and the maximum drying capacity of 1.3 million bd. ft. distributed amongst 22 independent producers are likely too small to compete in the West Coast hardwood commodity market of more than 100 million bd. ft. The 25 suppliers that are familiar with native hardwood species and the 429 manufacturers in California that use hardwoods form a large commodity network that is centered around the major population centers of the San Francisco bay area and the Los Angeles/San Diego region (Lubin and Shelly, 1995). Recent experience has shown that there is strong market interest in products made from California hardwoods, but because of lack of capital investment, high production costs, and an insufficient kiln capacity for hardwoods, these enterprises are struggling to survive. Conversations with many of these mill operators suggests that they are most successful when they produce a value-added product such as custom manufacturing blanks, flooring, furniture, or other finished customer goods.

When considering the use of urban species, it is important to understand the limits of the raw material and manufacturing processes, and the expectations and demands of the market. These are common concerns for all types of business structures (small business, cooperative, large company). As a general rule, most urban trees will present more manufacturing difficulties than forest grown conifers and low-density hardwoods. This does not mean that valuable products are unattainable from high-density species, but rather that extra processing steps and great care are necessary. In many situations, the extra effort and care required to deal with these difficulties may not pay for low-value products, but higher-value uses are feasible. Obviously, some species are better suited for particular products than other species. Factors such as ecological concerns, resource availability, cost of production, and quality of the end product are important in determining the long-term utilization potential of urban species.

6.1. POTENTIAL MARKETS.

Urban trees could supply a portion of any wood market. The marketing limits are likely defined by an enterprise's production levels and ability to provide acceptable quality at competitive prices. The major wood markets include:

- Structural Lumber and Timber.
- Lumber Graded to Industry Standards -- Such as WWPA (Western Wood Products Association) for softwoods and NHLA (National Hardwood Lumber Association) for hardwoods.
- Re-manufactured Goods - including furniture, flooring, cabinetry, and numerous consumer goods such as picture frames, jewelry boxes, toys, etc.
- Specialty Lumber.

The first three are primarily commodity markets that demand large volumes of lumber that are readily available at a competitive price and manufactured to existing industry standards. It is unlikely that the urban wood source is reliable enough to provide entry into these commodity markets. However, within each of these categories there is a niche market, which is more flexible because a specific product or customer is targeted and the product is tailored to the customer’s needs. For example, lumber used in structural applications must be graded accordingly. However, an engineer could approve the use of timbers by evaluated strength on the basis of grain angle, presence and location of knots, and reported species strength values or laboratory tests. This approach would provide unique (niche market) structural timbers that could be extremely valuable in custom construction.

Another example is residential flooring. The primary requirement for hardwood flooring is that the wood be able to resist mechanical damage such as scratches and dents; softwood floors, on the other hand satisfy a "distressed" market that prefers the added character of scratches and dents. The hardness property (the force required to imbed a steel ball into wood) is a good indicator of the ability of wood to resist mechanical damage. Generally, a hardness value above 1,000 lbs. is required for a satisfactory hardwood floor. All of the high-density hardwoods (specific gravity above 0.5) are acceptable.

Producing specialty-use lumber is the most common product for most urban sawmill operators because only a simple agreement with the customer is needed. However, because this lumber usually does not meet the recognized quality standards of the national grading rules, it may have a low value, unless it is marketed for its uniqueness or unusual character (niche marketing). With the exception of the lower density species with poor machining characteristics (e.g. cottonwood), the higher density softwoods and most of the California hardwoods have a niche potential in the production of custom furniture, cabinets, and flooring. The unique character and color variation can be marketed as positive traits.

An emerging niche market that has real potential for urban trees is that of "certified" or "environmentally friendly " products made from wood obtained from a sustainable source that is sensitive to environmental concerns. Diverting wood from landfills may well meet these requirements. Although it is unclear how much more consumers are willing to spend for these certified products, it is certainly an area that should be investigated in any niche marketing approach.

In summary, niche markets hold the most promise for an urban wood enterprise. The commodity lumber markets demand large volumes of lumber, readily available at a competitive price and manufactured to existing industry standards. Formation of a wood processing cooperative may be helpful in maintaining the volume necessary to compete in this market and to afford independent producers the market power required. In contrast, the niche market is more flexible because a specific product or customer is targeted and the product is tailored to the customer's needs. Most of the urban wood species and products lend themselves to niche marketing. The "one of a kind" type of product would be the ideal situation for showcasing the unique characteristics of many of these urban species.

6.2. THE URBAN SAWLOG RESOURCE.

The estimated size or amount of sawlog-size material coming from urban areas each year was described in detail in Section 4.0. Overall, there are potentially millions of board feet in log-size material available each year that is suitable for lumber production. Operators of several of the custom mills described in Section 5.3. have noted that there is a much greater supply of logs than they can use. How much log volume and of what species a specific company will need will obviously depend on its type of products, volume of production, and annual sales. This will be addressed later in Section 7.4.7. The next topics in this section deal with where to find sawlogs and some of their relevant characteristics that affect their suitability for lumber production.

6.2.1. Where to Find Logs.

Potential sawlogs can come from many sources; basically, from wherever trees grow. Some of the best urban log sources are included in the following list:

- Tree care companies
- Municipal street & park Dept.
- Private home or landowners
- Landscape Co.
- Landfills & dumps
- Green waste disposal Co.

- State & county highway Dept.
- Land clearing & excavating Co.
- State & county park Dept.
- Firewood operations
- Urban forestry Dept.
- Utility Co.

Most of these sources can be found in telephone directories and the Yellow Pages. Some will be available on the Internet. A company can also advertise for logs in the newspaper, other local buy/sell publications, and by word-of-mouth by satisfied customers. There are many other potential sources that are not included above. Also, there certainly is no reason to limit log acquisition to only urban or related sources. Logs can also be obtained from agricultural lands (especially orchards) and from various types of forest land including private land and land under the jurisdiction of governmental agencies e.g. U.S. Forest Service, State Forestry, etc.

6.2.2. Factors that Affect Urban Sawlog Value.

Unfortunately, estimates of potential state and local urban sawlog volumes don't indicate how much of this material is actually suitable for conversion into lumber or other wood products. There are a number of factors that can reduce both lumber recovery and quality in conventional sawmilling operations that also must be considered when evaluating the potential volume of material that will be available for an urban custom mill. In addition, there will be some positive and negative factors that are unique to custom milling urban logs. Many of the factors that affect urban log availability are listed in the accompanying box. All of these factors may affect log and lumber quality and quantity, and these factors are evaluated by

FACTORS LIMITING URBAN SAWLOG UTILIZATION

- Species
- Log size
- Log quality*
- Log availability
- Embedded metal
- Wood characteristics

*Defects and Limitations:
Natural -- Decay, sweep, branchiness, spiral grain, cracks.
Processing -- Splitting, weathering checks, stains.
Manufacturing -- Drying problems (warping, collapse, etc.), wane, etc.

formal log and lumber grading rules. Grading is a complex subject that will only be briefly described in Section 8.6.1.

6.2.2.1. Species. Urban areas with their artificial environments support a tremendous variety of tree species including natives and exotics. George Hessinthaler (1997a), in comments about Salt lake City's urban forest, noted that there were currently over 200 species of trees with only a juniper as the original local native tree. At this time, there isn't much information about the suitability of many urban species for lumber production and some may have little practical use for this purpose. A number of the conventional and potentially useful native and non-native species are listed later in **Table 6.1.** Some of these are the same species for which Pillsbury and Thompson (1995) have developed urban volume tables. Many of the urban trees, regardless of species, will have features that will inherently limit their use.

6.2.2.2. Size. Size is an important limiting factor. Logs as small a 6 in. in diameter and less than 4 ft. in length can be cut on a band mill. But, unless small logs are extremely valuable because of species, figure, or some other unique characteristic, they are more expensive to mill and may not justify the added milling cost. Many of the logs may be too crooked to cut into boards greater than 4 ft. in length. However, this should not be an automatic limiting factor for a custom mill. Cal Oak Lumber Company revolutionized the milling of California hardwoods several years ago because it was set up to mill logs down to 4 ft. in length.

6.2.2.3. Log availability. A mill whose primary log supply comes from a limited urban area may find that logs in general and some key species in particular are intermittently available, and the latter are never available in large quantities. However, one of the advantages touted for custom mills is their flexibility. Each log can be a different species and the same log can be readily cut into different size products. Flexibility and some diversity in products plus custom milling are all important for the maintenance of a steady income if a full-time milling operation is the business goal.

6.2.2.4. Embedded metal and other objects. Given enough time, a healthy tree will eventually grow over and adsorb about anything that's attached to it. The object can become a hidden "land mine" later during sawing. Hall (1998) reports finding such items as wedges, horseshoes, railroad spikes, musket balls, insulators, and even a full can of beer, though aging in oak probably didn't help it's flavor. Hessenthaler found that up to one out of 20 logs may have too much metal to be milled (Chapman, 1996).

Obviously, any imbedded hard object can damage a saw blade or be a hazard to personnel. A detailed description by Cesa et al. (1994) of how to deal with foreign material in street trees is referred to in Section 8.3. and is included verbatim in **Appendix N**. They note that a visual inspection of a log for surface metal and a careful scan with a metal detector for embedded metal is necessary. When possible, the object should be removed; but, if there is too much metal or its poorly placed, the log may have to be discarded.

6.2.2.5. Log quality. There is a large variety of natural, processing, and manufacturing defects that can greatly reduce the volume and grade of lumber recovered from a log. Examples of each of these types of defects are listed in the preceding box. Only natural defects will be briefly described here in general terms as they affect potential lumber recovery. Section 8.1. has some information about "proper log handling and manufacturing" as described by Cesa et al. (1994) that briefly describes how to cut a log to obtain the maximum amount of lumber recovery. This and especially lumber grading are complex subjects and they are beyond the scope of this report, except in general terms.

In addition to size, a major "defect" that will be encountered with urban logs will be that many are crooked and bent (sweep). Hall (1998) found that loss due to sweep was indirectly related to acceptable log length; the shorter the acceptable length, the higher the yield.

Hessenthaller can cut logs as short as 3 ft. long because this produces lumber as long as he needs for his jewelry cases. Spiral grain (wood fibers growing in a spiral course along the trunk of a tree instead of vertically) is a serious problem for some species (e.g. blue gum) that isn't solved by cutting shorter length logs or other milling practices.

For conventional lumber (i.e. graded), branchiness, which produces knots, is an important factor reducing "grade". There are many different kinds of knots and some cause extensive grade reduction. Open-grown street trees tend to have more branches that those in a closed canopy forest environment. However, this branchiness may be somewhat countered by the pruning that occurs to street trees. And, contrary to what might be expected, tree forks or crotches may contain highly "figured" wood that greatly enhances its value for specialty uses (Cesa et al., 1994; Faison, 1997). Broken, decayed branches also indicate potential heart rot, another type of defect that can have a serious negative effect on log quality.

Hall (1998) developed a rule-of-thumb for the minimum specifications for a sawlog grade California black oak log that will produce a profit, as follows: "The minimum 'paying' sawlog grade black oak must be reasonably straight, at least 14 in. DIB (diameter inside bark) and 8 ft. plus trim in length. It must be 50% sound and have a minimum equivalent of 2 faces clear in 8 ft. segments." Specifications for madrone and tanoak are slightly different. How well this rule would supply to urban sawlogs of various species with little or no production background remains to determined; but, it does provide a starting point.

6.2.3. Wood Characteristics.

The diverse range of environmental conditions in urban regions throughout California support a diverse list of urban tree species and a great variation in properties within species. Urban trees grow in a variety of settings, from "open-grown" in fields and parks to heavily pruned street trees, often resulting in a spreading tree form with much branching. A summary of important physical and woodworking properties for some of the more common trees found in urban areas is presented in **Tables 6.1.** and **6.2.,** respectively. This information is a compilation from a variety of sources in which property measurements were often not performed in a standard or comparable manner. An attempt was made to standardize this information and is offered as a starting point for understanding these woods.

6.2.3.1. Appearance properties. The properties of many of the timberland species are fairly well known. Less is known about the woodland and urban species; however, some general comments about their properties can be made on the basis of tree form, genus characteristics, and wood density. Most urban woods would likely be manufactured into finished products that highlight appearance. This means that in addition to how well the wood can be worked with machine tools (machinability), the appearance characteristics such as color, texture, figure, and how well the wood finishes are also important considerations. Color and texture are inherent species-related characteristics, but figure is related to the pattern of growth rings exposed on the wood surfaces and is influenced by how the tree grows as well as how the lumber is cut from a log with respect to the grain aspect. Grain deviations around knots and tree growth irregularities have a major influence on figure. Lumber surfaces that tend to expose the surface that is tangential to growth rings (i.e. flat-sawn) will show more figure than the quarter-sawn surface (perpendicular to the growth rings). An excellent review of figure in wood is found in the book, "Understanding Wood" (Hoadley, 1980).

In general, the fine textured, high-density woods will yield surfaces with a uniform appearance. The relative importance of these properties is dependent on the specific requirements of the finished product and the market place value. Often a positive characteristic for one product can be a negative characteristic in another. For example, the variable color in madrone or the high figure of California black walnut may be very desirable in a piece of custom made furniture, but it is undesirable in a mass produced furniture or cabinet line where a uniform appearance is expected by the customer.

6.2.3.2. Physical properties. Knowledge of physical properties provides a basis for predicting how wood reacts to manufacturing forces and how it will perform in service. Properties for many of the species found in urban communities of California are listed in **Table 6.1** . Density is the wood property that has the greatest effect on the manufacturing and performance characteristics of wood. Density is the mass of wood per unit volume and is often given in g/cm^3. Specific gravity is a unitless ratio of the density of wood at standard conditions (usually ovendry mass/green volume) to the density of water at ambient conditions. Specific gravity is a measure of relative density.

Machining, surface quality, drying, finishing, and dimensional stability are all directly related to density. Most of the hardwoods, and softwoods with a specific density greater than 0.5 (measured on the basis of an oven-dry mass and a green volume), yield a high quality surface when machined with woodworking tools. However, these high-density woods are more difficult to dry and exhibit less dimensional stability than the lower density woods, that is, those below 0.4. But, the easier drying and improved stability of these lower density woods is off set by their poorer machining and finishing qualities.

The higher density species are generally more difficult to dry and less dimensionally stable than species with lower density. Dimensional stability is in wood is defined as the ability to maintain its size and shape when it is exposed to fluctuations in humidity. As a general rule, the dimensional change of wood in response to a given change in moisture content is approximately twice as much in the tangential direction as it is in the radial direction. In a standing tree, both the tangential and radial direction are in the horizontal plane; tangential is tangent to the growth rings and radial is the direction from the bark to the center of the tree (pith). In **Table 6.1.,** the warp index is a measure of dimensional stability. The warp index is the ratio of the across-the-grain tangential to radial total shrinkage values for wood dried to an oven-dry condition (0% MC).

Species with a dimensional stability ratio greater than 2 are considered warp prone. This does not mean that high-density species with an high dimensional stability ratio can not be valuable lumber species. It simply means that greater care is required in the drying process and the wood should not be used in environments where the moisture content is expected to fluctuate dramatically (more than a range of 6%). The ratio of tangential to radial shrinkage is not the only cause of warp. Variation in the direction of the grain within a board (grain deviation) is also a contributing factor.

The machinability values in **Table 6.2.** were the results of tests performed on many indigenous species of North America in which the wood was tested with a series of machining tools and the quality of the surface produced was rated (Davis, 1962). A relative ranking (1 is unacceptable, 10 is excellent) of the surface quality is based on the surface quality after

Table 6.1. Physical properties of various tree species found in urban areas of California

Species	Common Name	Native CA, USA Domestic or Exotic Species	Specific Gravity	Density at 12% MC (lbs./ft3)	Hardness at 12% MC (lbs.)	Tangential Shrinkage (%)	Warp Index
Acacia longifolia [18]	Acacia (golden wattle)	exotic	0.59	41	(1750)	(>10)	(>2)
Alnus rubra	Red alder	native	0.39	27	620 [3]	7.3 [3]	1.7
Arbutus menziesii	Madrone	native	0.61	42	1530 [3]	13.7 [3]	2.4
Castanopsis chrysophylla	Chinkapin	native	0.44	31	780 [3]	7.4 [3]	1.6
Ceratonia siliqua	Carob tree, Locust tree	exotic	na	na	na	na	na
Chamaecyparis lawsoniana [1]	Port-Orford cedar	native	0.39	27	630	6.9	1.5
Cinnamomum camphora [18]	Camphor tree	exotic	0.40	28	na	na	na
Cupressus macrocarpa	Monterey cypress	native	0.45	32	na	na	na
Eucalyptus globulus [19]	Blue gum	exotic	0.63	44	1650	15.3	2.0
Fraxinus velutina 'Modesto'	Modesto ash	native	(0.54)	(38)	na	na	na
Jacaranda mimosifolia	Jacaranda	exotic	(0.31)	(22)	(350)	(8.2) 10	(1.4)
Juglans hindsii	California black walnut	native	na	na	na	na	na
Liquidambar styraciflua	American sweet gum	native	0.52	36	na	10.2 [1]	1.9
Lithocarpus denisflorus	Tanoak	native	0.59	41	1450 [3]	12 [3]	1.9
Magnolia grandiflora	Southern magnolia	domestic	0.46	32	1020 [2]	6.6 [1]	1.2
Pinus radiata	Monterey pine	native	0.42	29	na	na	na
Pistacia chinensis	Chinese pistache	exotic	1.00	61	na	na	na
Platanus sp.	Sycamore	domestic	0.46	32	610	8.4	1.7
Platanus acerifolia	London plane	exotic	0.42	29		7.8 [9]	
Populus trichocarpa	Cottonwood (black)	domestic	0.33	23	390 [3]	8.6 [3]	2.4
Pseudotsuga menziesii	Douglas-fir	native	0.48	33	710 [2]	7.6 [1]	1.6
Quercus garryana	Oregon white oak	native	0.66	46	1780 [3]	9 3	2.1
Quercus ilex	Holly oak	exotic	na	na	na	na	na
Quercus kelloggii	California black oak	native	0.50	35	1080 [3]	7.8 [3]	2.1
Quercus lobata	California white oak	native	0.60	42	1570 [3]	9.8 [3]	2.4
Sequoia sempervirens	Redwood	native	0.35	24	na	4.9 [1]	2.2
Ulmus parvifolia chinensis	Chinese elm	exotic	na	(30 to 40)	na	na	na
Umbellaria californica	California bay laurel	native	0.54	38	1460 [3]	8.1 [3]	2.9 [3]
Zelkova serrata	Japanese zelkova, Makino	exotic	0.54	38	na	na	na

Note: Superscript numbers refer to source information listed on reference page; numbers in parenthesis were estimated from similar species or general genus information; na means information is not available; specific gravity values were converted from values reported in citations to a common standard of oven-dry, green volume basis; density values were converted to a common 12% MC basis.

References for Tables 6.1. and Table 6.2. -- Sources of species information and notes on specific gravity

1. Wood Handbook. 1987. USDA Forest Service Agriculture Handbook 72. Specific gravity values reported on a basis of oven dry mass and volume at a green moisture content.
2. Hough's Encyclopedia of American Woods. 1957. E.S. Harrar. Density values are reported on a basis of oven dry mass and oven dry volume.
3. "Quality Processing of California's Hardwoods". May 1995. John R. Shelly. Density values are reported on a basis of mass and volume at 12% moisture content.
4. Silvical Characteristics of California Laurel. 1958. William I. Stein. USDA Forest Service, PSW, Silvical Series No. 2.

5. Silvical Characteristics of Pacific Madrone. 1958. Robert F. Tarrant. USDA Forest Service, PSW, Silvical Series No. 6.

6. Silvical Characteristics of Red Alder. 1957. Norman P. Worthiington. USDA Forest Service, PSW, Silvical Series No. 1.

7. Silvical Characteristics of California Black Oak. 1969. Phillip M. McDonald. USDA Forest Service, PSW, Research paper PSW 53.

8. Tanoak: A Bibliography for a Promising Species. 1977. Phillip M. McDonald. USDA Forest Service, PSW, GTR PSW-22.

9. Tropical Woods. Yale University School of Forestry. 7:17; 19:62; 71:32; 8:18; 52:4; 25:31; 71:31; 68:9.

10. Amazon Timbers: Characteristics & Utilization. 1981. Vol. 1, Tapajos National Forest, IBDF, CNPq. Brasillia. Specific gravity values are reported on a basis of oven dry mass and green volume.
11. Fine Hardwood Selectorama. 1978. American Walnut Association, Indianapolis. IN, Specific gravity values are reported on a basis of oven dry mass and a green MC content.
12. Commercial Foreign Woods on the American Market. 1959. David A. Kribs. Pennsylvania State University, University Park, PA. Density values are reported on a basis of mass and volume at 12% MC.
13. Commercial Timbers of the World. 1965. F. H. Titmuss. London: Technical Press Ltd.

14. The Hardwoods of Australia and their Economics. 1919. Richard T. Baker, Dept. of Education. New South Wales.

15. Philippine Woods. 1938. Luis J. Reyes. Philippine Islands, Bureau of Forestry, Density values are reported on a basis of mass and volume at 12% MC.
16. A Manual of Indian Timbers. 1972. J.S. Gamble, Dehra Dun: Bishen Singh Mahendra Pal Singh.

17. World Woods in color. 1986. William A. Lincoln. New York: Macmillan Publishing Co.

18. Tropical Timbers of the World. 1984 Martiun Chudnoff. USDA Forest Service Agricultural Handbook Number 607.

19. Strength and Related Properties of Woods Grown in the United States. 1935. L.J. Markwardt and T.R.C. Wilson. USDA Technical Bulletin No. 479. Washington, DC.

planing and shaping. The fine textured, high-density woods such as madrone and Oregon white oak are exceptiona in machinability. Machining studies have not been performed on most urban grown species, but it is expected that the higher density, fine textured woods (Chinese pistache (*Pistacia chinensis*), eucalyptus, etc.) will machine fairly well. However, it is important to note that the higher frequency of knots and grain deviations ofte found in urban grown species may result in a higher percentage of surface defects than found in forest grown trees.

6.2.3.3. Mechanical properties. Except for structural uses, mechanical properties such as strength and stiffness are not very important. Most of the urban woods have a specific density above 0.4, placing them in the moderate- to high-density range that has acceptable mechanical properties for most uses. Low density wood (specific gravity less than 0.4) should not be used for structural products such as chairs without careful design considerations to insure that the anticipated weight load can be supported. For some uses, mechanical properties are very important. For example, hardness is crucial for many types of hardwood flooring. A hardness value greater than 1,000 lbs. is considered sufficient for a floor material that provides acceptable resistance to marring, denting, and abrasion. Wood with lower hardness values are often used for floors, the difference being that with these floors the marring is expected and considered a valuable addition to the character of its appearance.

6.3. Milling Residues.

In the context of this report, residues are all of the various types of woody material that results from the production of lumber from urban sawlogs. This includes bark, sawdust, slabs, edgings, ends, and unmerchantabl logs or parts of logs. This material will have to be disposed one way or another; and if not utilized profitably, it may become an expensive liability. However, there are many potential profit producing uses for the various types of residue material (**Table 6.3.**). Firewood and chip residues are discussed in detail by Hall (1998) who at one time successfully marketed boxed Cal Oak firewood at supermarkets and marketed chips for both pulp and fuel. Producing mulch and compost from green waste was thoroughly described by Integrated Urban Forestry, Inc. (1995), but it did not include sawlog residue. Several other potential uses for mill residue are listed in **Table 6.3.;** however, a discussion of these various uses is not covered in this report. This list is only to point out what are some of the residue utilization possibilities.

Table 6.2. Woodworking properties of various species found in urban areas of California

Species	Common Name	Machinability	Texture	Color	Workability Comments
Acacia longifolia [18]	Acacia (golden wattle)	na	coarse[9]	brown or chocolate color[14]	hard, heavy & tough; similar to hickory[9]; relatively easy to work, finishes with a high polish & luster[12]
Alnus rubra	Red alder	5	fine[3]	uniform, light brown[3]	easy to work, accepts finishes exceptionally well[6]
Arbutus menziesii	Madrone	10	fine[3]	variable, reddish[3]	easily machined[5]
Castanopsis chrysophylla	Chinkapin	6	medium[3]	uniform, light brown[3]	fair to good machining, glueing & fastening; excellent finish-holding capacity[2]
Ceratonia siliqua	Carob tree, Locust tree	na	na	sapwood is white, heartwood red[16]	wood is hard, tree can be difficult to grow[16]
Chamaecyparis lawsoniana [1]	Port-Orford cedar	na	fine	light yellow to pale brown	highly resistant to decay, dimensionally stable
Cinnamomum camphora [18]	Camphor tree	na	fine [12]	light yellow-brown, light pinkish or reddish brown, usually with darker streaks[12]	works easily with a smooth, lustrous finish[12]
Cupressus macrocarpa	Monterey cypress	(5)	fine, even[2]	yellow-brown to pinkish brown[2]	straight grain; works without difficulty, but knots can be troublesome. High resistance to insect & fungal attack [17]
Eucalyptus globulus [19]	Blue gum	(6)	medium, even[2]	dark or yellowish brown[2]	difficult to work with hand tools, works easily with power[2]
Fraxinus velutina 'Modesto'	Modesto ash	(6)	na	na	na
Jacaranda mimosifolia	Jacaranda	(3)	medium[10]	white to yellowish white[10]; plain, ordinary - not related to rosewood species[9]	easily sawn & planed[10]
Juglans hindsii	California black walnut	(6)	medium[3]	uniform, dark brown[3]	prized for gun stocks, decay resistant
Liquidambar styraciflua	American sweet gum	5	medium, can vary with site[2]	grayish pink to deep red[2]	softer, straighter grained trees work easily; refractory trees are difficult[2]
Lithocarpus denisflorus	Tanoak	8	medium[3]	variable, golden brown[3]	wood is tough & hard, machines easily & finishes well[8]
Magnolia grandiflora	Southern magnolia	6	even[2]	yellow, greenish yellow or greenish brown[2]	not difficult to work with either hand or power tools; suitable for steamed bent components[2]

Table 6.2. Woodworking properties of various species found in urban areas of California con't.

Species	Common Name	Machinability	Texture	Color	Workability Comments
Pinus radiata	Monterey pine	na	soft & brittle[2]	reddish brown to brownish pink[2]	soft, brittle, knotty, light in weight & lacking in strength; pulpwood potential[2]
Pistacia chinensis	Chinese pistache	na	very fine	variable and unusual -- olive brown with narrow, dark brown concentric bands[15]	grain is crossed; very hard, strong & tough; seasons well, very durable; used for carving[15]
Platanus sp.	Sycamore	1	fine texture	light reddish brown	interlocked grain can make some machining difficult[13]
Platanus acerifolia	London plane	(1)	fine & uniform[13]	yellowish white or brownish[13]	hard, tough & rather difficult to work, but can be finished to a good, clean surface[13]
Populus trichocarpa	Cottonwood (black)	(1)	coarse[3]	uniform, gray brown[3]	nail & screw-holding ability is low, otherwise relatively easy to work & finish[2]
Pseudotsuga menziesii	Douglas-fir	na	straight-grained[2]	pale yellow, light brown[2]	easier to work with power than without; doesn't hold paint well[2]
Quercus garryana	Oregon white oak	8	fine[3]	uniform, cream[3]	good machining characteristics, except for shaping; nice bonding properties[2]
Quercus ilex	Holly oak	na	na	na	na
Quercus kelloggii	California black oak	7	medium[3]	uniform, medium brown[3]	hardness & finishing properties suitable for flooring[7]
Quercus lobata	California white oak	na	uneven[2]	moderate, dark brown[2]	can be brittle & difficult to work[2]
Sequoia sempervirens	Redwood	na	uniform, coarse[2]	light red, reddish brown[2]	all around high marks for workability[2]
Ulmus parvifolia chinensis	Chinese elm	na	coarse & uneven[13]	dull reddish brown[13]	interlocked grain can make some machining difficult[13]
Umbellaria californica	California bay laurel	6	medium[3]	uniform, cream[3]	good workability & luster[4]
Zelkova serrata	Japanese zelkova	na	coarse12	uniformly cream or light reddish brown with golden luster[12]	straight grain, easy to work and takes a high lustrous finish[12]. Hard, tough & resilient - very strong for its weight; durable[17]

Note: Superscript numbers refer to the source of information listed on the table reference page; numbers in parenthesis were estimated from similar species or general genus information; na means information is not available.

Table 6.3. Potential products for parts of a log that don't yield graded lumber[1]

Economic Value	Wood Product	Product Requirements
Low Value	Firewood.	High density species unsuitable for higher products, cut to standard lengths (10 -16 in.), air dried (preferred moisture content <20%).
	Chipped or hogged fuel.	No specific requirements, high density and low moisture content (<20%) is preferred.
	Chipped for compost or mulch.	Most species (some have herbicidal properties).
Moderate Value	Non-grade lumber.	Any species, log length, quality, can be used, but creative marketing sometimes needed.
	Pallets, dunnage, shipping containers, etc.	High strength/weight ratio desired, low quality wood acceptable.
	Fencing & landscape timbers.	Species resistant to decay, or wood that can be effectively pressure treated with preservatives.
	Chemical feed stock (producing wood extractives or ethanol.	Clean, dry chips of a single species are preferred.
	Pulp or composite panel chips.	Clean chips or specific species and particle size, low to moderate density species required.
	Charcoal - (activated or lump for cooking.	High density hardwoods of any quality or species, activated requires special processing.
	Animal bedding or litter.	Low density wood, clean chips. shavings, or sawdust (some woods may have chemicals injurious to come animals).
	Excelsior - specialized wood shavings for packaging.	Low density wood, dried.
	Flavor wood - chips added to cooking fire for smoke or flavor	High density hardwood with interesting aroma or flavor characteristics.
	Molded products, e.g. densified fuels (fuel pellets or fire logs).	Mixed species acceptable, uniform particle size and moisture content.
High Value	Non-grade lumber or burls for custom furniture, picture frames, artistic woodworking, and other specialty uses.	Attractive appearance and character, various lengths, clear (knots sometimes acceptable for special appearance), good machining and finishing characteristics.
	Cooperage staves for wine barrels.	Wood with low permeability (e.g. white oak), favorable flavor characteristics, knot free.
	Tool handles.	High density impact strength (toughness), straight grain, knot free, standard handle lengths.

[1]Modified from Table 8-1 in "Guidelines for Managing California's Hardwood Rangelands" (Shelly and Tiejte, 1996.)

7.0. SETTING UP AN URBAN SAWMILL BUSINESS.

One of the primary goals of this project is to provide information that can be used as a guide for the establishment of an urban sawmill business. An urban sawmill provides an opportunity to capitalize on a resource that is grossly underutilized, that may often be "free", and will help the environment at the same time. This may sound almost too good to be true; however, if you've read the description of the custom mills in Section 5.3., you realize that this business requires hard work, good planning, and an adequate economic base to get started and keep going until the business gets established. There are a number of recent publications that give pertinent information about setting up a small milling operation in general and utilizing urban sawlogs in particular such as:

RECENT PUBLICATIONS RELEVANT TO CUSTOM SAWMILLING

- Recycling Municipal Trees - A Guide for Marketing Sawlogs from Street Tree Removals in Municipalities. Cesa, Lempicki, and Knotts (1994).
- Your Sawmill Business - Sawing for Others. Watt (1998).
- Sawmilling Urban Waste Logs: An Income-Generating Option for Arborists. Blanche and Carino (1996).
- Trees to Furniture. Sherrill, Sherrill, and Romanos (1997).
- A Management Handbook for Hardwood Sawmills. Sierra Resource Group (1997).
- The Management, Manufacture, Marketing of California Black Oak, Pacific Madrone, and Tanoak. Hall (1998).
- Wood Products Value-Added Manufacturing and Finishing: Efficacy, Waste Reduction Regulations. Bailey, Liebl, and Wengert (1998).

Information from these publications and other sources are presented in the sections that follow. Topics include: Business Aspects of a Custom Sawmill Enterprise, Marketing Custom Sawmill Products, Financial Management, Sawmill and Related Equipment, and two Examples of a custom sawmill enterprise.

7.1. BUSINESS ASPECTS OF A CUSTOM SAWMILL ENTERPRISE.

Two initial factors that need to be considered before establishing an urban custom sawmill business are: 1. At what level do you want to be involved in this business, e.g. full-time, part-time, or as a hobby; and 2. What products do you visualize producing, e.g. green lumber, kiln-dried lumber, secondary products, other? Obviously, these are closely related topics and knowing one may automatically answer the other. A successful sawmill business, like most businesses, requires both management and technical expertise. The management side of the business is thoroughly covered in “A Management Handbook for Hardwood Sawmills” that was developed by the Sierra Resource Group (1997), a forest products industry consulting firm, for the High Sierra Resource Conservation Development Area. This Handbook covers the following topics:

- Business planning
- Marketing
- Cash flow forecasting
- Basic cost accounting
- Using computers
- The Internet as a tool

7.1.1. The Business Plan.

A brief summary of the chapter about “Business Planning” is described in this section with the basic premise that: “You can’t get there unless you know where you want to go.” This involves planning to identify specific goals and how to achieve them. A good business plan may also enhance your chances of getting financing to help establish or enlarge your business. The Sierra Research Group (1997) note the following general characteristics of a sound business plan:

- It’s based on facts and solid assumptions.
- It’s realistic and considers the use of available resources.
- It’s simple and flexible, but also maintains continuity of direction.
- It identifies potential pitfalls and setbacks, expected financial goals, and the resources needed to accomplish these goals.

For most people, learning the characteristics of a good business plan is going to be a lot easier than producing a good business plan. However, keeping these characteristics in mind may provide a set of guides to reflect on as the business plan develops. The Sierra Resource Group noted that there is no preset format or specific organization for a business plan. Each plan will be different to match each different set of circumstances, with some plans being very simple and others very complex. The Sierra Resource Group also identified fourteen key elements that might be included in most business plans. The length and complexity of each of these elements will also depend on the specific needs of each plan. The major elements of a business plan are briefly described in the following paragraphs and include:

7.1.1.1. A description of the present situation. The first element provides a general introduction to what the business plan is about. In this case, it would include a description of the opportunities derived from milling urban sawlogs. If already in business, the plan might include a brief history of the business along with the background and experience of the key personnel, products produced, plus major customers and competitors if any, a description of current facilities, and a summary of the financial performance for the last 5 years.

7.1.1.2. The previous plan. There should be a brief summary of any previous plans and an analysis of how well the business met its goals. It should also be pointed out how and why the new plan differs from the old plan.

7.1.1.3. Identification of key issues. Any issues or factors that could have an impact on the business should be identified, including both positive and negative effects and how to deal with them. This might include changes in the status of current or potential customers, new potential products or loss of old ones, loss of key personnel, potential effects of new environmental or other governmental regulations, changes in the availability of urban sawlogs, etc.

7.1.1.4. Business goals and objectives. The three previous elements of a business plan set the stage for this one which basically asks : Why are you in this business in the first place? Or probably a more appropriate question might be: Why do you want to get into the urban milling business? What is it you want to accomplish? Examples of goals and objectives related to a custom urban sawmill are given in the Management Handbook for Hardwood Sawmills (Sierra Resource Group, 1997). Some examples of general goals plus others pertinent to starting an urban sawmill business are as follows:

- Establish a "Trees to Furniture" project either alone or with partners.

This could be the simplest and least expensive way to get involved in utilizing urban sawlogs. There is a description of this program in Section 5.4. Basically, it amounts to locating suitable urban logs, making arrangements to get them milled in-place or transporting them to a mill to get them sawn, then utilizing or selling the lumber produced. The primary requirements will be a truck to transport the logs and/or the lumber produced and a place to store the lumber as it dries.

- Establish a portable sawmill business and cut lumber for others.

This would be the next level of involvement in an urban sawmill business that primarily involves milling lumber from urban sawlogs either by the board foot or by the hour. The sawmill is moved to a log site where the lumber that is produced is left for the log owner to utilize. In addition to a portable sawmill, the primary other requirements are a truck equipped with a loading system or possibly a fork-lift to move logs. (This type of operation is described later in Section 7.5.)

- Establish a custom sawmill operation and cut lumber for others and for sale.

This might be a "permanent" mill operation with all of the sawlogs transported to the mill even if a portable mill is used. There would have to be enough room to store logs and air dry lumber, plus an office and room to store finished lumber, i.e. lumber that has been completely air-dried and possibly planed. This could be a two- or three-person operation, with the latter being more effective for a full-time business with maximum output. The specific mill equipment requirements and other details are covered in depth in Section 7.5., Setting up a Sawmill Operation.

- Other general goals and objectives.

So far, the most complex business considered has been a basic milling operation with both custom and wholesale lumber marketing of air dried rough or finished lumber. A sawmill business might involve only primary log breakdown with someone else handling subsequent processing and marketing. On the other hand, additional operations might include such things as:

1. Marketing firewood -- The unmerchantable material and processing waste will have to be disposed some how.

2. Selling lumber retail -- This produces somewhat higher lumber values, but it can seriously impact lumber production unless it is operated as a separate business.

3. Production and marketing of value-added products -- It's already been pointed out that current custom millers consider marketing green or even kiln-dried lumber is a lot of work with a minimum economic return. Producing specialty or niche market products will probably be more financially rewarding than selling only lumber. Producing and marketing a value-added product e.g. Hessenthaler's golf ball trophies or Seawater's Adirondack chairs, yield considerably more profit per board foot than selling lumber.

- Specific goals and objectives. A number of specific goals might be set up that are short term, less than a year, and which can be readily quantified. These might involve a variety of production and economic goals some of which may prove to be hard to attain the first year in business when there is no experience to moderate expectations.

7.1.1.5. Critical assumptions. A number of important assumptions will most likely be made when establishing or running a custom sawmill business that are important to its attaining its specific goals and objectives (Sierra Resource Group, 1997). This might include such things as expected resource availability, interest rates, lumber prices, the economy in general, and a variety of factors that could affect a business. These items should be at least briefly described and discussed, as will as their potential impact on the business.

7.1.1.6. Marketing. The Sierra Resource Group (1997) devote a chapter to the subject of marketing which is summarized in Section 7.2. They also note that; "All businesses are driven by their markets." For a business to survive, there has to be a need for its products. Although sawing lumber is hard work, it can also be very enjoyable. However, fun or not, there will have to be a market for a mill's products. The Sierra Resource Group list the following major steps in market planning:

- **Market definition** -- involves the identification, description, and size of the market available.
- **Definition of problems and opportunities** -- includes internal and external issues that may have an effect on the market, e.g. manufacturing and financial constraints and opportunities.
- **Establishment of marketing opportunities** -- those that pertain to a specific product or customer.
- **Definition of marketing strategy** -- describes how to attain specific market objectives, e.g. market segment to target, distribution, advertising, etc.

7.1.1.7. Description and analysis of the competition. It is important to know who your competitors are, if there are any. How much does it cost them to produce the same products that you do? Knowing this will help establish competitive product prices.

7.1.1.8. Resources. How much volume in sawlogs will be needed to produce the volume of different kinds of products that you intend to make? Where do you expect to get the required logs? What is the log acquisition plan? Are there alternative sources?

7.1.1.9. Facilities and equipment. What equipment do you have and what do you need for your current projected business output? What about future output? What opportunities are there to increase overrun? What are the current bottlenecks and how can they be eliminated?

7.1.1.10. Residuals and by-products. A sawmill, as already noted, produces a considerable amount of waste material, including sawdust, shavings, slabs, edgings, and unusable logs. Most of this material has potential to be sold or used to produce income, and if nothing else, disposed in some environmentally favorable fashion. If it's going to be sold, then a plan has to be developed including expected customers, needed facilities, prices, added personnel, etc. Hall (1998) found that selling residuals was an important source of income; it included selling boxed firewood in grocery stores.

7.1.1.11. Environmental issues. Any federal, state, or local environmental restrictions and requirements that affect the business need to be identified. There should also be plans to reduce and mitigate any unacceptable impact that the business might have on the environment.

7.1.1.12. Personnel and human resource issues. Although a custom mill might only be a one- to two-person operation, there should be an analysis of personnel requirements and skills, plus the identification of safety and training needs, wages, health benefits, etc.

7.1.1.13. Administration. This item deals with how a business is going to be managed and includes policy, cost accounting, work scheduling, use of computers and the Internet, personnel management, etc. This section may seem simple or even unnecessary for a small to part-time operation, but these items should still be developed as an important part of a business plan.

7.1.1.14. Financial projection. The Sierra Resource Group (1997) recommended that the various projected business costs and incomes for the first year be listed on a month-to-month basis and annually for the next year or two. These items are tied to sales projections that are based on production and the required log volumes to meet these projections.

In summary, a complete, well thought out and researched business plan is believed to be essential for a custom sawmill operation to be economically successful. The fourteen previous items are those that the Sierra Research Group (1997) consider to be necessary components of a complete business plan. While no amount of planning will automatically guarantee success, careful planning should greatly increase the chance of a successful enterprise and prevent unnecessary and unproductive surprises.

7.2. MARKETING CUSTOM SAWMILL PRODUCTS.

Obviously, for a custom mill to make a profit, it's going to have to successfully market its products. Although product identification and potential uses of these products are the objectives of Phases II and III of this project, some introductory comments about marketing are appropriate here as they pertain to the "Business Plan" and setting up a custom mill operation. Key marketing steps in a business plan were noted earlier in Section 7.1.1.6. and include market definition, problems and opportunities, market objectives, and market strategy.

Basically, for a small custom mill to be successful, the Sierra Resource Group (1997) noted that it would be necessary : "-- to match resource availability and manufacturing capabilities with products that customers need and want at a profit." This means that it will be necessary to understand your customer's needs, know thoroughly what your mill will produce and at what cost, charge a realistic price that produces a true profit, and communicate effectively with your customers.

The Sierra Resource Group (1997) also described some of the differences between running a wholesale and a retail operation.

7.2.1. A Wholesale Operation.

An urban, custom sawmill business may be set up primarily as a wholesale operation, cutting lumber by special order or for other trade customers. Small, custom mills have some advantages over large commercial mills in that they can respond more quickly to accommodate special customer requests and requirements. They can quickly adapt production for special runs or kiln dry requests, assuming a kiln is available. Small mills will probably have lower fixed costs than large mills, and urban mills will usually be very close to their customers.

On the other hand, small custom mills may have some disadvantages compared to large mills. A small mill is not as likely to have as much capital or staying power when there are market declines. Limited cash seems to be a continual problem for many of the small mills currently in business. But, this is not an inherent problem with size per se, but is directly related to the financial base of an individual mill owner. Small mills will probably have higher variable costs than large mills, and large mills will probably have stronger marketing and sales capabilities (Sierra Resource Group, 1997). This is self-evident for a one- or two-person custom mill operation.

Other marketing suggestions by the Sierra Resource Group (1997) include:

- Find out as much about your customers as you can, i.e. their product requirements. suppliers, what products fit your mill capacity, etc.
- You must thoroughly understand your products' costs.
- Take advantage of FAX, E-mail, and the Internet to compensate for small size and lack of a large marketing staff.
- Have continuity in customer contact.

- Provide your customers information about your products and what you can do for them.

These are some of the strategies that should help a small business, or any business, enhance its products marketability.

7.2.2. Retail Operation.

Most custom sawmill operations will probably have both wholesale and retail customers. How many of the latter will depend on what the business objectives are. However, a small operation may have a very difficult time dealing with retail customers while trying to maintain milling production. Spending time with small retail sales may not be worth the income generated at the expense of reduced lumber production. Consequently, a small retail sideline may not be profitable if the total costs are determined (Sierra Resource Group, 1997). It should have its own space and preferably its own staff, and basically be a separate operation. This could be difficult to achieve for a small custom milling business.

7.2.3. Marketing Systems.

The Sierra Resource Group (1997) list four types of systems that should be considered for managing and controlling key marketing functions. These are:

- **Order entry and tracking** -- to document and process customer orders.
- **Warehousing and inventory** -- to determine what products are where, and to whom are they obligated.
- **Customer tracking** -- to develop a consolidated filing system for customer information.
- **Sales analysis** -- to tabulate sales by customer and commodity.

The Sierra Resource Group (1997) suggested that the above systems be maintained in a personnel computer, and they describe database software that can be used for these systems.

7.3. FINANCIAL MANAGEMENT.

The presumption in this section is that a custom sawmill business' primary goal is to make a satisfactory profit. This will require at least some understanding of basic accounting techniques. In addition, every business should have professional accounting support and should be able to get practical guidance from periodic financial data (Hall, 1998). Some of the accounting techniques that will be briefly covered here are; 1. cash flow, 2. profit and loss statements, 3. financial support, and 4. product pricing.

7.3.1. Cash Flow.

Having adequate "cash flow" is one of the most critical necessities for a small business, and the importance of cash flow forecasting and management can't be over stressed (Sierra Resource Group, 1997). They also note that traditional, double entry bookkeeping systems, i.e. expenses and revenues are synchronized with time periods, may mask how much money is or will be available. Income entered as a "receivable" may not result in cash until the bill is actually paid. It was noted earlier that shortage of adequate operating funds has been a constant problem for some of the current custom sawmills.

7.3.1.1. Cash flow forecasting. A modified version of an example of a computer-generated cash flow forecasting spreadsheet from "A Management Handbook for Hardwood Sawmill" (Sierra Resource Group, 1997) is shown in **Table 7.1.** Only four of the twelve monthly forecasts are illustrated. This spreadsheet lists many of the different costs that may have to be considered in a custom sawmill operation. However, in addition to lumber products, it also includes reference to the manufacture and sale of hardwood flooring. It's important that values truly represent revenues and expenses. Two different classes of money movements are illustrated in this example. The first deals with monthly cash flow in and out of the business based on producing and selling products. These involve either fixed or variable costs. Fixed costs are those that are paid regardless of production levels, e.g. rent, interest, equipment leasing, etc. Variable costs are related to actual production or sales , e.g. log purchase, payroll, gasoline, etc.

The second class of money movement involves monthly movement of capital in and out of the business unrelated to the direct manufacture and sale of products. The "bottom line" (as emphasized by Hall, 1998) for the first two months is a minus $726 for January and a plus $5,061 for February (**Table 7.1.**).

7.3.1.2. Cash management techniques. The Sierra Resource Group (1997) describe seven other cash management techniques that are briefly reviewed here.

- **Inventories** -- All of a mill's logs, lumber, extra parts, etc. are part of its potential cash assets. If any of these items sit around unused or unsold far beyond their production or replacement lead times, then cash needed for various purchases and expenditures is tied up and unavailable. Have a sale if inventories become too high.

- **Receivables** -- These are unpaid assets that can tie-up a substantial amount of cash. Basically, don't sell to customers who don't pay promptly or not at all. It might "pay" to screen your customers, e.g. by informal credit investigations. This won't be fun, but neither are efforts to extract payments from reluctant customers.

- **Payables** -- Don't become someone else's delinquent receivable; however, you can take advantage of the latitude allowed by the terms of payment while not becoming a problem customer (Sierra Resource Group, 1997). Also, good planning allows a business to take advantage of discounts for prompt payment.

- **Investing excess cash** -- Should there be excess cash available, it can be used to take advantage of discounts, as noted above, payoff high priced debt, and even be invested in high interest income producing accounts. Excess cash can also be used to purchase "good deals" for materials that are temporarily available at unusual low cost.

- **Commercial lines of credit** -- A potential option for obtaining cash, especially if there are wide swings in cash requirements, might be from a pre- established loan

Table 7.1. ILLUSTRATIVE CASH FLOW FORECAST FOR AN HARDWOOD SAWMILL [1]

	Beginning	January		February		March		April	
	Balance	Forecast	Actual	Forecast	Actual	Forecast	Actual	Forecast	Actual
CASH FLOWS									
Green lumber sales		$8,500		$6,000		$6,500		$6,500	
KD lumber sales		$13,500		$15,500		$16,000		$18,000	
Firewood sales		$5,000		$5,000		$3,000		$1,000	
Flooring sales		$4,400		$11,300		$10,000		$10,000	
Pallet stock				$4,000		$4,000		$4,000	
Log sales		$3,000							
Chip/sawdust sales		$500		$500		$500		$500	
Other sales		$500		$500		$500		$500	
TOTAL CASH IN		$35,400		$42,800		$40,500		$40,500	
CASH OUTFLOWS									
Variable Costs									
Purchased logs		$12,000		$5,000		$49,000		$10,000	
Purchased lumber		$1,000							
Finish woodworking		$500		$500		$500		$500	
Payroll		$4,500		$4,500		$4,500		$4,500	
Electricity		$2,000		$3,000		$3,000		$3,000	
Gasoline		$200		$200		$200		$200	
Shipping		$100		$100		$100		$100	
Repairs/ maintenance		$500		$500		$500		$500	
Saw filling/Replacements		$500		$500		$500		$500	
Paint - end sealer		$50		$500		$500		$500	
Other variable costs		$200		$200		$200		$200	
Total Variable Costs		$22,250		$14,550		$18,550		$19,550	
Fixed Costs									
Owner's salaries		$5,000		$5,000		$5,000		$5,000	
Rent		$1,500		$1,500		$1,500		$1,500	
Payroll taxes		$4,500		$4,500		$4,500		$4,500	
Office supplies		$200		$200		$200		$200	
Water		$200		$200		$200		$200	
Telephone		$300		$300		$300		$300	
Advertising		$200		$00		$200		$200	
Legal/acctg./consulting		$1,000		$1,000		$1,000		$1,000	
Lease - loader		$1,067		$1,067		$1,067		$1,067	
Lease - resaw		$1,032		$1,032		$1,032		$1,032	
Interest - Bank of B.		$1,000		$1,000		$1,000		$1,000	
State taxes		$1,000						$3,000	
Federal taxes		$5,000						$12,000	
Other fixed costs		$500		$500		$500		$500	
Total Fixed Costs		$18,999		$12,999		$12,999		$26,999	
NET OPERATING FUNDS		($7,849)		$15,251		$8,951		($6,049)	
CAPITAL									
Plus: Capital in									
Line of credit		$4,500						$3,100	
New loan required						$100,000			
From personal savings				$20,000					
Total Capital In		$4,500		$20,000		$100,000		$3,100	
Less Capital Out									
To line of credit						$4,500			
Loan - Bank of B.						$100,000			
Loan - MNC				$30,000					
Loan - HFC		$377		$377		$377		$377	
Total Capital Out		$377		$30,371		$104,877		$377	
TOTAL CAPITAL FLOW		$4,123		($10,377)		($4,877)		$2,723	
NET CASH FLOW		($3,726)		$4,875		$4,074		($3,326)	
CASH ON HAND	$3,000	($726)		$5,601		$9,675		$6,349	

[1] Adapted from "A Management Handbook for Hardwood sawmills" by the Sierra Resource Group, 1997. Part of an annual cash flow forecast for an hardwood sawmill operation. Although some of the cost items have been omitted from the original version of this forecast, most of the key cost factors are represented.

arrangement with a bank or other lending entity. However, this should usually be done only when really necessary, and the loan should be repaid as soon as possible. (Also, note later in Section 7.3.5.1., the possibility of getting a low interest loan from the Integrated Waste Management Board's Recycling Market Development Zone Loan Program.)

- **Leasing** -- Another cash management option is to lease equipment and/or vehicles. The Sierra Resource Group (1997) referred to both long and short term leasing with the former being basically another type of loan. When equipment is only needed occasionally and for short periods, it might be more economical to lease or rent it when it's needed. However, with good credit and a favorable loan interest rate, it might be more economical in the long run to buy the needed equipment.

- **Subcontracting** -- It might be more economical and practical to subcontract some operations that will be short-lived or where it involves technology or skills that you don't have and may not want. This will eliminate potential difficulties in hiring and layoff of employees, etc.; however, some profit will be shared with the subcontractors.

Successful use of any of the above and other cash management techniques will obviously depend on each business' particular needs and financial situation. A business owner should be aware of all of the possible opportunities that can keep his business viable.

7.3.2. Basic Cost Accounting.

Understanding your operational costs is essential if an urban sawmill is going to compete successfully in the lumber business (Sierra Resource Group, 1997). They also noted that when the market is up, prices are probably related to supply and demand and not to costs; when the market is down, prices are driven by costs. Two types of cost, referred to in Section 7.3.1.1., are fixed costs that are not directly related to lumber production, and variable costs that are related to production. If the net product price exceeds the variable costs to produce lumber, then there is a positive contribution toward the fixed costs. A mill can operate for a short time without covering its fixed costs, especially if it would be expensive to reduce the size of these costs.

Other cost factors include residuals or by-products of lumber production, i.e. sawdust, chips, and firewood that can be sold to offset variable costs. That is, assuming that they are sold for a profit. If not sold, they may become an expensive liability, both monetarily and environmentally.

7.3.2.1. Cost centers. A sawmill has a number of operations or "cost centers" that should be identified and the costs monitored regularly (Sierra Resource Group, 1997). It may not be reasonable or necessary to do this monthly, but it should be done when there are large changes in processing or major variable costs. Typical cost centers for a small urban custom sawmill would be:

URBAN SAWMILL COST CENTERS

- Log cost (acquisition and transportation to the log yard).
- Log yard cost (log handling and delivery to the saw).
- Primary breakdown (milling operation only).
- Secondary breakdown including resawing (optional, if set up for this type production), edging, and ripping.
- Air drying.
- Kiln drying (optional, but important).
- Finishing (planing, sanding, etc.)
- Secondary manufacturing (chairs, jewelry cases, pencil blocks, etc.).

The major variable costs for each cost center should be identified and then quantified. Some examples of the factors that affect these costs are:

Factors that Affect Variable Costs

- Output (e.g. MBF/day).
- Over/underrun (%).
- Residual/by-product volume
- Energy consumption
- Direct labor costs
- Associated labor costs
- Supplies

Ideally, the data for these variable costs are based on average actual production, but in lieu of actual data, reasonable estimates can be made by knowledgeable personnel. Initial data or estimates may not be accurate and should be updated as experience is gained. Costs should be calculated in terms of output, and in this case that means cost per MBF, or lineal feet of product, or per cord of firewood.

A modified example from the Sierra Resource Group's 1997 Handbook for Hardwood Sawmills for the milling cost center in shown in the following box. They made the following assumptions for a primary breakdown milling operation using a Wood-Mizer® bandsaw: 1. Lumber production capacity at 1,500 bd. ft./shift, 2. Overrun at 125% above log scale, 3. Firewood production at 0.67 cords/1,500 MBF of lumber, and 4. Gas consumption at 2.5 gal/shift at $1.50/gal. Also included is the cost for labor for the mill operator at $100/shift and for a fork-lift/cleanup man at $50/shift. The original example also included additional production of 3,000 bd. ft./shift with a Mobile Dimension saw; consequently, the cost for the fork-lift/cleanup man here is three times what it was in original example in the Sierra Resource Group's handbook.

PRIMARY BREAKDOWN -- MILLING OPERATION COST CENTER [1]

Wood-Mizer® milling factors	Values or costs
Operating assumptions per shift:	
Over/underrun (%)	125 %
Shift capacity (bd. ft. of lumber)	1,500 bd. ft..
Products:	
Firewood (cords)	0.67 cords
Firewood profit/cord ($)	$60.00
Firewood credit/shift ($)	$40.20
Firewood credit/MBF	$26.80
Fuel costs:	
Gasoline used/shift (gal.)	2.5 gal.
Gasoline cost/gal. ($)	$1.50
Gasoline cost/shift ($)	$3.75
Gasoline cost/MBF ($)	$2.50
Labor costs:	
Operator cost/shift ($)	$100.00
Operator cost/MBF ($)	$66.67
Fork-lift/Cleanup man cost/shift ($)	$50.00
Fork-lift/Cleanup man cost/MBF ($)	$11.79
Total sawmill cost/MBF ($)	$35.79

[1]Adapted from Sierra Resource Group's 1997 Handbook for Hardwood Sawmills.

Costs are similarly determined for each of the other cost centers. Also note, that the average production rate of 1,500 bd. ft./8 hour shift is quite high, but this is based on the production of cants or thick timbers during primary log breakdown that will be recut later during resawing. This would obviously be and additional cost borne by the next cost center, i.e. resawing.

7.3.3. Other Financial Statements.

Hall (1998) notes that financial statements can either be short, rather simple balance sheets and profit and loss statements, or they can be complicated documents. However, his reference to these items is in the context of a small, start-up sawmill operation which is also the focus of this report. With a balance sheet, the net value of the sawmill business can be determined. As described by Hall (1998), it contains the following three basic items:

- Current assets -- includes cash, accounts receivable (that are already collected), inventory value (which should be the lower of either the cost or sale value), current value of depreciated assets (for equipment, plant facilities, etc.), and for any other assets.

- Liabilities -- include all short and long term liabilities.
- Equity -- is the business' net worth.

Hall also briefly describes and illustrates one of Cal Oak Lumber Company's "Profit and Loss Statements". The components are very similar to those for the Cash Flow Forecast illustrated in Section 7.3.1.1., except that Hall's values are for completed transactions. The primary components of an Income Statement are shown in the box that follows. Hall (1998) found

MAJOR COMPONENTS OF AN INCOME STATEMENT [1]

1.0. Sales Income.	$XXX
1.1. Less freight and discounts.	$XXX
1.2. Net sales income.	1.0. - 1.1.
2.0. Less Cost of Goods Sold.	
2.1. Beginning inventory.	$XXX
2.2. Variable costs.	$XXX
2.3. Subtotal.	2.1. + 2.2.
2.4. Less ending inventory.	$XXX
2.5. Total cost of goods sold.	2.3. - 2.4.
3.0. Gross Profit.	1.2. - 2.5.
4.0. Administration Expenses.	
4.1. Various fixed costs (itemized)	$XXX
4.2. Total fixed costs = sum of items in 4.1.	
5.0. Net from Milling Operations.	3.0. - 4.2.
5.1. Other income (if any).	$XXX
6.0. Net Profit (Loss).	5.0 + 5.1.

[1] Adapted from a Cal Oak Lumber Company Income Statement (Hall, 1998).

that, at least for Cal Oak, if administrative costs are less that 15% of sales volume, then he expects to make a profit.

In summary, financial statements are important tools that can be used to ensure that an operation is fiscally viable and to satisfy tax reporting requirements. Getting professional help from a certified public accountant is desirable, or may even be essential, for most businesses, especially if the owner has limited financial training and is just starting a business.

7.3.4. Computers and the Internet.

In today's business world using a computer and electronic communications can greatly simplify a wide variety of management tasks and expand your customer audience to a world-wide basis. The Sierra Resource Group (1997) provide introductory information in their sawmill management handbook about "Using Computers" and the "Internet as a Tool". If you're not well versed in these subjects, this reference will give you an elementary idea of what they involve. They also provide a diskette with a copy of a spreadsheet that can be used to calculate the Sawmill Cost Center values like those in the example in Section 7.3.2.1. It was also noted earlier in Section 5.3.5. that Dave Parmenter's California Hardwood Producers, Inc. had an interactive website last year via Jim Hafferty's Burls & More company through which he could buy and sell logs and sell his various products. Any new business should at least be able to access the Internet.

7.3.5. Financial Support.

Every business needs money to get started, keep running, and eventually to expand, should that be the goal of the owner(s). If the funds to do part or all of these steps are not personally available, then obviously some sort of financial assistance will have to be obtained. It's already been noted that inadequate cash flow, much less funds for capital improvement, are common perennial problems for some custom sawmills. Hall (1998) writes that getting loans for hardwood sawmills historically has been harder than it has been for other enterprises, because of the poor financial track record of hardwood mills.

Custom sawmills using urban logs have very limited background at this time on which to judge their financial success. In spite of this, getting funds for a new urban sawmill business will also depend on a number of other factors including the owner's credit rating, business skills, and equity in the business. Hessenthaler (1997a) estimated that it would take a minimum of about $70,000 to get a portable sawmill and other basic equipment needed to set up an urban milling operation. An example of the equipment and funds needed to set up a custom mill is covered later in Section 7.5. The focus here is how to get startup capital for a new custom mill.

7.3.5.1. Recycling Market Development Zone (RMDZ) Loan Program.

Between 1992 and 1995, the California Integrated Waste Management Board (CIWMB) established forty RMDZs and a low interest fixed rate loan program to assist recycling businesses and local governments facilitate development of markets for recycled materials (**Figure 7.1**.). Some of the details about the RMDZ loans are shown in **Appendix O**. Eligible businesses or governmental agencies can borrow up to $1,000,000 for up to 50% of the cost of a project and a bank or other lender can finance the other 50%. Current loan interest rate is 5.7% and the loans have a maximum life of 10 years. Priority loan consideration is given to source reduction projects that use materials that are normally disposed in solid waste landfills and can be used as feed stock to manufacture recycled-content end products. Special consideration is also given to projects that utilize mixed waste paper, compostable materials, plastics, and construction and demolition materials. Utilizing urban sawlogs for lumber and value-added products satisfies the objectives of this loan program and one of the custom mills has already received such a loan. Milling of Monterey pine killed by pitch canker or other factors seems to be especially appropriate for this program.

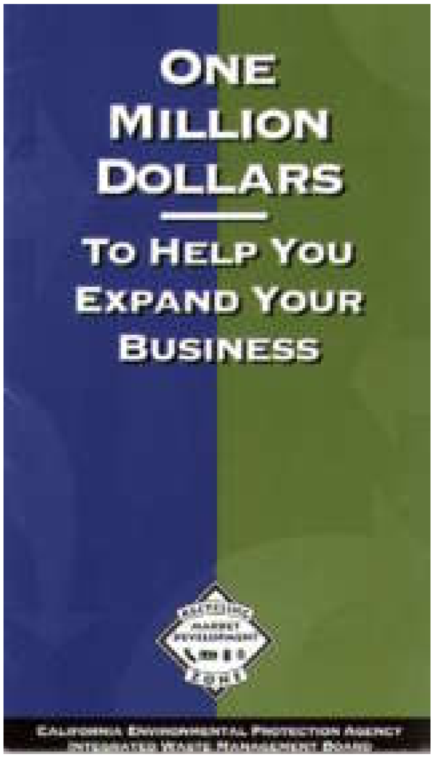


FIGURE 7.1. The Recycling Market De-velopment Zone Loan Program can provide low interest loans for urban sawmill startup and expan-sion.

The CIWMB also provides technical financial assistance for businesses seeking financing who use recyclable materials. Financial Assistance Questionnaires and general loan information can be obtained by calling the Zone Administration Branch at (916) 255-2708. The CIWMB also has a website that gives extensive information about the loan program and waste management in general. The address is:

(http://www.ciwmb.ca.gov/rmdz/zones/default.htm).

7.3.5.2. Conventional loans. Business financing can be obtained from banks or other lending agencies. Hall (1998) provides a brief overview of what to expect from your "Friendly Banker" (In this case, Joe Drakulic, North State National Bank, Chico, CA) should you approach him for a business loan. For those who haven't gotten such a loan before, the following information should help you get started. The first item that's essential for the whole process is to be prepared. Consider preparing a loan package that covers the following items:

Items for a Loan Package

- What is the specific purpose of the loan?
- How much money will be needed?
- When and how long will the funds be needed?
- How will sufficient cash flow be generated to repay the loan?
- What collateral can be use to backup the loan?
- Finally, prepare a comprehensive business plan.

A business plan is essential; if you don't have one you're probably going to waste the lender's time. Key elements that go into a business plan were covered in Section 7.1.1.

7.3.5.3. County grants. In addition to the CIWMB loan program described in Section 7.3.5.1., the County Integrated Waste Management Authorities may sponsor recycling oriented grants. For example, in 1996, San Luis Obispo County had a $40,000 grant program wherein successful applicants could receive up to $10,000 to purchase, lease, or rent equipment to start or expand source reduction and/or recycling efforts. Don Seawater's Pacific
Coast Lumber Company received a $10,000 grant to buy a crane truck that was essential for log acquisition. A similar program was available in 1998, and Don received $5,000 to purchase a kiln.

7.3.5.4. Other technical and financial assistance. There are a variety of other sources both for lending opportunities and for technical assistance for new and operating businesses. The following sources came from Hall (1998) and other references:

- The Small Business Administration -- Contact local SBA office or SBA Answer Desk at (800) 927-5722; website: http://www.sba.gov/. The SBA have a variety of programs to help small businesses.
- National Business Incubation Association -- 20 E. Circle Dr., Suite 90, Athens, OH 45701; phone: (614) 593-4331.
- Association for Enterprise Opportunities -- 70 E. Lake St., Suite 620, Chicago, IL 60601-5907, phone: (703) 351-5269.
- California Trade and Commerce Agency -- Along with other governmental agencies have developed the "California Hardwood Industry Initiate" to promote increased investment in business working with California hardwoods. Website: http.//commerce.ca.gov/regional/hardwood/index.html.
- Local and Regional Economic Developmental Organizations -- e.g. Sierra Region, contact Betty Riley, Extension Dir., Sierra Planning and Economic Development District, 560 Wall St., Aurburn, CA 95603. Phone: (916) 823-4703. Or, North Coast, contact Jim Kimbrell, Executive Director, Arcata Economic Development Corp., 100 Ericson Ct., Arcata, CA, 95521. Phone: (707) 822-4616 ex. 215.
- SCORE® -- The Service Corps of Retired Executives (SCORE) is a nation-wide support group of volunteer business executives who donate their time to help new and inexperienced entrepreneurs get businesses established. They provide confidential counseling, training and workshops, business information, and business management help. See the SCORE® Fact sheet in **Appendix P** for more details about SCORE®. Their phone number is: (800) 634-0245 and their website is:

  http://www.score.org.

- Other grants -- A number of other organizations provide funding for research oriented grants that are relevant to urban sawlog utilization. For example, the National Urban and Community Forestry Advisory Council, phone: (970) 929-9264: and the Forest Products Conservation and Recycling Competition sponsored by the U.S.D.A. Forest Service, phone: (609) 231-9327 have offered grants for recycling related projects. As noted, most of these grants are research oriented and not touted to be for business related operations.

7.3.6. Prices for Lumber and Other Wood Products.

It's necessary to know what the potential value might be for lumber products from an urban sawmill, and what the key factors are that affect their value (See the following box). Price is not static. In addition to the general effects of "supply and demand" on price, there are many other factors that affect it. Several of these factors are briefly described in the sections that follow.

WHOLESALE PRICES FOR DIFFERENT HARDWOODS [1]

Species	Thickness	Grade	Kiln dried	Surface [2]	Volume (bd. ft.) <250	Volume (bd. ft.) >250
Red oak (*Quercus rubra*):					(per bd. ft.)	
	1-inch	FAS	Yes	Rough	$2.89	$2.67
	1-inch	#1 com.	Yes	Rough	$2.10	$1.80
	1-inch	#2 com.	Yes	Rough	$1.63	$1.35
	2-inch	FAS	Yes	Rough	$4.20	$3.60
	3-1nch	FAS	Yes	Rough	$6.74	$6.00
Yellow poplar (*Liriodendron tulipifera*):						
	1-inch	FAS	Yes	Rough	$1.94	$1.72
Eastern black walnut (*Juglans nigra*):						
	1-inch	FAS	Yes	Rough	$4.47	$3.99
Pau (Pernambuco, Brazil)						
	---	---	---	---	$40.00	$36.00

[1]Adapted from the Summer/Fall 1997 MacBeath Hardwood Wholesale Price Catalogue.
[2]For S2S (Surfaced two sides) add 8¢/bd. ft.

7.3.6.1. Species. One of the basic factors that affects lumber price is tree species, and price is undoubtedly related to supply, location, and other factors. The price for different species of U.S. hardwoods (in the previous box) ranged from $1.94/bd. ft. for poplar to $4.47/bd. ft. for eastern black walnut. All of the species in this example were 1 in. thick, FAS, kiln dried, and rough. One of the highest priced exotic hardwoods was pau (Brazilian pernambuco) at $40.00/bd. ft. All things being equal, species probably has one of the greatest effects on commercial lumber prices.

7.3.6.2. Grain and figure. Different types of wood grain are described in **Appendix B** . Two basic patterns of grain are found in plain (or flat) and quartersawn lumber. The later is less common and somewhat more expensive to mill. Flat sawn lumber generally has more "figure", but for some species the unusual appearance of the exposed wood's rays in quartersawn lumber greatly enhances its physical appearance (e.g. the ray fleck in beech, oak, and sycamore). The extra dimensional stability of quarter-sawn lumber in the width dimension can also increase its value for some products (e.g. flooring). California Hardwood Producer's list price for #1 common sycamore was $3/bd. ft. compared to $4.25/bd. ft. for quartersawn lumber.

In regard to figure, unique patterns of grain, buds, or other grain features can greatly increase the value of lumber. A premium price is often paid for high figured wood from burls, or unusual tree forms such as "crotches". However, some species such as walnut and maple are known for their frequency of figure development. As a rule, figure is not generally common; therefore, it can greatly affect lumber price.

7.3.6.3. Thickness. Because thicker lumber requires more care to dry and higher drying costs than thinner lumber, it has a higher value than suggested by the extra volume alone. The price/board foot of a 3-inch thick piece of lumber may be double the price/bd. ft. of a board 1-inch thick. In the box above, 3-inch thick red oak is listed at $6.75/bd. ft. compared to $2.89/bd. ft. for 1-inch thick lumber.

7.3.6.4. Grade. Lumber grade has a major effect on its price. Note the variation on price of 1-inch, kiln-dried, rough, red oak lumber listed in the box. FAS grade lumber is $2.98/bd. ft. compared to $2.00/bd. ft. for #1 common, and $1.63 for #2 common. In regard to sawing for grade, Hall (1998) has a rule-of-thumb that states: "As long as the price ratio between Sel. & Btr., #1 Com. and #2 Com. remains relatively constant, one should usually saw for maximum recovery of Sel. & Brt. regardless of loss in board foot tally." Hall also noted that: "The grades, #1 Common & Better, are the mill's profit areas - in most cases, other grades by themselves are losers." Obviously, a clear understanding of lumber grades (See Section 8.6.1.) and how to maximize the amount of the best grade from a log is essential for a successful urban sawmill business.

7.3.6.5. Green vs. kiln dried. The difference in value between green and kiln-dried oak lumber was briefly discussed in Section 3.3.1., What is a Tree Worth?. In 1997, California Hardwood Producers, Inc. was selling select, kiln-dried, 4/4 white oak at $3.75/bd. ft., while Cal Oak bought 4/4, select and better, rough, green lumber from a portable mill owner for only $0.90/bd. ft. Although it's difficult to compare lumber prices of different companies for different types of lumber, this example indicates that kiln-drying markedly increased the value of hardwoods over comparable green lumber. It was noted in Section 3.3.1. that kiln-drying costs only around 5 to 10¢/bd. ft. and perhaps 10 to 20¢/bd. ft. for small operations.

7.3.6.6. Rough vs. surfaced lumber. Lumber that comes from a saw has a rough texture, thus primary reduction results in "rough" lumber. Running rough lumber through a planer does two things. It provides a smooth wood surface and it somewhat reduces lumber thickness and width from the "nominal" size to an "actual" size, e.g. 2 X 4's (nominal size) to 1 1/2 X 3 1/2 in. (actual size). McBeath Hardwood Company's 1997 price catalogue indicates that the added cost to produce S2S lumber for most species was 8¢/bd. ft. The Sierra Resource Group (1997) indicates that the variable costs for planing is slightly less than 4¢/bd. ft. The cost to surface lumber is similar to that for kiln-drying.

7.3.6.7. Wholesale vs. retail. The price of lumber for wholesale customers (e.g. contractors, commercial woodworkers, etc.) is generally going to be somewhat less than it is for regular "off-the-street" customers. For one thing, wholesale transactions don't include Sales Tax, and high volume is often a factor. However, the custom mills apparently don't have dual price systems and neither do some of the large lumber outlets.

7.3.6.8. Volume. Price may be tied to the volume of lumber purchased as is common for many other kinds of products. This is shown in the previous box where the price for less than 250 bd. ft. of 1-inch, FAS, kiln-dried, rough red oak is $2.89/bd. ft. compared to $2.67 for sales larger than 250 bd. ft. Volume discounts are something that can be negotiated on a case by case basis.

7.3.6.9. Location. Where a mill is and its accessibility to a given species of sawlog may affect the relative price of lumber produced. Although no specific evidence is provided for this statement, it's certainly true for other products. If nothing else, it could directly affect shipping costs, and accessibility to customers.

7.3.6.10. "Green" vs. "non-green". Some customers may be willing to pay a higher price for a product if it can be certified that it is being produced in a "environmentally friendly" manner. This directly applies to the utilization of discarded urban sawlogs. Dave Faison (1997) noted that "certified" wood can add 10% to the profit for a reused wood product. Capitalizing on this will depend on the concern and willingness of customers to support green products.

7.3.6.11. Profit margin. Obviously, the percent profit wanted or needed by a milling operation will affect the price of the products marketed. A business with a high fixed debt will not have the luxury of setting lumber prices at the same level that a mill with a low debt can do. A brief discussion of required net income is described in Section 7.3.7. that follows.

7.3.6.12. Other factors. There are a number of other factors that can affect the price of lumber. A company may have a sale to move all or some of their inventory. Consequently, lumber prices may drop markedly for a sale. Another factor is a discount for payments received before a set time limit, e.g. 30 days. This is a common technique to encourage prompt payment for accounts receivable.

In summary, there are many factors that control the price of lumber. Some are at the discretion of the mill owner(s), but others like, supply and demand, interest rates, etc. are determined by uncontrolled outside factors.

7.3.7. Investment Considerations.

This section is based in part on a short article on "Sawmilling Urban Waste Logs" by Blanche and Carino (1996). The authors briefly discuss marketing considerations, production facilities, and investment considerations, with the last topic the focus of this section. Blanche and Carino noted that before investing capital for a sawmill, the economic desirability of such an investment should be evaluated. However, they didn't know of any documented evidence of investment in the milling of urban sawlogs. Probably the best current available information on custom mill economics is "A Management Handbook for Hardwood Sawmills" by the Sierra Resource Group (1997) whose data are based on California Hardwood Producers, Inc.

Blanche and Carino (1997) provided an estimate of the daily log input required to produce a "desired" return on a variety of capital investment scenarios. Their calculations include the following assumptions: 1. An economic life of 8 years, 2. An average price of $250/MBF for green lumber, and 3. An average lumber recovery factor (i.e. bd. ft. of lumber/ft^3 of log volume) of 7.2 which equates to a 60% conversion of total log volume into lumber volume.

A similar estimate of desired yearly net income for return on initial investment for additional capital investment values and a different lumber recovery rate and average lumber price/MBF are shown in **Table 7.2.** Hall (1998) reported that the green lumber recovery for California hardwoods is about the same as the Scribner log scale volume, with about 25% loss for defect compensated by a 25% gain in overrun. In terms of total log volume, there is about a 50% loss in volume to various residues, e.g. sawdust, slabs, edgings, etc. Keep in mind, the scaled log volume takes many of these losses into account. Using Hall's information, there would be a lumber recovery factor of about 6, instead of the 7.2 used by Blanche and Carino. In regard to lumber price, Hall (1998) reported that the "mill run" price for rough, green California black oak lumber from a portable mill operation was $330 to $385/MBF or about $360/MBF on the average The mill run lumber ranged from select and better grades at $900/MBF to pallet grade lumber at $250/MBF. The $360/MBF figure is used in the following calculations instead of $260/MBF used by Blanche and Carino. Keep in mind, these prices are quite low and don't reflect the increased value for lumber drying and finishing, nor the commercial price of lumber at retail or wholesale outlets.

Although not stated in their article, Blanche and Carino (1987) apparently used a work year of 250 days for their lumber production calculations. This does not seem to be a realistic number of days on which to base lumber production estimates, especially for a small operation of 1-3 workers. Watt (1997) describes a one-man, portable, bandsaw operation where he assumed 200 days for milling and 50 days for maintenance. Fifty days seems high for maintenance, but it could also account for the time spent for log acquisition. Consequently, 200 days for milling are used in the lumber production projections **Table 7.2.**

Based on the above information, the "desired" yearly net income and desired daily production levels can be estimated for different levels of capital investment, required rates of return, and expected profit margins. The formula for calculating desired yearly income is:

CALCULATIONS FOR DESIRED YEARLY INCOME FOR A GIVEN RETURN ON INVESTMENT

<u>Desired yearly net income (A)</u>:

$$A = \text{Capital investment}/[(1 + i)^n - 1]/i(1 + i)^n$$

Where: A = yearly net income
i = rate of return = 10, 15, or 20%
n = number of years of economic life = 8 years.

<u>For Example:</u> For a capital investment = $40,000

i = 10%
n = 8 years.

Then: $A = \$40,000/[(1 + 0.1)^8 - 1]/0.1(1 + 0.1)^8 = \$40,000/5.33 = \$7,508.90$

Total yearly income (T):

T = yearly net income (A)/% profit margin (PM).
T for a 5% PM = $7,508.90/0.05 = $150,178.00 total yearly income.

Daily Total income (DI):

DI = Total yearly income (T)/number of milling days [assume 200 days]
DI = $150,178.00/200 days = $750.90/day gross income.

Desired daily production level (DP) in MBF:

DP = Total daily gross income (DI)/lumber cost/MBF [assume $360/MBF]
DP = $750.90 per day/$360.00 per bd. ft. = 2.09 MBF/day.

Required daily log volume (DLV) in ft^3:

DLV = Daily production in MBF/Lumber recovery factor [assume 6.0 for bd. ft./ft^3]
DLV = 2.09 MBF/6 bd. ft./ft^3 = 347.6 ft^3/day.

This would amount to a daily requirement of about 47 logs 12 inches in diameter and 10 ft. long, or about 19 logs 16 inches in diameter and 10 ft. long.

The required yearly net income (**Table 7.2.**) ranges from $7,500 at 10% rate of return and a 5% profit margin for a $40,000 investment, as just calculated, to $31,300 for a 20% rate of return and 20% profit margin for a $120,000 investment. Daily board foot lumber production for the latter conditions at 8.7 MBF/day is beyond the combined capacity of several small portable sawmills. Daily lumber production for the $7,500 yearly net income on a $40,000 is 2.1 MBF. This also would be beyond the expected daily production rate for a single Wood-Mizer type band mill with a two-man crew. However, Hall (1998) referring to Parmenter's California Producers, Inc. mill, estimates that the average production from a Wood-Mizer mill is about 1,000 bd. ft./day. If only cants are being cut that are then resawn, daily production can jump to 2,000 bd. ft./day for a 3-man crew, but this also requires a resaw. Keep in mind that the required daily production for a given investment and required rate of return can be greatly reduced if the expected profit margin goes up, the value for lumber increases, or if the number of milling days per year increases.

Table 7.2. Estimated daily lumber production needed to satisfy different levels of capital investment and required rates of return for different expected profit margins[1, 2]

Initial capital investment ($)	Required rate of return (%)	Desired yearly net income ($)	Total yearly income ($)	Expected profit margin (%)	Desired production level (MBF/day)	Required volume log input (ft^3/day)
$40,000	10	$7,500	$150,200	5	2.10	350
			75,000	10	1.00	170
			37,500	20	0.50	80
	15	8,900	178,000	5	2.50	420
			89,000	10	1.20	200
			44,500	20	0.60	100
	20	10,400	208,000	5	2.89	480
			104,000	10	1.44	240
			52,000	20	0.72	120
$80,000	10	15,000	300,400	5	4.17	700
			150,200	10	2.09	350
			75,000	20	1.04	170
	15	17,800	356,000	5	4.94	820
			178,000	10	2.47	410
			89,000	20	1.24	210
	20	20,800	416,000	5	5.78	960
			208,000	10	2.89	480
			104,000	20	1.44	240
$120,000	10	22,500	450,000	5	6.25	1,040
			225,000	10	3.13	520
			112,500	20	1.56	2.60
	15	26,700	534,000	5	7.42	1,240
			267,000	10	3.71	620
			133,500	20	1.85	310
	20	31,300	626,000	5	8.69	1,450
			313,000	10	4.35	720
			156,500	20	2.17	360

[1]Adapted from "Sawmilling Urban Waste Logs" by Blanche and Carino (1996).
[2]Assumptions used for this tables' calculations:

1. Interest life expectancy (n) =8 years.
2. Interest rate (i) = 10, 15, or 20%.
3. Lumber recovery rate at 50% = 6 bd. ft./ft^3.
4. Average lumber price = $360 per MBF for rough, green lumber.
5. Average number of working days/year = 200 days.

7.4. SAWMILL AND RELATED EQUIPMENT.

Various "cost centers", or steps, in the production of lumber from log acquisition to finished product were identified in Section 7.3.2.1. In this section, the key equipment needed for each of these steps is identified along with references to some of the potential sources for this equipment. However, not all of the minor equipment that might be needed is identified nor are all of the possible equipment sources listed. A few of the general equipment sources are as follows:

KEY EQUIPMENT SOURCES

- **TMS Machinery Sales** -- Claims to be the "World's Largest Listing of New & Surplus Forestry Equipment". It's catalogue is published monthly and is free to individuals in the field of wood products and related industries. It covers all aspects of the sawmill business. Phone: (800) 766-6701; Fax: (207) 783-4220; Website: www.auburnmachinery.com; E-mail: auburnmach@aol.com; P.O. Box 3065, Auburn, ME 04212-3065.

- **The Portable Sawmill Encyclopedia** -- Claims to be "-- absolutely the best single tool possible for prospective buyers and/or owners of portable saw-mills", and contains information about mill manufacturers (including 50 narrow and 8 wide band portable mills + 20 circular mills.), support equipment manufacturers, trade shows, etc. Phone: (800) 459-2148 or (205) 969-39563; Fax: (205) 967-4620; Website: http://www.sawmill-exchange.com; Address: Sawmill Exchange, P.O. Box 131267, Birmingham, AL 35213-6267.

- **Bailey's** -- Claims to be "The World's Largest -- Mail Order Woodsman Supply Company -- at Discounted Prices." Their listings include chain saws and other hand equipment and Alaskan and Lucas mills. Phone: (707) 984-6133; Fax: (707) 984-8115; E-mail: baileys@bbaileys.com; Website: http://www.bbaileys.com: Address: P.O. Box 550, 44650 Highway 101, Laytonville, CA 95454.

- **Other Equipment Sources** -- The Websites for a few additional equipment sources and information are as follows:

  -- Iris Forest Products Industry Directory: http://woodtechmag.com

  -- Steve Shook's Directory of Forest Products, Wood Science, and Marketing: http://foresstdirectory.com

  -- Wood Technology Directory: http://woodtechmag.com

  -- Sawmill & Woodlot Management: http://www.midmaine.com/~sawmill

(Note: Trade names, commercial brands, and equipment sources and costs mentioned in this report are solely for information. No endorsement by the authors or any sponsoring agency is implied. Equipment manufacturers, models, and costs may have changed or are no longer available.)

The last source listed above, Sawmill & Woodlot Management, is also a bimonthly magazine that is “Devoted to Small Sawmill & Woodlot Owners and Operators” with pertinent articles about milling, woodlot management, equipment advertisements, etc.

At a minimum, an urban wood processor needs a portable sawmill, equipment to move the logs, and a method of drying lumber. There are probably more that fifty manufacturers of portable and mini-sawmills, each with their own pluses and minuses. It is not possible to review them here, but here is some information to consider when contemplating such a purchase. It is important to think about and compare how the mills can handle logs and what their limits of operation are.

Specific sources for the log acquisition and milling equipment referred to in the next sections are listed in the box that follows. The disclaimer noted in the previous box applies here also. Many of the following items can be purchsed from many additional sources as noted above.

SOME SPECIFIC SOURCES FOR EQUIPMENT LISTED IN THIS REPORT

Bailey’s P.O. Box 550, 44650 Highway 101 Laytonville, CA 95454.	Phone: (707) 984-6133 FAX: (707) 984-8115 E-mail: baileys@bbaileys.com Website: http://www.bbaileys.com
Baker Products P.O. Box 128 Ellington, Missouri 63638	Phone: (573) 663-7711 FAX: (573) 663-2787
Cook’s Saw & Machine 160 Ken Lane Newton, AL 36352	Phone: (800) 473-4804 Fax: (334) 692-3704
Ebac Lumber Driers 106 John Jefferson Rd. Suite 102 Williamsburg, VA 23185	Phone: (800) 433-9011 FAX: (804) 229-3321
Fisher Research Laboratory 200 W. Willmott Road Los Banos, CA 93635 (See **Appendix N** for additional sources.)	Phone: (209) 826-3292 FAX: (209) 826-0416
Forestry Suppliers Inc. 205 W. Rankin St. P.O. Box 8397 Jackson, MS 39284	Phone: (800) 647-5368 FAX: (800) 543-4203 Website: www.forestry-suppliers.com

EOUIPMENT SOURCES CONTINUED

Mighty Mite Industries 3931 N.E. Columbia Blvd. P.O. Box 20427 Portland, Or 97220	Phone: (503) 288-5923 FAX: (503) 288-5582 E-mail: mytmite@pacifier.com Website: www.pacifier.com/~mytmite
Mobile Manufacturing Co. P.O. Box 258 Troutdale, OR 97060	Phone: (503) 666-5593 FAX: (503) 661-7548 E-mail: info@mobilemfy.com Website: www. mobilemfy.com
Morbark P.O. Box 1000 Winn, Michigan 48896	Phone: (800) 233-6065 FAX: (517) 866-2280
Nyle Dry Kiln Systems P.O. Box 1107 Bangor, Main 04402-1107	Phone: (800) 777-6953 FAX: (207) 989-1101 E-mail: lewis3@ibm.net
TMS Machinery Sales (Dec. 1997 Catalogue) P.O. Box 3065 Aurburn, ME 04212	Phone: (207) 888-4244 FAX: (207) 783-4200 E-mail: aueburnmach@aol.com Website; www.auburnmachinery.com
U-C Coatings Corp. P.O. Box 1066 Buffalo, N.Y. 14215	Phone: (716) 833-9366 FAX: (716) 833-0120 E-mail: uccoatings@banet.net Website: http://www. uccoatings.co
Wood-Mizer Products, Inc. 8180 West 10th St. Indianapolis, IN 46214	Phone: (800) 533-0182 FAX: (317) 273-1011 E-mail: woodmizer@woodmizer.com
Woodworkers Supply 5604 Alameda Place NE Albuquerque, NM 87113	Phone: (800) 645-9292 FAX: (800) 853-9663

7.4.1. Log Acquisition and Harvesting.

The equipment required for this first step of a sawmill business will directly depend on how the logs are to acquired and whether or not they will be milled on site or will be transported to another location. If milled on site, then log loading and transport equipment wouldn't be needed, but it would still be necessary to move logs to the mill itself. Keep in mind that green logs are very heavy. For example, a 10-inch diameter red oak log 10 ft. long would weigh about 350 lb., while a 24-inch diameter log the same length could weigh up to 2,000 lb. The larger logs can not be man-handled, and depending on conditions, a small tractor, fork-lift, or cable system may be needed to move the logs. Many urban logs, because of their size or location may not be accessible and will have to bucked into short lengths if they are to be removed. Cesa, et al. (1994) have some brief references to log loading and unloading safety procedures plus safety procedures for chainsaw operation.

If logs are to be milled at a permanent location, there are at least three ways that they could be obtained: **1.** The mill owner(s) could do the harvesting, **2.** The logs could obtained from a commercial tree service company or other entity and picked up at the harvest site, and **3.** The mill owner(s) might only use logs that are delivered to the mill location thus making some harvest equipment and possibly a crane truck or similar loading equipment unnecessary. The following equipment would be needed if all harvesting and transport steps were to be done.

7.4.1.1. Falling and bucking. It's assumed that a proposed urban milling business has qualified personnel to fall trees in an urban setting. Basic equipment would include the following items :

Equipment category*	Estimated cost new
1. Climbing gear and ropes --	$450 to $500
2. Chain saws (16 to 36 in. bar) --	$250 to $600
3. Chain saw accessories (files, gas cans wrenches, chains, sharpening tool, wedges, etc.) --	$150 to $250
4. Tools (cant hooks, axes) --	$125 to $150
5. Safety equipment (gloves, hard-hats, ear and eye protection, chaps, fire extinguisher)	$150 to $200
Approximate total:	**$1,125 to $1,700**

(* **Source:** Bailey's and Forestry Suppliers Inc. See Section 7.4. for contacts.)

7.4.1.2. Log skidding, loading, and transport. Moving logs to an on-site portable mill or to be loaded for transport is a demanding, difficult job, especially in an urban environment where access may be difficult, or economically prohibitive. There is a variety of loading and skidding equipment designed for regular logging operations that would be inappropriate for a small urban sawmill business because of size, cost, or limited use. Probably the most versatile unit is a crane or lineman truck that can be used to load and transport logs to a mill, and it can also be used to skid logs a short distance (possibly up to 150 ft. or so) to be milled or to be loaded. A crane truck could also serve as the primary log transportation vehicle.

Another loading and transport combination would include a 3 ton flatbed truck and a fork-lift for loading and limited skidding. Neil Elmer, a one-man logging, milling, drying, and furniture manufacturer business in Potter Valley, California, has a flatbed truck rigged with two electric wenches that roll a log up metal ramps from the side of the truck onto the bed. No doubt there are many other types of loading systems.

Estimated cost for the two systems noted here are:

Loading & transport system	Estimated cost Used	New
1. Crane/lineman truck -- (12-14,000 lb. capacity)	$25,000	$120,000
2. a. Fork-lift (8-12,000 lb. capacity) --	$6-10,000	$30,000
b. Flatbed truck (3 ton capacity) - -	$10,000	$40,000

Note: The above are only rough estimates of the cost for an appropriate loading and transport system. In formation about used forestry equipment can be obtained from sources like the TMS Machinery Sales noted in the box at the beginning of this section.

7.4.1.3. Slash disposal. A sawmill business engaged in extensive urban harvesting would have to deal with the limbs, tops, and other slash that are generated. One way would be to load it on a truck and transport it to a green waste disposal operation; this would not require any additional specialized equipment. Or, the slash could be disposed at a landfill, but that's not acceptable considering the focus of this report. A third way, would be to chip the slash and leave it on site if that was acceptable. This last method would require buying or leasing a chipper; however, a chipper would probably not be a high priority item for most urban milling operations. On the other, hand the chipper could also be used to help dispose mill waste, and thus could serve a dual purpose for a milling operation.

Like most other milling equipment, chippers come in a wide range of size capacities. Some of the newer chippers are reported to handle material up to 30 in. in diameter. This would be considerably heavier duty than what would be needed for a custom sawmill operation, and material this large might be milled into lumber. Estimated costs for small to moderate-sized chippers are:

Chippers*:	Estimated cost Used	New
■ **Morbark** : Model 2100D, disk-style, 75-135 h.p., 14 X 14 in. throat, wt. 5,500 lbs., up to 12-inch diameter stems.	N/A	$25,000
■ **Morbark** : Model 2070, disk-style, 24-35 h.p., 10 X 10-in. throat, weight 2,000 lbs., cuts up to 7-inch stock.	N/A	$12,500-$16,000
■ **Morbark** : Model 2050, pocket drum chipper, 8 X 10-inch throat, weight 1,140 lbs., cuts 3-5-inch diameter stems.	N/A	$7,000
■ **Morbark** : (no model), 58-inch chipper, 125 h.p., 3K, electric motor, cyclone.	$13,000	N/A

(* **Source:** Morbark and TMS Machinery Sales. See Section 7.4. for contacts.)

7.4.2. Log Handling, Storage, and Preparation -- Mill Location.

This section deals with log storage and manipulation prior to milling. It assumes that logs will be milled at a permanent location, and they will be delivered to this site probably by one of the three methods listed above in Section 7.4.1. Only the major equipment required at this stage of a mill operation are described here, land and facilities requirements are covered later in Section 7.4.7., Mill Facilities.

7.4.2.1. Log handling. After logs are delivered to a mill site, it will be necessary to be able to move them to and from a storage area to the mill itself (**Fig. 5.4.**). It would likewise be necessary to be able move the lumber and lumber stacks that result from the milling operation. Although large, specialized, expensive log moving equipment is available for a major commercial milling operation, it would be inappropriate for a small custom urban mill. The fork lift and/or crane truck identified in Section 7.4.1.2., Log skidding, Loading, and Transport, would most likely be the same units used for log handling at the mill site. The following is a repeat of some of the cost information listed in Section 7.4.1.2.:

	Estimated cost	
Loading & transport system	**Used**	**New**
1. Crane/lineman truck -- (12-14,000 lb. capacity)	$25,000	$120,000
2. a. Fork-lift (10-12,000 lb. capacity) --	$6-10,000	$30,000

Other, inexpensive items that will be needed such as cant hooks were listed in Section 7.4.1.1.

7.4.2.2. Log storage. This amounts to grouping or piling logs at a specific location usually by some category, e.g. species, size, condition, or other factor. Problems with severe cracking and checking of stored logs, especially during long periods in dry environments were referred to earlier in this report, and are described in detail in Section 8.2. Log Storage. One way to reduce cracking and checking is to keep logs moist by means of a sprinkling system. However, the details and cost for such a system are not included in this report. One of the easiest and least expensive ways to reduce log drying is to coat the ends of the logs, where checking is most prevalent, with a water proof sealer coat. Some operators simply use paint for a sealer although paint may not be very effective; the best sealers contain waxes. Commercial products are available for this purpose as follows:

	Estimated cost
	New
■ **Bailey's-Seal** : End sealer for green logs and lumber	
1. Five gal.	$42.00
2. + Five gal (each).	$40.00
■ **ANCHORSEA** L® : End sealer for green logs and lumber	
1. Five gal	$45.00
2. Fifty-five gal drum	$225.50

(**Source:** Bailey's and U-C Coatings Corp. See Section 7.4. for contacts.)

7.4.2.3. Log preparation. Several things may have to be done to a log before it's ready to be milled including debarking, bucking, and testing for metal and other unwanted objects buried in a log.

- **Debarking --** In a large commercial sawmill, just prior to milling, a log is usually debarked either mechanically or hydraulically, depending on species, to keep rocks, dirt, and other debris away from the saw blade. Although debarking usually wouldn't be done in an urban custom milling operation because of the expense, some portable mills are equipped with a small rotary device located in front of the blade that removes a narrow strip of bark along the saw line (e.g. Cook saws have a debarking attachment, and Wood-Mizer now lists a debarking option for $1,395.). Morbark and other companies manufacture mill-like debarkers and also see TMS Machinery Sales for used debarkers.

- **Bucking --** Cutting logs to the desired length prior to milling will usually be done with a chain saw. Information about chain saws and accessories are covered in Section 7.4.1.1. A milling operation will probably have at least two or three chain saws of different bar lengths. Chain saws may also be used to split logs too large to go through a saw directly. Saws will vary from $250 to $600 or more depending on bar length, brand, horse power, etc.
- **Dealing with metal and other embedded material --** Another key step in log preparation that's especially important with urban logs, is to detect metal and other foreign objects imbedded in a log. Such material is both hazardous to the sawyer and other workers, and damaging to equipment. This is thoroughly described in information copied from Cesa et al. (1994) and covered in Section 8.3. and **Appendix 15.**

Some objects can be found visually, but buried metal will require a metal detector. Cesa et. al. indicate that basic metal detectors range in price from $250 to $500 and they list four metal detector manufacturers (See **Appendix N.**). However, it is unclear how effective these units are for finding metal embedded in dense wood. A detector designed for scanning logs is marketed by Bailey's, but for a price.

		Estimated cost	
		Used	**New**
■ **Fisher Research Laboratory**	: M96, 8-inch probe	N/A	$500

(**Source:** Fisher Research Laboratory. See Section 7.4. for contacts.)

7.4.3. Primary Log Breakdown -- Milling Equipment.

The key piece of equipment in a sawmilling business is obviously going to be a headrig. Although lumber can be processed with chain saw equipment, it is not considered productive for a commercial effort. However, they can make sense for the person producing lumber for his own use. Blanche and Carino (1996) discuss some of the factors that affect equipment selections for an urban milling operation. They noted that because of the high financial risk associated with an unstable or unpredictable market and log supply in an urban setting that there may be no choice but to operate a small sawmill. And, the choice of mill should be based on production needs (generally low for an urban custom mill), operating efficiency, and it should be economic to operate. Based on these criteria, they felt that a portable band headrig satisfied all of these requirements. They estimated that a $30,000 to $50,000 capital investment would be adequate to get started, and this would be enough to buy a bandmill, edger, and a lift truck. This is a bit low for a complete mill setup. Earlier, it was noted that Hessenthaler (1997a) estimated that it would take about $70,000 to get a sawmill business started. However, as will be shown in the following paragraphs, there is a wide range in the type and price of equipment that's available, plus there are some good sources of used equipment.

Because a headrig is the most critical piece of equipment for a milling operation, there are several factors that should be considered before its acquisition. The Anonymous (1997) author of "Portable Sawmill Encyclopedia" listed the eight factors that follow that should be considered before buying a portable sawmill.

7.4.3.1. Factors to consider before buying a sawmill.

- **Level of income needed** -- Is the mill going to provide zero, part-time, all of your income? This will affect the rate of production needed, and thus the type of saw and its potential milling capacity relative to the cost of the mill.

- **Production rate** -- How much daily production is needed to satisfy income and production goals (see Section 7.3.7.) per day, week, etc.? Remember, a mill will probably be able to cut more lumber per day than you can supply logs for it, day after day. Basically, greater production means greater operating costs. Lumber production rate also depends on log size, (more from larger logs), log shape (more from straight logs), and log condition (more when less defect), and lumber thickness.

- **Band vs. circular saws** -- This is an important choice because there are important advantages and disadvantages for each type of saw. Portable bandsaw blades have kerfs from about 0.028 to 0.032 in. thick, compared to 0.190 to 0.230 in. for a portable circular saw. Consequently, band saws may produce up to 20% more lumber per log. On the other hand, band saws often produce a wavy cut compared to a circular saw, which has a much more rigid blade. Band saws can produce lumber or cants as wide as the log being cut, which is usually up to 30 in. in diameter. Circular saws can't readily cut boards wider than the cutting depth of the saw blade, which may be 6 to 15 in.

  Anecdotal information suggest that portable circular saws have higher production rates than portable band sawmills. However, remember that sustainable production with a portable mill is also a function of human effort. And, production rate is a function of saw kerf, log size, time required to load a new log, and the size of the lumber being cut. If the goal is to produce grade lumber, the ability to turn a log to maximize grade during log breakdown may be more important than production rate. If so, a band sawmill would be preferred to a circular saw mill.

- **Manual vs. hydraulic** -- Log loading for a basic portable saw is usually done by hand. These saws are less expensive, possibly half the price of a saw equipped with hydraulic loading and positioning equipment. Hydraulic log loader and turners minimize log handling and increase production, plus saving wear and tear on one's body. Anonymous (1997) reported that hydraulic accessories may increase saw cost by $5,000 to as much $80,000.

- **Manual vs. motorized carriage** -- The headrig or carriage for the less expensive saws is usually moved manually. While this may give a sawyer a feel for the appropriate rate of cutting, it is more time consuming and labor intensive than a motorized headrig. Consequently, production will be less. The new saws even have a computerized set works so that the blade is automatically positioned for each cut, and two or more board thicknesses can be preset in the computer. This ensures uniform board thickness and is faster than manually positioning the saw for repetitive cutting.

- **Log size** -- A mill should be able to handle the largest logs that you expect to cut. Some of the smaller, less expensive manual mills are actually easier to use on large logs than are the $20,000+ larger portable mills. However, large logs can also be cut or split in half, thereby "doubling" the size capacity of a mill. But cutting of splitting a log is half is a very difficult and time consuming job.

- **Saw sharpening equipment** -- Blades have to be sharpened (changed) after every few hours of use at best. Automatic sharpeners suitable for 1.25-inch wide bandsaw blades (a size common for portable mills) may cost between $1,500 to $2,000. Blades can also be sharpened by a blade-service company, and sharpening may cost around $5 per blade (Anonymous, 1997).

- **Other saw equipment** -- In addition to a basic saw, a number of other accessories and extras can add several thousands of dollars to the total cost of a mill setup. Other items might include a trailer package, a sawmill extension to increase product length, debarker, lumber haul back system, edger, etc. that make the milling job both easier and may greatly increase milling capacity, for a price.

7.4.3.2. **Chain saw mills**. There are a number of companies that make attachments or support frames that can be used with a chainsaw to mill lumber. This is by far the least expensive way to do it. However, these are mills are very labor intensive and the product will be rough. High maintenance and high wood loss due to the wide blade kerf are limiting factors. They are probably good for remote areas or where a small volume of lumber is required, but they are not recommended for an urban milling operation except for specialized uses. Two chainsaw mills are briefly described as follows:

- **Alaskan mill** -- This involves a guide bar that's attached to a chainsaw and a sawbar that slides along the top of the log. An "oiler and helper" handle may also be attached at the end of the bar making milling a two-man operation. Maximum log diameter, depending on bar length, ranges from 20 to 54 in. width with no limitations on log length. Costs range from $139 for a small, basic 24-inch mill to $629 for the large, deluxe model.

	Estimated cost	
	Used	New
■ Small, 24-inch, minimum cut, basic mill,	N/A	$139

maximum cut is 20 in.

	Used	New
■ Large, 56-inch, maximum cut, complete mill. maximum cut is 54 in.	N/A	$629

• **Woodbug ®** -- This mill basically uses a metal frame (10 or 20 ft. long) and a carriage to hold a chainsaw. Log diameter is limited to 19 in. Bailey's advertises two Woodbug mills:

	Estimated cost	
	Used	**New**
■ Ten-foot basic Woodbug sawmill package (Weight 175 lb.), cuts 7- to 8-ft. long lumber	N/A	$ 830
■ Twenty-foot basic Woodbug sawmill package (Wt. 325 lbs.), cuts 17- to 18-ft. long lumber.	N/A	$ 1,600

(**Source:** Bailey's. See Section 7.4. for contacts.)

7.4.3.3. Band mills. Some of the features of band sawmills have already been noted earlier in Section 7.4.3.1. and throughout the report. A band mill is simply a loop of saw blade that movies continuously over two wheels, namely a drive and a guide wheel. Blade widths vary from less that 1/2 in. to about 3 in. The blades in a large commercial mill may be up to 12 in. in width with a saw kerf of 0.16 in. Band mills considered suitable for an urban sawmill business are often portable. Two of the more common portable band mills found in the west are Wood-Mizer® and Mighty Mite. They have similar components and capabilities with one main difference in that the headrig of Mighty Mite is supported on both sides of the saw headrig while the Wood-Mizer is supported on only one side (**Fig. 5.10.**) Possible problems might arise with odd-shaped or oversized logs on a double mast system.

Maximum lumber production rate for both mills will be between 1,000 and 2,000 bd. ft. per day (Note earlier comments on lumber production rates in Section 7.4.3.1.). Wild Iris is currently setting up a complete milling operation in Piercy, CA that uses a Cook band mill that is rated at 4,000 to 5,000 bd. ft./day, although the production goal is only 2,000 to 3,000 bd. ft./ day (Personal communication, Senerchia, 1997). To give you some idea of the production rate of a larger stationary mill, Morbark has a modular circular mill capable of producing up to 40,000 bd. ft. per day; however, this is way out of the range of mills believed suitable for an urban custom operation. Some examples of band mills and related equipment, and their relative costs are as follows:

	Estimated cost	
	Used	**New**
• **Band mills*.**		
■ **Wood-Mizer:** Basic Model (LT25G15), non hydraulic, 16.8-ft. bed, without trailer package, 15 h.p. gas engine.	N/A	$7,670
■ **Wood-Mizer** : Super Hydraulic (Model LT40HDD40), 21-ft. bed, 40 h.p. diesel engine, 36-inch diameter log capacity, with board return. Add $1,500 for trailer package.	N/A	$26,600

■ **Mighty Mite** : Generation IIIa, 29 h.p. gas engine, 16.5-ft. bed, without trailer package, 30-in. saw throat and 36-inch log diameter capacity.	N/A	$15,000
■ **Mighty Mite** : Mark IV6, 29 h.p. diesel engine, hydraulic log 24.5-ft. bed, loaders & turners, trailer package, 30-in. saw throat.	N/A	$28,000
■ **Cook:** Model AC-36-35WG, 35 h.p., hydraulic log handling and head control, max. diameter 36 in, length 21 ft.	N/A	$25,000
• **Blades*.**		
■ **Wood-Mizer:** 1.25 wide X 0.035 thick X 158 in. long.	N/A	$16
1.50 wide X 0.045 thick X 158 in. long.	N/A	$23
■ **Mighty Mite** : 1.25 in. wide X 13 ft. 10 in. long, 1/16 saw kerf.	N/A	$28
• **Blade sharpeners***		
■ **Cook:** Automatic blade sharpener, 3/4 to 2 in. wide blades.	N/A	$1,500
■ **Wood-Mizer:** Automatic blade sharpener, tooth setter carriage included.	N/A	$1,850
■ **Mighty Mite** : Complete blade maintenance kit with automatic blade sharpener, set tool, stands.	N/A	$2,250
• **Band saw tooth setter*:**		
■ **Cook:** Clamping pressure 850 p.s.i., dial tooth set indicator.	N/A	$350

(***Sources:** Mighty Mite Industries, Wood-Mizer Products, Inc., Cook's Saw & Machine)

7.4.3.4. <u>Circular saw mills.</u> Circular saw mills have also been discussed earlier in this Section, and their advantages and disadvantages described. Although generally considered to be more productive, they have less flexibility in cutting the width of individual boards than band mills, which somewhat reduces their suitability for custom milling where odd shapes (e.g. branch crotches) and sizes are desirable. A Mobile Dimension saw is probably the most popular portable circular saw in California. It operates with two (sometimes three) saw blades at right angles to each other so that two (or three) sides of a board are at the same time. The Australian Lucas mill, a relatively inexpensive portable mill that can be carried in the bed of a pickup truck, has a single circular blade that cuts horizontally in one direction and rotates to a vertical position for the reverse direction of movement of the saw head. It's reported to produce a cutting rate similar to a Mobile Dimension saw, but the saw must be pushed through a log manually. The blades for a Lucas mill have five carbide cutting teeth that can be sharpened in a few minutes. It can also be equipped with a slabbing bar (chainsaw) that can cut slabs 50 to 60 in. wide.

Prices for circular sawmills are as follows:

	Estimated cost	
	Used	**New**
• **Circular saw mills*.**		
■ **Lucas mill:** Model 6 Complete 6-inch mill, 16 h.p engine, 20- foot rails, plus three saw blades.	N/A	$9,600
■ **Lucas mill:** Complete 8-inch mill, same as 6-inch mill but able to cut 8-inch wide boards.	N/A	$12,700
■ **Mobile Dimension mill:** Model 128; 1,700 cc engine; board and block package; cuts any diameter, lumber to 8 1/4 X 12 1/4 in. to 16 ft. 4 in. long.	N/A	$14,230
■ **Mobile Dimension mill:** Model 128, trailer/dual axles, steel ramps, 1,835 cc. motor, (470 hours on used machine), cuts lumber to 8 1/4 X 12 1/4 in. to 20 ft 4 in. long, 48 in. in diameter.	$16,500	$23,860
■ **Mighty Mite** : Eight types of circular saws ranging from $29,500 to $ 43,000. Model D1212WT, 100 h.p. turbo diesel, log diameter 8 to 84 in., max. length 41 ft., max. cut 12 X 12 in.	N/A	$43,000
• **Lucas mill accessories*.**		
■ **Slabbing bars:** for 6- and 8-inch mills, respectively.	N/A	$940-$1,000
■ **Saw blades:** for 6- and 8-inch mills, respectively.	N/A	$100 -$160

(***Sources:** Bailey's, Mighty Mite Industries, and Mobile Manufacturing Co.)

7.4.4. Secondary breakdown.

Secondary breakdown as used in this report consists of cutting processes after primary log breakdown that are used to manufacture rough lumber, e.g. resawing, edging, and trimming.

7.4.4.1. **Resawing.** This basically amounts to recutting cants and slabs from primary log breakdown. This large material is cut with a saw designed to efficiently recut thick, rectangular shaped material into lumber. To speed up the process, some resaws are equipped with a "merry-go-round" arrangement that automatically returns a cant for another pass through the resaw. This combination of primary and secondary milling is one of the fastest ways to produce lumber from portable mills (Hall, 1998). However, a resaw would probably not be an essential piece of equipment for a small volume urban mill where a high rate of production is not a primary goal. There are many different sizes and models of resaws that are currently available. Wood-Mizer markets a resaw attachment that can be used with their band sawmills. The December 1997 TMS Machine Sales Catalogue listed 95 used resaws for sale ranging in price from $2,000 to $55,000 with many in the $5,000 to $6,000 range. Some examples of resaws that might be suitable for a custom sawmill operation are as follows:

	Estimated cost	
	Used	**New**
• **Resaws*:**		
■ **Wood-Mizer:** Resaw attachment, cuts cants up to 4 in. thick by 12 in. wide, 100 fpm feed rate.	N/A	$1,400
■ **Cook:** Resaw, 1 1/4 in. bandsaw, cuts cants up to 12 X 12 in. and 4 to 20 ft. long, 25 h.p. gas or electric motor.	N/A	$15,000
■ **Mighty Mite:** Band resaw, single head with return.	$5,500	N/A
■ **Baker:** Twin band resaw, auto feed, cuts 12 X 12 in. cants.	N/A	$82,000

(***Sources:** Wood-Mizer Products, Inc., Mighty Mite Industries, Cook's Saw & Machine, Baker Products, and TMS Machinery Sales)

7.4.4.2. **Edging.** Edging is the process where an "edger", often comprised of several, moveable, parallel saw blades, is used to square the edges of the lumber or cants, and to cut wide boards into narrower ones. Edging is important for softwoods, but especially so for hardwoods to remove defects and to maximize lumber grade. The saw blades may be "set" using laser beams to mark the position of the intended cut.

Just as with resaws, edgers come in a wide range of sizes designed for a large commercial mill down to smaller machines suitable for a small custom mill. A heavy-duty table saw might be adequate for much of the edging that is required for a custom mill. Also, individual or multiple boards can be edged with a band sawmill by setting them on edge and cutting them the desired width. Used edgers in the TMS 1997 Machine Sales Catalogue ranged from $5,000 to $ 94,000 with most being about $4,000 to $ 10,000. Some prices for edgers are:

	Estimated cost	
	Used	**New**
• **Edgers*.**		
■ **Delta:** Unisaw table saw, 10 in., 3 h.p., 230 v.	N/A	$1,600
■ **Wood-Mizer:** Portable edger, 13 h.p., gas engine, processes boards up to 14 in wide and 2.5 in. thick.	N/A	$2,300

(***Sources:** Wood-Mizer Products, Inc. and Woodworkers Supply)

7.4.4.3. **Trimming.** Similar to edging, but boards are cross-cut to attain desired board length or to remove defects. A large variety of commercial saws are available and used saws can range from $1,200 to $ 30,000. A commercial radial arm saw will probably be sufficient for a small custom mill. Some examples of trim saws are as follows:

	Estimated cost	
	Used	**New**
• **Trim saws*** .		
■ Mighty Mite: Electric (20 h.p.) & diesel models (29 h.p.), cuts any length, full 12 X 12 in. capacity, power feed and saw control.	N/A	$20,000
■ Delta: Radial saw Model 33-890, 12 in., (larger saws are available).	N/A	$1,690

(***Sources:** Woodworkers Supply and Mighty Mite Industries)

7.4.5. Lumber drying.

A detailed description of lumber drying is covered later in Section 8.3. including the drying process (8.3.1.), conditions (8.3.2.), methods including kiln manufacturers (8.3.3.), and defects (8.3.4.). The critical need for dry lumber has been pointed out throughout this report, especially for hardwoods. There must be adequate space for both green and dry lumber storage, covered later in Section 7.4.7. Mill Facilities; this also includes room for air drying.

7.4.5.1. Air drying. Although no specific equipment is needed for air-drying, a fork lift will be needed to move stacked lumber. This could be the same unit noted in Section 7.4.2.1. Log Handling and Storage. There may also be a need for a shed to keep the drying lumber out of direct sunlight and reduce the drying effect of the wind. Because of the importance of using uniform-size stickers of the proper wood species, it might be necessary to have a small saw or stickering jig dedicated for this use, at least for a high production mill. This might cost around $500 (Senerchia, 1997). The cost and/or need for a drying shed is so variable, that no dollar estimate is provided.

7.4.5.2. Kiln-drying. Seven kinds of kiln-drying methods are described in Section 8.3.3.2.; namely, solar, steam heated, hot water, dehumidification kilns, vacuum, radio frequency, and microwave. Only reference to equipment for solar and dehumidification kilns are covered in this Section.

- **Solar kilns:** The cost for a solar kiln can range from a few hundred dollars for a homemade unit to over $1,700 for a Wood-Mizer Solar Dry™ kiln. Solar kilns are certainly good for some lumber drying requirements and as a complement to conventional kilns, but they don't readily reach the 150^{o}F needed to kill some wood insects and diseases. Consequently, specific cost information isn't provided in this report.

- **Dehumidification kilns*:** Several brands and sizes of dehumidification kilns are available commercially. Only the price for a couple of kilns is presented here, and reference to these and other kiln manufacturers are given in Section 8.3.3.3.

	Estimated cost Used	New
■ **Nyle:** Low Temperature Kiln (120° F), Model L-50 (dries 500-1,000 bd. ft.), 1/2 h.p., dehumidification system includes fan, heater, (Does not include kiln structure.)	N/A	$2,260
■ **Nyle:** Low Temperature Kiln (120° F), Model L-200 (dries 1,500- 3,000 bd. ft.). Similar to Model L-50.	$2,800	$3,450
■ **Nyle:** High Temperature Kilns (160° F). Sizes range from 3,000 to 24,000 bd. ft. for softwoods and double that volume for hardwoods.		
- Model L-300 (300 to 6,000 bd. ft.)	N/A	$9,450
- Model L-2500 (24,000 to 45,000 bd. ft.)	N/A	$32,500
■ **Ebac:** LD 3000, operating temperature 140° F, 3,000 bd. ft. capacity.	$2,250	$3,200
■ **Ebac:** Model MF2, 3,000 bd. ft. capacity, temperature to 140°F.	$4,500	$6,300
■ **Ebac**: Model MF4, 10,000 bd. ft. capacity.	N/A	$10,000

(***Sources:** Nyle Dry Kiln Systems, Ebac Lumber Driers, and TMS Machinery Sales)

7.4.5.3. Moisture meters. Moisture meters are essential for determining the moisture content of lumber. Meters range in price from $150 to $1,500. They are available from most kiln manufacturers, general supply catalogues, and from specific manufacturers. See Section 8.3.3.4. for a brief description of moisture meters and other meter sources.

7.4.6. Lumber finishing.

Planing or sanding rough lumber may be part of a milling operation, with planing the more common of the two. Hessenthaler (1997b) uses a special thirty-six-inch wide dual head abrasive/planer wide-belt sander for figured wood that might be ruined by planing due to the irregular grain pattern common for this type of wood. Like the other equipment, both planners and sanders are available in a wide variety of sizes.

7.4.6.1. Planers. Planers range in size from 12-inch bench models to those handling lumber more than 40 in. wide. Bench-size planers handling up to 12.5-inch boards cost around $400 new, but are probably not adequate for a milling operation. Planers are sold by a number of wood machinery manufacturers.

	Estimated cost Used	New
• **Planers*** .		
■ **Delta**: DC-380, 15-inch, 2 h.p., 230 V., cuts stock up to 6.5 in. thick.	N/A	$1,200

	Used	New
■ **Woodteck ®**: 20-inch, 3 h.p., 230 V. cuts stock up to 8 in. thick.	N/A	$1,500
■ **Crescent Planer:** 24-inch, 10 h.p., 4 knives.	$6,500	N/A

(***Sources:** Woodworkers Supply and TMS Machinery Sales)

7.4.6.2. Sanders. An industrial-size sander may be a suitable type of finishing equipment for an urban custom mill that routinely produces figured wood.

• **Sanders*.**

	Estimated cost	
	Used	**New**
■ **Woodtek:** 13-inch wide belt sander, 5-inch maximum stock thickness by 12-inch width, 3 h.p., single phase, 1,720 r.p.m.	N/A	$1,150
■ **RYOBI:** 16-inch drum sander, stock thickness to 3 in, maximum, 1 h.p. 1720 RPM.	N/A	$570
■ **Dankaert:** 42-inch contact roll and pad, 40 and 20 h.p.	$5,800	N/A

(***Sources:** Woodworkers Supply and TMS Machinery Sales)

7.4.7. Mill facilities.

Even a small one- to two-man milling business will need adequate space for log storage, milling, lumber drying and storage, residue accumulation, and office space. Secondary manufacturing, if any, and a retail sales operation would require additional space. Because individual requirements and preferences, land and facilities availability, and cost are going to be so variable among businesses, it's difficult to give specific size and cost estimates for any of these items. Log storage, lumber drying, and residue accumulation will probably require an area of at least 1 to 1.5 acres

For example, D. Seawater's current Pacific Coast Lumber sawmill operation is on a 1.5 a. site which seems to be adequate for two outside mills, log and lumber storage, etc., and rent is about $1,000/month. He also rents an adjacent 30 x 50 ft. bay in a small industrial building that costs an additional $600/month. Included in this area is a 12 x 20 ft. office and some limited space for lumber storage, plus some woodworking equipment (e.g. table saw). About 1/3 of the area is used for the assembly and storage of his Adirondack chairs.

Adequate utilities are another important factor and include water, phone, and electrical service. There should be both 110 and 230 v. circuits available, and some heavy equipment might even require 460v. Utilities cost D. Seawater about $160 per month and his electric bill will go up, perhaps $20-30/mo. with his kiln.

Although not part of the business facilities per se, there are some governmental requirements that must be considered. For example, the area has to be properly zoned for a mill operation.

This would have to be checked through the local authorities along with the need for any additional business, environmental, or other operating permits.

7.5. SETTING UP A SAW MILL OPERATION.

In Section 7.1.14., Business Goals and Objectives, three types of mill operations were described. Specific information about the equipment requirements, costs, etc. for setting up the following two types of urban sawmill enterprises are presented in this section:

1. A portable (mobile) sawmill where lumber is cut for others. In this setup, the mill is moved to a log site and the lumber produced is usually left on site for the log owner.

2. A custom sawmill operation at a “permanent” location where lumber is cut for others and for sale. Even though a portable mill is used, it is left at a permanent site where there is room for log storage, milling, lumber drying and storage, and sales.

7.5.1. Sawmill Cost Centers.

Various sawmill operations or cost centers were identified by the Sierra Resource Group (1997), and those for a potential urban sawmill operation were noted in Section 7.3.2.1. These cost centers and their relevance to the two types of sawmill operations described here are listed in **Table 7.3.** The mobile operation is extremely flexible and requires fewer processing steps, less equipment, and less time dedicated to the mill’s final product, namely lumber. Getting to the log site and milling logs are the basic requirements for this type of operation. On the other hand, permanent mill operations involve all of the cost centers, except secondary manufacturing which is not considered in this example.

7.5.2. Pros and Cons for Mobible vs. Stationary Mill Operations.

There are advantages and disadvantages for both sawmill operator and the log owner that should be evaluated if one is thinking about establishing an urban sawmill business. Some of the positive and negative aspects of a mobile milling operation are included in the following list:

Positive: Log owner -- doesn’t have to transport logs to the mill and lumber back to his site.
-- gets to keep slabs, etc. for firewood.

Miller -- no log transport or log transport equipment.
-- no rent for a mill site.
-- no drying or finishing equipment.
-- great flexibility.

Negative: Log owner -- gets rough, unfinished, green lumber.

Miller -- less productive than a stationary mill (time spent on moving and setup). Possibly 20% less productive according to Watt (1998).

-- potential damage to equipment when moving to and from a site.

-- normally makes less income (Watt, 1998).

-- may not be suitable for an urban site where milling would be inappropriate or illegal.

Table 7.3. Cost centers for two types of urban sawmill operations

Cost center	Sawmill operations	
	Mobile	Stationary
1. Log acquisition and transport	+ / - [1]	yes
2. Log storage, handling, and delivery to saw	N/A [2]	yes
3. Primary breakdown (resawing optional)	yes	yes
4. Secondary breakdown (edging, trimming)	+ / -	yes
5. Air drying	+ / -	yes
6. Kiln drying	N/A	yes
7. Finishing	N/A	yes

[1] +/- means that this cost center may or may not be a factor. The flip side of the above pros and cons for a mobile mill operation are generally true for a permanent setup.
[2] N/A = not applicable for this operation.

7.5.3. Mill Operation Assumptions.

A large number of factors are involved in every sawmill business. Where possible, the same scale or factor size is used for both types of mill operation described here. All of the assumptions used for the mill setup calculations are listed in **Table 7.4** . Keep in mind, the specific values or rates for a particular milling operation can vary greatly from those used in these examples. And, the values presented will have to be modified for a different set of assumptions.

7.5.3.1. Milling charge per hour vs. charge per board foot. The cost to a customer for milling lumber can be assessed three ways (Watt, 1998), e.g. on a per hour or per MBF basis and by bartering. Only the first two methods are considered in this report, and each has advantages and disadvantages for miller. Some of these advantages/disadvantages are as follows:

Sawing by the board foot :

- **Positive** -- Less pressure on the miller to do the job; most common method used; and most customers familiar with it.
- **Negative** -- Because time not a factor, logs owners more inclined to supply dirtier, more crooked, and smaller logs than when they pay by the hour.

-- Also, owners are less likely to help move logs, deal with slabs, etc.

Sawing by the hour:

- **Positive** -- Buyer inclined to supply good logs free of dirt and larger and straighter logs. This results in greater production per hour.
- **Negative:** -- Pressure to work at a faster pace.
  -- Log owners won't know what they will have to pay until the job is done.

Although these factors may be of minor importance in most sawmilling jobs, it is a good idea to be aware of the potential consequences of the different payment methods.

Table 7.4. Assumptions used for estimating the cost of setting up and running two types of urban sawmill businesses

Assumptions	Type of mill operation	
	Mobile	Stationary
1. Number of milling days/yr.	200 days	220 days
2. Number of days maintenance, log acquisition (plus moving and setup for the mobile mill)	50 days	30 days +
3. Milling rate (average)	750 bf. ft/day	1,000 bd. ft/day
4. Charge for cutting 1 MBF	$500/MBF	$500/MBF
5. Charge per hour	$47/hour	$60/hour
6. Log resource availability	Unlimited	Unlimited
7. Log cost (permanent mill only)	N/A	$50/MBF
8. Lumber recovery rate at 50%	6 bd. ft/ft^3	6 bd. ft/ft^3
9. Average selling price/MBF for 4/4, rough, green lumber (1/2 hardwood - 1/2 softwood).	$500/MBF*	$500/MBF*
10. Average selling price/MBF for 4/4, Kiln dried S2S lumber (1/2 hardwood - 1/2 softwood)	N/A	$900/MBF*
11. Interest rate for RMDZ loan for 10 yr.	5.7%	5.7%
12. Interest rate for commercial loan for 8 yr.	12%	12%
13. Interest rate for return on private loan to to mill for 8 yr.	10%	10%
14. Kiln cost/MBF**	N/A	2.5% of sales
15. Payroll taxes (social security, Medicare, state/federal taxes, workers comp.)**	27% of payroll	27% of payroll
16. Depreciation, straightline for 10 yr.	10%/yr	10%/yr.

17. Insurance (general)**	1.2% of sales	1.2% of sales
18. Taxes (federal and state)**	1% of sales	1% of sales

*Lumber prices vary greatly depending on grade, species, and moisture content. These are average values for "mill run" grades of California black oak (Hall, 1998). The same price/bd. ft. is assumed for both hardwoods and softwoods.
**Based on Hall (1998).

7.5.4. Start-up Costs. Essential equipment and its estimated cost for a mobile and a Stationary urban sawmill are listed by cost center in **Table 7.5.** The total estimated start-up costs for a mobile and a stationary urban sawmill operation are $48,000 and $101,500 respectively.

Table 7.5. Start-up costs -- equipment and supplies for a mobile and a stationary urban sawmill business

Cost center	Equipment			
	Mobile mill		Stationary mill	
	Item	Cost ($)	Item	Cost ($)
1. Log acquisition and transport	Falling/bucking	$1,500	Falling/bucking	$1,500
	Pickup (used)	$13,000*	Flatbed truck (3T) (used)	$15,000*
	Log wenching system	$2,500*	Crane truck (used)	$25,000*
2. Log storage, delivery to saw	N/A	N/A	Fork lift 10-12M lbs. (used)	$10,000*
	N/A	N/A	Chain saws (2)	$1,000
	Scaling equipment	$50	Scaling equipment	$50
3. Primary breakdown	Wood-Mizer Super Hydraulic LT40HD40	$28,000*	Wood-Mizer Super Hydraulic LT40HD40	$28,000*
	Saw blades 1.25 X 0.034 X 158 in. (15) all purpose	$240	Saw blades 1.25 X 0.034 X 158 in. (15) all purpose	$240
	Blade sharpener Wood-Mizer	$1,840*	Blade sharpener Wood-Mizer	$1,840*
4. Resaw	N/A	N/A	N/A	N/A
5. Secondary breakdown	Edging (Set boards on edge, mill for width)	N/A	Edger, Delta table saw	$1,700*
	Trimming	N/A	Trimming, radial arm saw, 12 in.	$1,200*
6. Lumber drying	N/A	N/A	Nyle dry kiln, L300	$9,250*
	N/A	N/A	Kiln chamber refrigerator trailer	$3,000*
7. Finishing	N/A	N/A	Planer, Woodteck, 20-inch planer	$1,500*

8. Miscellaneous including license	Tools, files, gas cans, etc.	$820	Tools, files, gas cans, etc.	$2,170
Total estimated equipment start-up costs:		$48,000		$101,500
*Items depreciated --	Total:	$45,340		$95,510

Loan information was listed in **Table 7.4.** The total start-up cost annual annuity for principal and interest is calculated as follows:

1. One half of the cost for each type of mill will be financed by an RMDZ Loan (Section 7.3.5.1.). This is calculated as ten-year loan at 5.7%/yr.
2. One quarter of the start-up costs by a bank loan for eight years at 12%/yr, and
3. One quarter with personal savings. Expected return on private loan at 10% for 8 yr.

7.5.4.1. Mill start-up financing . The annual interest payments (a) for financing a mobile and a stationary sawmill is calculated using the following formula:

$$a = [i(1 + i)^n/(1 + i)^n - 1]P$$

Where: **i** = interest rate; **n** = loan period; **P** = principal or loan amount.

The annual loan payments for principal and interest for the mobile and stationary custom sawmills are listed in Table 7.6. The total annual loan payments for mobile and stationary mills are $7,875 and $$16,700 respectively.

Example: Annual payment for the RMDZ loan for 50% of total start-up costs for the mobile mill is as follows:

$$a = [i(1 + i)^{10}/(1 + i)^{10} - 1]P; \quad i = 5.7\%; \quad n = 10 \text{ yr.}; \quad P = \$48,000/2$$

$$a = [0.057(1 + 0.057)^{10}/(1 + 0.057)^{10} - 1] \times 24,000$$

$$a = [0.057(1.74)/(1.74) - 1] \times 24,000 = [0.099/0.74] \times 24,000$$

$$a = 0.134 \times 24,000 = \underline{\$3,216/\text{yr.}}$$

Table 7.6. Annual principal and interest payments by type of loan for start-up costs for a mobile and a stationary urban, custom sawmill business[1]

Type of loan	Type of milling operation	
	Mobile	Stationary
A. RMDZ Loan: 1. 50% of start-up cost 2. Interest at 5.7% 3. Loan term = 10 yr.	$3,216	$6,800
B. Bank loan: 1. 25% of start-up cost 2. Interest at 12% 3. Loan term = 8 yr.	$2,408	$5,092
C. Personal investment:	$2,253	$4,763

1. 25% of start-up cost		
2. Interest at 12%		
3. Loan term = 8 yr.		
Total annual finance cost =	$7,875	$16,700

[1]Total initial start-up costs are $48,000 and $101,500 for the mobile and stationary mills respectively (see Table 7.5.).

In summary, based on the financial assumptions presented above, the annual financial cost for the interest and principal for the total start-up cost for the mobile and stationary urban sawmill operation are $7,900 and $16,700 respectively. They are considered to be fixed costs in the Profit and Loss information presented later in this section.

7.5.5 Operational Costs.

For simplicity, operating costs as described in this section are a combination of fixed costs (costs that occur whether milling lumber or not) and variable costs (costs directly related to lumber production). Examples of both of these types of costs are shown in **Table 7.7.** Sherill et al. (1997) estimated that direct costs for producing green lumber from urban sawlogs was about $0.50 to $0.75/bd. ft. Hall (1998) indicated that the production of

Table 7.7. Typical variable and fixed costs expected in an urban sawmill operation[1]

Variable costs	Fixed costs
Log cost (plus acquisition)	Depreciation
Payroll (salaries and wages)	Insurances (general, health, life)
Payroll taxes	Payroll taxes and workers comp.
Gas - oil	Rent
Vehicle mileage	Taxes (state and federal)
Vehicle maintenance	Telephone and utilities
Kiln charges	Licenses
Utilities	Principal and interest payments
Supplies	Salaries
Miscellaneous	Miscellaneous

[1]Cost items are based on information in Table 7.1. (Cash flow forecast), & Hall (1998)

KD S2S California black oak lumber by a hypothetical "large mill" to be $0.78/bd. ft. Almost half of the production cost (i.e. 48%) or $375/MBF was for log acquisition, $99/MBF (13%) was for milling rough, green lumber, and $149/MBF (19%) was for processing rough, green lumber into kiln-dried S2S lumber. The latter includes the cost for drying, and losses due to degrade during drying, and for shrinkage. In regard to log cost, it is not expected to be a major part of an urban mill's operating expenses; and in some situations, a mill may be paid to take logs that would otherwise be expensive to dispose. Therefore, in the following calculations, log cost is assumed to be only $50/MBF or about 5% of the total operating cost.

Hall also reported a "rule of thumb" for estimating direct non-payroll costs. Milling costs are a combination of payroll costs (PC), benefit costs (BC), and other direct non-payroll costs (NPC). BC costs were estimated to be 44% of the payroll cost. And, NPC were estimated to be equal to 1/2 of the payroll + benefits costs. In other words, the total cost of producing rough, green lumber =

$$PC + 44\% \text{ of } PC + 50\% \text{ of } (PC + BC) = 2.16(PC).$$

Hall also estimated that general and administrative costs (i.e. fixed costs) equal to 14% of its selling price. We don't know how appropriate Hall's values would be for an urban custom mill, but they provide a good reference point.

The individual monthly and annual cost per item or activity for both a mobile and a stationary urban sawmill operation are shown in **Table 7.8** and are briefly described as follows:

- **Log cost** - The assumption used in this report is that most urban logs are going to be free. However, a small cost, i.e. $50/MBF, is included for minor log purchase. This amounts to $50/MBF X 220 MBF/yr. = $11,000/yr.

- **Gas/oil** - This cost is for gas/oil for all saws and non-road equipment use, eg. forklift and any other non-travel requirements. Although the values used are arbitrary, they are generally based on current milling operations. Gas/oil for the mobile and stationary mills are estimated to be around $85 and $150/mo. respectively.

- **Mileage** - This cost is for gas/oil use by mill vehicles for travel to a milling site, log acquisition, etc. It's estimated to be 25¢/mi. for 20,000 miles for the urban mobile sawmill ($3,000/yr.) and for 30,000 mi. for the stationary sawmill ($7,500/yr.).

- **Vehicle maintenance** - Good vehicle maintenance is essential for a continuous mill operation. And, like gas/oil, is generally based on current milling operations. The monthly estimated cost for the mobile mill is $250/mo., and it is $500/mo. for the stationary mill.

- **Utilities** - A token monthly utility cost is assigned to the mobile mill operation for phone calls and other minor utility expenses. The $500/mo. cost assigned to the stationary mill is based on Pacific Coast Lumber's mill operation.

- **Kiln costs** - Kiln drying is not part of the mobile sawmill operation; so, there are no monthly utility charges. Kiln use adds another $400/mo. to the stationary mill's cost of operation. Hall (1998, p. 194) estimated kiln costs to be ca. 2.5% of gross profit.

- **Payroll costs** - Payroll costs are based on 250 work days/yr. @ 8 hr./day (or 2,000 hr./yr.). Earnings or payroll costs for the mobile mill owner/operator are estimated to be $32,000/yr. The operator is also earning 10%/yr. on the 25% investment in the mill business and any net income above operating costs.

The three-person payroll for the stationary mill is broken down as follows:

Helper @ $10/hr. X 2,000 hr. =	$20,000/yr.
Assistant @ $14/hr. 2,000 hr. =	$28,000/yr.
Owner @ $16/hr. X 2,000 hr. =	$32,000/yr.
Total payroll for stationary mill =	$80,000/yr.

Table 7.8. Combined variable and fixed costs for a simplified profit and loss estimate for a mobile and a stationary urban, custom sawmill enterprise

Cost items[1]	Estimated expenses			
	Mobile mill (1-person)		stationary mill (3-person)	
	Monthly	Annual	Monthly	Annual
Logs ($50/MBF)	N/A	N/A	$920	$11,000
Mileage (20,000/30,000 mi. @ 25¢/mi.)	$420	$5,000	$625	$7,500
Vehicle maintenance ($250/ $500/mo.)	$250	$3,000	$500	$6,000
Gas/oil ($1,000/$1,800/yr.)	$85	$1,000	$150	$1,800
Utilities ($30/$500/mo.)	$30	$400	$500	$6,000
Kiln (2.5% of net monthly sales)[2]	N/A	N/A	$400	$4,800
Payroll ($2,670/$6,670/mo.)	$2,670	$32,000	$6,665	$80,000
Payroll taxes (27% payroll)[2]	$720	$8,600	$1,800	$21,600
Principal and interest (See Section 7.5.4. & Table 6)	$660	$7,900	$1,390	$16,700
Depreciation (10% straightline)	$375	$4,500	$800	$9,600
Rent ($50/$1,500/mo.)	$50	$600	$1,500	$18,000
Insurance (1.2% of monthly sales income)[2]	$80	$1,000	$190	$2,300
Taxes (1% of mo. income)[2]	$60	$800	$160	$1,900
Miscellaneous	$50	$600	$75	$900
Total estimated costs for 1st year =	$5,450	$65,400	$15,675	$188,100

[1]First and second items in parentheses refer to a mobile & a stationary business respectively.
[2]Based on information by Hall (1998).

- **Payroll burden (Taxes)** - The payroll burden is calculated as a percent of gross pay. It is based on Hall's (1998) theoretical proforma for a hardwood lumber business and is broken down as follows:

  I. Social security, Medicare, and state/federal taxes = 13% of payroll

  2. Workers compensation = 14% of payroll.

  This amounts to a total of 27% of payroll and for the:

  Mobile sawmill = $32,000 X 0.27 = $8,600/yr., and
  Stationary sawmill = $80,000 0.27 = $21,600/yr.

  Note: Hall lists an additional 17% of payroll for health insurance, pension plan, and vacation leave as additional payroll burden that are not included in this study's calculations.

- **Principal and interest** - The equipment and supplies required to start-up either a mobile or stationary location urban sawmill are listed in **Table 7.5.** And, the annual cost for principal and interest payments were listed in **Table 7.6.** The annual cost for the principal and interest for the mobile and stationary mills is $7,900 and $16,700 respectively.

- **Depreciation** - under today's income tax code, depreciation is calculated using specific I.R.S. guidelines. In lieu of these guidelines, depreciation is here assumed to be on a straight-line basis at 10%/yr. for 10 yrs. Under this assumption, annual depreciation for the mobile and stationary sawmills are $4,500 and $9,600/yr. respectively. The total amounts being depreciated are listed at the bottom of Table 7.5. and are $45,300 for the mobile mill and $95,500 for the stationary mill.

- **Rent** - The monthly rent for a given urban sawmill business will vary tremendously from situation to situation depending on location, size, facilities available, etc. The rent used in these calculations is assumed to be token amount of $50/mo. for the mobile mill, possibly for equipment storage, etc. The $1,500/mo. for the stationary mill is based on the amount paid by Pacific Coast Lumber.

- **Insurance** - General insurance (excluding health and life insurance) is assumed to be 1.2% of the monthly sales income as per Hall (1998) for Cal Oak's 1985 income statement. Insurance is estimated to be $80 and $190/mo. for the mobile and stationary sawmill respectively. (See income information in 7.5.6. the next section.)

- **Taxes** - Hall (1998) indicated that a small cost for taxes and licenses amounts to 1% of the total monthly income (see Hall p. 194). This is 1% of $6,250 (See income information in 7.5.6. the next section.) or $63/mo. for the mobile mill and 1% of $15,625 or $156/mo. for the stationary mill.

- **Miscellaneous** - Arbitrary amounts of $50/mo. for the mobile mill and $75/mo. for the stationary mill have been assigned for the cost of miscellaneous items , e.g. paper, nails, and other minor items.

In summary, the total annual monthly and annual expenses for the mobile and stationary mills are as follows:

	Total expenses	
	Monthly	Annual
Mobile sawmill	$5,450	$65,400
Stationary sawmill	$15,675	$188,100

7.5.6. Gross First-year Income.

The estimated first-year annual gross income for both a mobile and a stationary urban sawmill operation are shown inn **Table 7.9.** The one-person mobile business assumes that out 250 working days per year, 200 days involve milling; and, 50 days are spent for maintenance, locating milling customers, and moving to a new mill site. On the average, 750 bd. ft. are expected to be cut each day for a yearly production of 150MBF of green, rough lumber. Payment for milling is based on two methods, i.e. on an hourly basis at approximately $47/hour, or on the amount of lumber cut, in this example at $500/MBF. Annual gross income was $75,000 for either method of payment.

The estimated annual gross income for the three-person stationary sawmill at $188,100 is about 2 1/2 times greater than that for the mobile mill (**Table 7.9** .). However, start-up costs are more than double for the stationary mill at $101,500, and the entire operation, especially kiln drying, is much more complex than a mobile mill cutting for others. Note: The annual income calculations here assume that a year's lumber production can be cut, dried, and sold within one year. It will actually take longer because drying and selling the twelfth month's production will carry over into the following year. However, on an ongoing basis, these annual estimates should be correct.

Table 7.9. Estimated gross annual income for the initial year of operation for a mobile and a stationary urban sawmill business

Payment basis	Daily production	Yearly production	Income per work unit	Gross annual income
Mobile sawmill business (based on 200 cutting days/yr.)				
$/bd. ft.	750 bd. ft.	150MBF	$500/bd. ft.	$75,000
$/hour	8 hrs	1,600 hrs.	46.88/hr.	$75,000
Stationary location business (based on 220 cutting days/yr.)				
$/bd. ft. for:				
Green, rough	1,000 bd. ft	220MBF	$500/bd. ft.	$110,000
KD S2S	950 bd. ft	209MBF[1]	$900/bd. ft.	$188,100

[1]This assumes a 5% reduction in volume for loss to shrinkage during drying (Hall, 1998)

For simplicity, there are some cost factors that were partially or not included in the annual sawmill income estimates in Table 7.9. Some of these assumptions are as follows:

It was assumed that the drying and planing of lumber cut during the year can be processed and sold the same year. However, the lumber cut the last part of the year will have to be dried and planed the following year.

· It was assumed that all of the lumber produced was of high enough quality to be kiln dried. Hall (1998) indicated that only the #2 Common and higher grades would be kiln dried; consequently, up to 40% of the average mill run of lumber production may not be dried.

· It is assumed that half of the lumber production will be from coniferous species and the $900/MBF reflects an average price for all kiln-dried, S2S lumber.

7.5.7. Cost and Profit of Dealing with Mill Residue.

One of the major by-products of milling lumber is the wide assortment of different size woody residue that is produced. Hall (1998) estimated that 3.6 T. of woody residue were produced for each MBF of lumber milled as follows:

Residue category	Tons/MBF	Percent of total residue
Pulp-chips	1.52 T.	42.2%
Fuelwood (16-in.)	0.72 T.	20.0%
Fuel (sawdust, shavings, etc.)	1.36 T.	37.8%
Total woody residue:	3.60 T.	100.0%

Dealing with this woody residue can either be a big financial burden of an important source of income.

Assuming that mill production is 220 MBF/yr. and at 3.60 T. of residue/MBF, then the annual residue production is estimated to be 792 T./yr. NEOS Corp. (1994) reported that the average western landfill disposal costs were ca. $30/T. If all of the residue were dumped at a landfill, it could cost around $23,760 (792 X $30/T.). This would be a very high business expense for a small mill operation. Although this is not likely to happen, there is still an expense if only a part of the residue had to be dumped.

On the other hand, if 20% of the mill residue were sold for firewood, and the remaining 80% given away (possibly sold) for compost, mulch, animal bedding material, etc., a significant profit should be realized just from the firewood alone. Hall (1998) estimated that 0.26 cords of oak firewood were produced for each MBF of lumber produced. The ratio of cords to MBF can be almost double for coniferous species, but it's usually worth less per cord. Hall estimated that 66% of the firewood production costs were borne by the milling operation. If the retail price was $150/cord, the net profit would be $100/cord, and annual production would be 57 cords (220MBF X 0.26 cords/MBF). Therefore, total net income for firewood sales would be $5,700 (57.2 X $100/cord). An effective sales program, where all of the residues are marketed would obviously produce even greater profit. Hall also reported that he expected all milling residues to be worth about $81/MBF of lumber produced. However, he did have a very ambitious firewood marketing program.

7.5.8. Summary of Start-up Costs and One-year Profit and Loss Estimates.

A summary of the estimated start-up costs for a mobile and a permanent urban, custom sawmill operation and the expected profits and losses are shown in **Table 7.10.** All of these values can vary greatly from one milling operation to another (depending on a variety of assumptions), and they are provided only as a general guide to urban sawmill economics.

Table 7.10. Urban sawmill start-up costs and first-year annual profit and loss estimates

	Sawmill operation	
Factor	Mobile mill	Stationary mill
Start-up costs	$48,000	$101,500
Gross income		
Rough, green lumber	$75,000	($ 110,000)
Kiln dried, S2S lumber	N/A	$188,100
Operating costs	$65,400	$188,100
Net income	$9,600	$0.00
Residue income	N/A	$5,700
Total potential net income:	$9,600	$5,700

8.0. MANUFACTURING TECHNIQUES AND QUALITY CONTROL.

Quality should be a prime consideration every step of the way, from harvesting a tree to drying the lumber (Shelly, 1995). Urban trees present definite manufacturing challenges. However, there are techniques that can be used to minimize the problems and maximize the quality of the lumber produced. The following discussion refers specifically to the manufacture of lumber for high value uses, but many of the same ideas can be applied to the lower value uses. A basic knowledge of wood behavior and processing techniques are important tools to minimize the problems associated with lumber production from urban trees. Processing lumber involves four basic steps: log preparation and harvesting, milling, drying, and quality assessment.

8.1. LOG PREPARATION.

8.1.1. Tree Selection, Harvesting, and Log Production.

It is important to recognize the utilization potential of trees before they are cut. Some trees will have very little lumber potential and when removed should be used as firewood or other low value product. Some of the factors to consider when choosing trees for cutting were covered in the "Trees to Furniture" bookelet by Sherrill, et al. (1997) and are listed in the following box.

FACTORS TO CONSIDER WHEN CHOOSING TREES FOR CUTTING[1]

- **Old logs are hard to cut** -- Logs already on the ground, if not rotted, may be very hard to cut it they've dried considerably. If possible, find out how long they've been cut.
- **Look for consistency in log size** -- Large-diameter logs may take extra effort and time to handle, and very small logs may take too much handling to be worth the time.
- **Look for clean logs** -- Logs coated with mud and/or rocks will have to be cleaned or debarked which will take extra time, otherwise the sawmill's blade will quickly dull which will cost you money.
- **Bulk is cheaper** -- Costs per board foot are lower for a large job where fixed costs are spread over more units of production.

[1]Adapted from "Trees to Furniture" by Sherrill et al., 1997.)

Of the trees that are selected to be processed for lumber, it is important to cut log lengths that maximize the amount of highest quality lumber. This means cutting to lengths that maximize straight grain and minimize the presence of knots or other defects such as decay or insect damage. Some suggested methods for properly manufacturing sawlogs were illustrated by Cesa et al. (1994) and are shown in **Appendix Q** . For urban hardwoods this often means short log lengths of 6 feet, or if your sawmill can handle it, even 4 feet. The trade-off is that processing short logs dramatically increases your operating costs because you have more logs to handle. Cesa et al. (1994) provide the following size requirements for ranking sawlogs:

Rank	Log description	
Best	Diameter - Length -	16 in. or larger at small end of log. 8 ft. or longer.
Good	Diameter - Length -	14 in. or larger at small end of log. 8 ft. or longer.
Fair	Diameter - Length -	12 in. or longer at small end of log. 6 ft. or longer.
Poor	Small in length and diameter; or large with many knots, branches, rot, or cracks; or with large or numerous metal objects.	

However, remember that there will usually be exceptions to a general ranking system. Short or small logs with highly figured wood may be more valuable than larger logs lacking figure and with defects.

8.1.2. Log Storage.

If logs must be stored for more than a couple of weeks, it is necessary to take precautions to minimize the amount of degradation that can occur to the wood. The three mechanisms by which logs deteriorate include drying, insect attack, and fungi attack.

Logs begin drying as soon as the tree is cut, especially from the ends. As the logs dry, the wood near the exposed surfaces begins shrinking and drying checks develop. Bark on the logs slows down the drying process but often when logs are transported sections of bark are knocked loose, exposing raw wood that begins drying and checking.

Numerous wood-boring insects use wood for food or shelter. Some prefer living trees or fresh logs and some prefer dry wood. Because insect damage is usually most prevalent in the outer portion of a log, where the highest grade lumber is usually found, insect populations that are not controlled can lead to serious reduction in the value of the wood produced from infested logs.

Fungi can also cause many defects in stored logs. A group of stain fungi can quickly inoculate exposed sapwood and penetrate deep into logs, feeding on the parenchyma cells that contain stored food. These stain fungi can cause serious blue and brown staining throughout the logs in a matter of months. However, some staining, e.g. blue stain, does not physically degrade the strength properties of the wood, but primarily affects its appearance. Another group of fungi, decay fungi, actually feed on the wood cell walls, completely destroying the wood they feed on. These decay organisms work slowly but can cause major damage to stored logs, especially the sapwood.

One control method actually works in minimizing all three degradation mechanisms. Water is the answer. Keeping logs wet, for example under a water spray, retards or stops drying, provides too much water for successful insect establishment and survival, and minimizes the amount of oxygen available to stain and decay fungi, slowing down their growth. The rate at which logs deteriorate is a function of temperature and humidity. They deteriorate more slowly during the cold winter months and rainy weather. Under proper conditions, most logs can be stored for at least a year without significant degradation if the following steps are followed:

1. Seal the ends of the logs with a wax-based end seal as soon as they are cut. (See Section 7.4.2.2. for information about sealers.)
2. Keep the logs wet.

8.1.3. Dealing with embedded Materials.

It's already been noted (Sections 6.2.2.4. and 7.4.2.3.) that metal and other embedded objects can cause serious injuries to personnel and damage to equipment (**Figure 8.1.**).

Figure 8.1. Wire is one of the more common embedded materials found in the trunks of trees removed from rural roadsides. In this example, the wire is easily detected. When an object is completely embedded, the only visible indicator may be a dark stain at the end of the log.

Hall (1998) noted that Cal Oak's policy was that no log that was suspected of containing metal should reach the headrig. He also noted that where a log comes from can also be a clue to potential embedded objects, e.g. along fence of utility lines, near old buildings, etc. Consequently, urban trees would rank high in the potential risk category. Hall also indicated that metal detectors help locate metal objects, but: "--our experience is that they often do not penetrate over 6 in." A complete discussion about how to deal with metal and other embedded objects is given by Cesa et al. in **Appendix N** .

8.2. MILLING TECHNIQUES.

The primary goal of any sawmilling operation should be to produce the greatest number (maximum yield) of uniformly thick, high quality boards possible in each log. To maximize yield, it is important to carefully select a rough/green thickness and to remove as little waste wood as possible when squaring up a round log. The rough/green thickness must take into account the amount of thickness reduction due to planing (about 3/16 inch), and the loss to shrinkage when the board is dried (about 5%). As an example, to produce a surfaced, 1-inch-thick, kiln dried board the rough/green thickness should be 1.25-inch (0.19-inch planing allowance +0.06-inch shrinkage allowance). To maximize quality, it is helpful to visualize how the boards can be cut from a log before sawing it into lumber. In most cases, the highest quality boards will be obtained by positioning the log so that the knots are positioned on the edges of a board so that they can be removed by edging the lumber. Of course, this rule does not apply if a niche product is desired which highlights grain deviations and small, tight knots.

8.2.1. Flat-Sawn versus Quarter-Sawn.

An important milling decision is whether to maximize flat-sawn or quarter-sawn boards (**Fig. 8.2.**). The wide surface of a flat-sawn board exhibits a wood surface that approximates the tangential aspect (tangent to the growth rings) and the wide surface of a quarter-sawn board approximates the radial aspect. Quarter-sawn boards are more dimensionally stable than flat-sawn boards because the widest dimension of the board exhibits dimensional change in the radial dimension which is about one-half of the dimensional change in the tangential direction (the wide face of a flat-sawn board). Although flat-sawn boards exhibit more dimensional change in the wide surface, the trade off is that they offer a more interesting appearance (more character and figure), because of the way the growth rings are exposed on the flat-sawn surface.

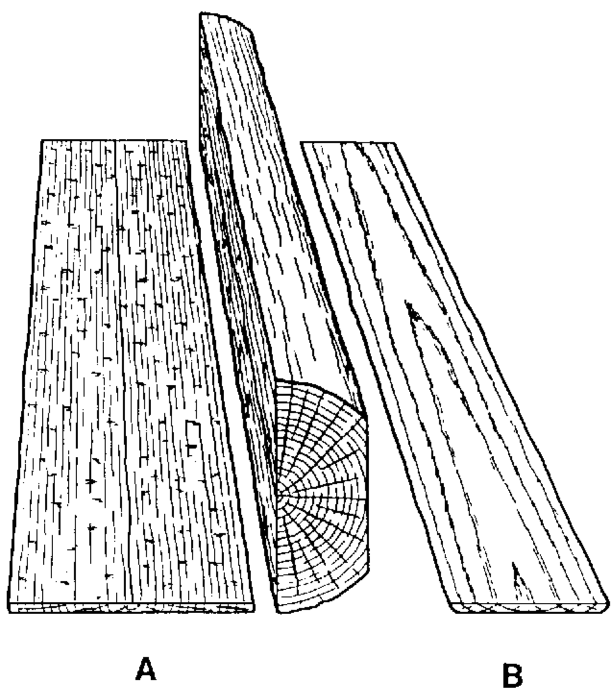


Fig. 8.2. An example of quartered (A) and plane sawed (B) boards cut from a log. (U.S. Forest Products Laboratory, 1974).

Quarter-sawn material is desired for certain uses. For example, it is often preferred in hardwood flooring because it is less sensitive to the humidity fluctuations that often occur in structures and therefore it is more dimensionally stable. Another example is barrel staves for the tight cooperage (barrels) that is used in wine and whisky industry. Quarter-sawn wood is less permeable across its thickness than is flat-sawn wood because the orientation of the permeable ray cells are parallel to the wide face of a quarter-sawn board and thus are not a conduit for fluid flow across the thickness. Because a log is round, very little true flat-sawn or quarter-sawn lumber is normally produced; most lumber is something in between. During the normal course of log breakdown, most lumber will approach the appearance of flat-sawn. Special attention to the position of the grain with respect to the wide face of the lumber is required if the production of quarter-sawn lumber is to be maximized. One tried-and-true method is to cut the log lengthwise into quarters, then saw lumber alternately from each exposed quartered face.

8.3. LUMBER DRYING.

For all of the same reasons discussed in Section 6.2.3. "Wood Characteristics", lumber produced from urban trees is a challenge to dry. Little experiential knowledge exists for drying many of these species, but with an understanding of basic wood properties and proper care good results can be obtained. For example, the same lack of experience exists for many native California hardwoods, and they have a reputation for being hard to dry. However, as discussed by Shelly (1998), techniques exist to increase success in even the most difficult-to-dry species. Density is a good predictor of ease of drying, the magnitude of dimensional change expected in response to changes in wood moisture content, and the potential to warp. The higher density species (specific gravity of 0.5 or greater) are generally more difficult to dry and less dimensionally stable than species with a lower density (specific gravity less than 0.5). The following discussion presents a basic description of drying methods, recommended techniques, and how to minimize drying defects.

8.3.1. The Drying Process.

Wood dries naturally and will eventually reach a moisture content (MC) that is in equilibrium with the amount of moisture in the air surrounding it, called the equilibrium moisture content (EMC). In most California locations, air-drying of wood will result in a moisture content no lower than 12%. For most interior uses of wood, the EMC of wood should be in the range of 6-8%. To reach these recommended final moisture contents for interior uses, it is necessary to kiln dry the wood. Construction lumber or wood used in exterior environments does not need to be dried to as low a moisture content as interior-use lumber. Green lumber is often used in construction in California and the EMC for exterior uses is in the range of 12-16% in most California climates. Although these moisture contents can be achieved by air-drying, it is often required to kiln-dry for other reasons, such as killing wood boring insects that may be present and solidifying the pitch that is often present in many softwood species.

8.3.2. Controlling Drying Conditions.

Energy is needed to evaporate and move water out of wood. Heat supplies the energy and air currents forced through stickered lumber carry the moisture away. The temperature and humidity of the air determine how fast the wood will dry and its final MC. Rapid drying from high temperatures and/or low humidities can cause serious drying defects. Many costly mistakes are a direct result of poorly controlled drying conditions, which can occur in controlled kilns or during air-drying.

8.3.2.1. Drying schedules and the critical stage. Drying defects occur because stresses are created inside wood as the water leaves and the wood shrinks. If these stresses are large enough, they can cause defects such as checks, honeycomb, casehardening, and collapse. Although most of these defects are not apparent until the wood is nearly dry, they actually begin to develop very early in drying. The critical stage is from the initial green MC (when the lumber is first cut from a fresh log) down to about 25%. When in this critical stage, the drying rate for 1-inch thick lumber should not exceed a 2-3% decrease in MC per day for the high-density species (specific gravity > 0.5). Lower density hardwoods can be dried at a rate of 3-6% decrease in MC per day, and many softwoods can be dried at rates as high as 20% decrease per day. Once the MC reaches about 25%, then more severe drying conditions can safely be used. The actual schedule of air temperature and relative humidity settings recommended for drying wood is influenced by the inherent wood characteristics of a species, lumber thickness, and the type of drying method used.

Drying schedules for many of the more common domestic and tropical species are available and serve as a good starting point for developing your own schedule (Boone, et al., 1988). The various steps in a kiln schedule provide the recommended drying conditions based on the MC of the lumber. A schedule is presented as a series of MC steps. Examples of drying schedules for a high density hardwood species and a low density softwood species are given in **Tables 8.1.** and **8.2.** To use these schedules, it is necessary to monitor the MC of the wood as it is drying by measuring the MC of sample boards. The target or final MC that the lumber will be dried to is based on the intended use of the lumber. The recommended final MC for most interior uses of wood, including softwoods and hardwoods used for flooring, furniture, cabinets, millwork, etc., is 8%. For exterior uses of wood, the recommended MC is either 15% or 19%. The schedule steps are usually based on MC steps of 5 percent. The last two steps of the schedule, i.e. the equalizing and conditioning steps, are needed to produce high quality lumber.

The equalizing step is used to narrow the moisture content range of the wood in the kiln (some lumber dries faster, some slower). It is a 24-hour period in which the final temperature setting of the kiln is maintained, but the relative humidity is controlled at 60% for an 8% final MC and 85% for a 15% final MC. The conditioning step is used to reduce casehardening stresses if they are present in the lumber. It takes from 4 to 48 hours to accomplish this with careful addition of steam to the kiln, maintaining the final temperature of the schedule, and a humidity of at least 80%. This step is necessary for lumber that will be resawn into smaller dimension pieces after it has been dried, but if it is not done properly the wood can be irreversibly damaged. A procedure for monitoring the casehardening stresses is outlined in the Dry Kiln Operator's Manual (Simpson, 1991).

Moisture content step schedules can be converted to schedules based on time once a kiln operator develops a data record from at least 6 different kiln runs with lumber of the same thickness and species. However, because wood from different trees of the same species can dry very differently, it is always a good idea to periodically check a time-based schedule with MC measurements of sample boards. The time required to dry the appropriate species with the following schedules ranges from 4-6 weeks for the hardwood schedule and 4-6 days for the softwood schedule.

Table 8.1. Drying schedule for a typical western hardwood species (Oregon white oak)

Step	Moisture Content	Temperature	Relative Humidity
1	Above 35% MC (critical zone)	110° F	90%
2	35% to 30% (critical zone)	110° F	87%
3	30% to 25% (critical zone)	120° F	83%
4	25% to 20%	130° F	74%
5	20% to 15%	140° F	46%
6	15% to final MC	160° F	21%
7	Equalize (24 hours)	160° F	60 or 85%
8	Condition (4-48 hours)	160° F	> 80%

Table 8.2. Drying schedule for a typical western softwood species (Ponderosa pine)

Step	Moisture Content	Temperature	Relative Humidity
1	Above 40% MC (critical zone)	140° F	64%
2	40% to 35% (critical zone)	140° F	54%
3	35% to 30% (critical zone)	140° F	46%
4	30% to 25% (critical zone)	150° F	41%
5	25% to 20%	160° F	36%
6	20% to 15%	160° F	35%
7	Equalize (24 hours)	160° F	60 or 85%
8	Condition (4-48 hours)	160° F	> 80%

8.3.3. Drying Methods.

The basic principle of any drying method is one of energy (heat) and mass (moisture) transfer. It doesn't matter if the heat comes from the sun, a dehumidifier, a steam-heated coil, or some other heat source. With a knowledge of drying principles and adequate control over the drying conditions, quality dried lumber can be produced with any of the following drying methods.

8.3.3.1. **Air-drying.** This method is effective if moisture contents less than 15% are not needed, if long drying times are not a concern, and if exposure to extreme temperatures and low humidity is avoided during the critical stage of drying (from green to 25% MC). Drying conditions can be too severe in an air yard. Good results can be achieved if the air temperature is kept below 90° F and the humidity above 80% during the critical stage. In many California regions, these ambient conditions cannot be expected, especially during the summer months. Some control over nature's drying conditions can be attained by taking the following steps:

1. Avoid direct sun exposure on the wood,

2. Position lumber stacks (relative to wind direction) to increase or decrease the amount of air that passes through the lumber stack, and

3. Partially enclose the stack of lumber (with a shed or plastic tarp) to capture some of the moisture given up by the wood and increase the humidity of the air surrounding the wood.

8.3.3.2. **Kiln-drying.** Ideally, the drying method should be capable of drying wood to 8% MC, achieving a temperature of 150° F (the temperature required to sterilize insect infested wood), and having a method to reintroduce moisture into the kiln so that casehardened lumber can be conditioned to relieve the drying stresses. A kiln is needed to accomplish these goals. Types of lumber dry kilns available include solar, steam-heated, hot water-heated, dehumidification, vacuum, radio frequency, and microwave kilns.

- **Solar kiln** -- This method is attractive to many small producers because it can be the least expensive kiln to build and operate. There are numerous design plans for solar kilns available (Wengert, 1985) and at least one company sells a complete package of materials and design specifications (i.e. Wood-Mizer). The simplest solar kilns are the greenhouse type that passively collect solar heat and distribute it through the lumber with a fan. It is important to monitor the kiln temperature and humidity and provide venting as a means of regulating the drying conditions. Improved solar designs, that separate the solar collector from the lumber, work better because they provide better control of the drying conditions and can optimize solar gain when more heat is needed and provide less heat during the critical stage of drying. The major limitations of solar kilns are the lack of complete control of drying conditions, the inability to achieve 150° F (to kill insects), and the inability to condition the lumber without auxiliary heat and humidification equipment.

- **Steam-heated kiln --** The workhorse of the lumber drying industry is the steam-heated kiln, sometimes referred to as a conventional kiln. Steam is used to deliver heat from a steam boiler (gas or wood residue fired) to fin-tube heat exchangers in an insulated drying chamber. Manufacturers of these kilns provide continuous recorder/controllers to monitor and regulate the drying conditions according to pre-determined drying schedules. Excellent control of drying conditions is achieved by regulating the amount of heat delivered by the steam system, venting the chamber to discharge excess heat or bring in drier outside air to lower the humidity, or increasing the humidity by spraying steam into the chamber. Temperatures as high as 185° F can be controlled and humidity can be added to condition the lumber. A major disadvantage of these kilns, especially for small operators, is the high cost of the equipment. If a steam boiler does not need to be purchased because an inexpensive source of steam is available, then they become more economical for the small producer.

- **Hot water kiln --** This type of kiln is similar to a small steam-heated kiln except that hot water is used to deliver the heat to the drying chamber instead of steam. The maximum temperature of these units is about 150° F and they have the capability of adding humidity to the chamber to condition lumber. Because a steam boiler is not required, these units are quite a bit less expensive than steam-heated kilns.

- **Dehumidification kiln --** Dehumidification kilns are very popular with small producers and woodworkers because of their low capital cost compared to all other lumber kilns except solar kilns. These kilns use a dehumidifier to both remove moisture from the air in the drying chamber and to supply the heat needed to dry the wood. A dehumidifier operates on the same thermodynamic heat-pump principle as a refrigerator or air conditioner. When moist air from the drying lumber passes over a cold, refrigeration coil (heat exchanger) the moisture in the air condenses onto the surface of the coil. When water condenses it gives off heat (latent heat of vaporization). This heat is recycled by the refrigerant cycle, back into the air stream that conducts the heat to the lumber. In all other convection lumber-drying methods discussed here, this latent heat held by the water molecules in air is lost when moist air is vented from the kiln. In a sense, dehumidification drying is very energy efficient. Some dehumidification units have a maximum operating temperature of only 120° F, but units are available that can reach 160° F. Dehumidification kilns do not normally come from the manufacturer with a method for humidifying the air; however, a small steam generator should be added to condition and minimize the occurrence of casehardened lumber.

- **Vacuum kiln** -- Wood can be successfully dried in a vacuum chamber. Because water vaporizes at a lower temperature in a vacuum than it does at atmospheric pressure wood can be dried faster and at lower temperatures than it can be in the convection methods described above. In theory, because wood losses strength as its temperature increases the wood dried in a vacuum will have few drying defects because the critical stage of drying is occurring at low wood temperatures when the wood is strong. Drying times can be reduced by as much as 50 to 70%, depending on the species. In practice, the best results are obtained when drying short pieces of wood (up to 2 feet in length) because the water vapor travels along the grain of the wood faster than it does across the grain. In longer boards it is common to have a great deal of moisture content variation in the dried product because moisture was trapped within the wood. Compared to the convection drying methods, capital, operating and maintenance costs are high, but the reduced drying time may offset these costs. It is important to evaluate these costs for your specific needs. For a small operator, the economic analysis will be more favorable when drying products with a higher value than grade lumber.

- **Radio Frequency and Microwave kilns** -- Wood can also be dried using radio frequency or microwave energy. In these kilns the energy waves heat the wood and the water in the wood by exciting the substance molecules; the water heats up much faster than the wood. These methods will dry most species of wood 80 to 90% faster than the convection kiln methods. The capital, operating, and maintenance costs are however very high and the same problem of non-uniform wet pockets that is found in vacuum drying also occurs with these methods. They can only be justified in special circumstances.

8.3.3.3. Kiln Manufacturers. Several manufacturers that have dry kilns in the 1-10 MBF capacity range that would be suitable for small urban processors are listed below. Other manufacturers probably exist but are unknown to the authors; however, current forest products supply directories should be consulted for more potential listings. The listing of these companies does not imply an endorsement by the authors, it is provided as a starting point for interested consumers.

American Kilns - 1614 Industrial Drive, Wilkesboro, NC 28697, Phone: (910) 838-6348. They offer a radio frequency/vacuum lumber drying system. Lumber capacity depends on model, ranging from 1,500 to 8,000 bd. ft.

American Wood Dryers - 15495 S.E. For-Mor Court, Clackamas, OR 97015, Phone: (503) 655-1955. A manufacturer of large, steam-heated commercial lumber kilns (50,000 + bd. ft.), they do have a Minikiln that operates on low-pressure steam (10 psi) and has a lumber capacity of 4,000 bd. ft.

Ebac Systems - 106 John Jefferson Road, Suite 102, Williamsburg, VA 23185, Phone: (800) 433-9011; FAX: (804) 229-3321. They offer lumber dehumidification units ranging from 1/2 to 25 horsepower compressor capacity, hardware, and plans for building drying chambers. Lumber capacity depends on the compressor model and ranges from 500 to 50,000 bd. ft.

Irvington Moore - Forest Products Division, P.O. Box 40666, Jacksonville, FL, 32203, Phone: (800) 874-8055. A manufacturer of large, steam-heated commercial lumber kilns (50,000 + bd. ft.), they do have a MiniKiln that operates on low-pressure steam (10 psi) and has a lumber capacity of 2,000 bd. ft.

Koetter Dry Kiln - P.O. Box 4129, Jeffersonville, IN 47131, Phone: (812) 284-2638. They offer a hot water-heated kiln with power venting. Lumber capacity depends on the model, ranging from 600 to 50,000 bd. ft.

Nyle Dry Kiln Systems - P.O. Box 1107, Bangor Maine 04402, Phone: 800-777-6953; FAX: (27) 989-1101. They offer lumber dehumidification units ranging from 1/2 to 25 horsepower compressor capacity, hardware, and plans for building drying chambers. Lumber capacity depends on the compressor model and ranges from 500 to 50,000 bd. ft.

Wood-Mizer Products - 8180 W. 10th Street, Indianapolis, IN, Phone: (800) 553-0182; FAX: (317) 273-1011. They offer a solar dry kiln kit (Model 3000 SolarDry) that includes plans and hardware (you supply construction materials and labor). Lumber capacity is 3,000 bd. ft.

Vacutherm - PO Box 305, Airport Road, Warren, VT 05674. Phone 802/496-4241, FAX (802) 496-9176, web <http://www.vacutherm.com/>http://www.vacutherm.com

In summary, with knowledge of drying principles and adequate control over the drying conditions, quality dry lumber can be produced with any drying method. If long drying times are not a concern, air-drying can be an effective method for the critical drying stage. But remember, even in an air yard the drying conditions can be too severe. A kiln is needed if a moisture content lower than 15% is required, or if the wood needs to be heat-treated to kill insects. Any lumber that will be remanufactured into other dimensions needs to be conditioned if casehardening stresses are present. Although it is believed by some that difficult to dry hardwoods must be air-dried before they are put into a kiln, this is generally not the case. All hardwoods can be dried from the green condition in any of the kilns discussed here. The decision to air-dry should be based on an economic analysis of the cost of operating the kiln and the length of time required to keep the lumber in process for the different drying methods. Keep in mind, long inventory times have a negative effect on cash flow as the money is tied up in inventory.

8.3.3.4. Moisture meters. A moisture meter is used to monitor the moisture content of lumber as it dries. Two types of meters nave been developed that are based on the good correlation between the electrical properties of wood and its moisture content below the fiber saturation point (FSP). This is the stage of wood drying where the cell walls are saturated and the cells cavities are free from water. For most wood, the FSP is approximately 25-30% M.C., based on oven dry weight. Moisture meters can not accurately measure MC above 25% or below 5%.

A resistance (or conductance) meter measures the electrical conductance between two contact electrodes which usually are pins that are imbedded into the wood. A dielectric meter measures the dielectric constant of the wood in an electromagnetic field produced by a surface electrode. The dielectric constant is essentially a measure of the potential energy/unit volume stored in the material in the form of electric polarization when the material is in a given electric field (U. S. Forest Products Laboratory, 1974). Both types of meters provide an accuracy of +/- 1.5%.

General procedures for the use of both types of meters are:

- Make measurements at least 2 ft. from the lumber ends and 2 in. from knots and lumber sides. These zones respond faster to humidity changes and often bias the measurements.

- At least three measurements per board are required to get a reliable average measurement for the board.

- Apply correction factors provided by the meter manufacturer. Resistence meters are very sensitive to the wood temperature, and dielectric meters are very sensitive to wood density (species correction is important).

Manufactures of moisture meters are[1]:

Resistance type	Dielectric Type
P.O. Box 68	326 Pine Grove Rd.
51 Indian Lane	Rogue River, OR 97537
Towaco, N.J. 07082	Phone: (541) 582-0541
Phone: (201) 334-2557	(800) 634-9961
FAX: (201) 334-2657	FAX: (541) 582-4138

Lignomat USA Ltd.
P.O. Box 30145
Portland, Or 97294
Phone: (800) 227-2015
FAX: (503) 225-1430

Lignomat USA Ltd.
P.O. Box 30145
Portland, Or 97294
Phone: (800) 227-2015
FAX: (503) 225-1430

([1]Contact these suppliers for a supplier near you.)

8.3.4. Drying Defects and How to Avoid Them.

Most of the problems encountered in drying are related to stresses that develop during drying. Warp, collapse, honeycomb, and casehardening are drying defects that occur because stresses are created inside wood as the water leaves and the wood shrinks. Although these defects are not apparent until the wood is nearly dry, they actually begin developing very early in drying, during the critical stage (from green to 25% MC).

8.3.4.1. Warp. Warp is defined as the condition when a piece of lumber or wood no longer is straight and/or flat; the geometry has deviated from the three planes that originally defined the shape. The stresses that cause lumber to warp are a direct result of the inherent differential shrinkage that occurs in wood across the grain, that is, between the tangential (tangent to the growth rings) and radial directions (parallel to the rays). Grain deviation is also a contributing factor to warp in lumber. It can be growth related such as spiral or interlocked grain (e.g. common in blue gum eucalyptus); a result of the sawing method, especially in crooked logs; or, due to the presence of knots. The high degree of grain deviation expected in most urban trees suggests that lumber cut from them would have a tendency to warp. Drying lumber in thicker dimensions or placing a uniformly distributed dead weight restraint on the boards to keep them flat during drying can minimize warp. Also, narrow boards will warp less than wider boards.

A method known as Saw-Dry-Rip takes advantage of the inherent resistance to warp in thicker dimensions by drying 4-inch or thicker flitches and cants and then resawing them to final sizes. The disadvantage of this technique is that it lengthens the time to dry the lumber, and it increases the chance of developing other drying defects such as collapse, honeycomb, and casehardening. If time is not a concern, this method has great potential for producing high quality lumber. However, if time is an important consideration in the optimization of the drying process, the risk of creating other drying defects can be too great. This is especially true with the high-density California hardwood species.

8.3.4.2. Surface Checks and End Checks. These defects are created in the critical stage of drying when the exposed surfaces of wood are rapidly drying and the shrinkage of the surface zone (shell) is restrained by a wetter core. **Slow drying during the critical stage minimizes this condition.**

8.3.4.3. Honeycomb. These are internal checks that develop perpendicular to the grain (separations along the rays that are planes of weakness). Honeycomb checks appear during the final stage of drying, but the conditions for their development are created in the critical stage when the dry shell is set in tension. **Slow drying during the critical stage minimizes this condition**. (End seal will help minimize end checks.)

8.3.4.4. Collapse. This term describes the condition where the wood cells collapse during drying creating a wavy, distorted appearance with unusual thickness variations in the piece. Collapse is caused by rapid removal of water from weakened, saturated cells. **Slow drying during the critical stage minimizes this condition.**

8.3.4.5. Casehardened Lumber. This term describes the condition where the shell is stressed in compression and the core in tension. Casehardening appears in the final stage of drying, but the conditions for its development are created in the critical stage when the shell is set in tension. **Slow drying during the critical stage minimizes this condition.**

8.3.4.6. Recovering from Defects. Surface checks, end checks, and honeycomb are permanent defects, nothing can be done to correct the defect once it occurs. Collapse and casehardening can be at least partially corrected. Much of the collapse can be recovered by exposing the dried lumber to saturated steam in a closed chamber for two hours. Casehardening is relieved by adding moisture back into the kiln at the end of the drying period to re-hydrate the surface zone, which causes a reduction of the compression stress in the shell. However, if the re-hydration is carried too far then reverse casehardening will occur; this is a permanent condition.

8.3.5. Recommendations for Drying Quality Lumber.

The following is a list of eleven steps that that should be followed to help guarantee drying quality lumber.

1. Segregate lumber by species and thickness. A general rule of thumb is that doubling the thickness of a board at least triples the drying time to the desired MC.
2. Stack the lumber with strong, dry stickers of a uniform thickness (3/4 or 1 inch thick by 1-1/4 inch wide). Lumber dries faster with thicker stickers that allow more air movement through the stack.
3. Align stickers vertically so that the weight of each board is carried by the load supports.
4. Seal the end grain of each board with a paraffin-based end sealant to reduce end checking. Commercial end sealers are available, check with forestry and lumber manufacturing suppliers. (See Section 7.4.2.2.)
5. Monitor the MC of sample boards during drying.
6. Control the drying conditions according to the MC of the lumber. **Be conservative during the critical stage**. As you gain experience with a particular species, thickness, and drying method, you can gradually alter the drying schedule to shorten the drying time. Remember, most drying defects don't appear until it's too late to do anything about them!
7. Dry to a target MC suitable for your customer's needs.
8. Check for casehardening and condition the lumber if necessary.
9. Check for honeycomb and collapse. A customer surprised by these defects will probably not be a repeat customer.

10. Store dried lumber in flat, solid stacks (no stickers) in a closed shed; a heated shed is ideal.

11. Re-check the MC before you ship the lumber, you may need to re-dry it. Remember, 8% MC lumber will gradually increase to an EMC of about 14% in an unheated storage shed.

8.3.6. A Word About California Hardwoods.

The native hardwoods of California can be grouped into three categories based on drying ease:

- **Easy** -- red alder, Oregon ash, birch, black cottonwood, and big leaf maple.
- **Moderately difficult** -- chinkapin, California laurel, and California black oak.
- **Difficult** -- tanoak, madrone, white oaks, and live oaks.

The difficult to dry species have a tendency to develop collapse and honeycomb if they are dried too fast during the critical stage. It is important to dry them slowly (2% - 3% MC decrease per day) at low temperatures and a high relative humidity (not above 110° F or below 85% RH) until a wood MC lower than 25% is reached.

8.4. Quality Assessment and Lumber Grading.

When lumber is bought or sold there must be an agreement over the quality and price between the buyer and seller. This can be accomplished by an implicit agreement or explicit contract between the two parties or by assigning quality classifications or grades with a commonly understood definition. When lumber is marketed locally or in niche markets it is often done by agreement or contract. When lumber is marketed as a commodity it must conform to the
commonly accepted lumber grades established in the commodity market. Many of the species being milled in urban sawmills will not be covered by the commodity rules as they only directly apply to the recognized commercial lumber species. However, because these grades are well understood by buyers and consumers it is helpful for the niche marketer to be familiar with the grade descriptions so that the niche product can be defined as “similar to”.

8.4.1. Standard Grades.

The standard commodity grades or quality specifications are defined by nationally recognized lumber grading organizations. These organizations establish the rules on the bases of the intended use of the lumber. Most grades are based on a visual inspection system that relates the defects in the wood to its intended use. All grades fall into one of three major categories: **1.** lumber intended for construction, **2.** lumber used where appearance is more important than strength (architectural uses), and **3.** lumber intended to be remanufactured into other products. Within these categories the highest grades will have the fewest defects that would be detrimental to the performance of the wood for an intended use. In general, the grades are identified by numbers or letters with the highest grades being labeled as Firsts, No. 1, A or some other character or phrase that clearly indicates the beginning of a sequence or few defects.

Grading rules not only establish the specific requirements for each grade but they also specify the standard sizes for each commodity product. **Table 8.3.** presents the standard thickness and width sizes for the more common softwood and hardwood products. Most standard lumber widths vary by 2-inch increments for softwoods and 1-inch increments for hardwoods. Standard lengths vary by 2-foot increments for softwoods and 1-foot increments for hardwoods. Information on more specialized commodity products can be obtained by referring to the grading rulebooks published by the grading organizations. A list of some of the more common grading organizations is presented at the end of this section.

The grades and rules are different for hardwoods and softwoods, and there are often exceptions and variations for specific species within a group. **Table 8.4.** (Softwood lumber grades) and **Table 8.5** (Hardwood lumber grades) are provided as an overview of the major grade classifications. In addition to these grades there are also numerous grades and specifications for special categories such as scaffolding planks, stadium seats, paneling, and siding. There are also special rules for certain species, such as redwood and western red cedar. As an example, the more common redwood grades are listed in **Table 8.6** .

Because of the large number of potential uses of wood there are numerous grade categories, too numerous to cover in this report. The following discussion is intended as an overview that will focus on the major categories and grading rules. However, keep in mind, the rules are very complicated and a thorough understanding requires diligent study of the specific rulebooks.

8.4.1.1. Softwood lumber grades. Graded softwood lumber is divided into three major use categories: 1. Construction, 2. Architectural, and 3. Remanufacturing **(Table 8.4.)** . Although lumber within each of these categories may have similar grade names, the grades are based on a different set of criteria for each use. Construction lumber is based on strength, architectural lumber is based on appearance, and remanufacturing lumber is based on thequantity of defect free material that can be cut from each piece (aka cuttings). The grades within each of these use categories are based on how the defects in the lumber are expected to affect the quality of the piece in its intended use.

- **Construction lumber** -- This category of softwood lumber is often referred to as "dimension" lumber. It is used for most of the wood construction applications in the United States. The lumber is manufactured to specific dimensions that are standard for building design and engineering. The size classifications within this category are based on the intended use for the material. For example, boards are used for sheathing purposes (e.g. 1 x 6), light framing sizes (e.g. 2 x 4, 2 x 6) are intended for framing walls; joists are intended to be loaded on edge or used as beams and are significantly wider than they are thick (e.g. 2 x 6), and larger structural members used as columns are designated as posts.

  Most dimension lumber is stress-rated, which means that minimum strength and stiffness design values are assigned to each grade. The grading system is based on the knowledge of how the defects present in the lumber effect the mechanical properties of the piece as a whole. The lumber can be graded visually, by following a set of rules established by grading agencies, or machine-graded. The visual grades are based on an assessment of the size, distribution, and location of defects in the lumber and how those defects affect the strength and stiffness of the lumber. Machine-graded lumber is individually proof-tested by being passed through a machine that measures the strength and stiffness of the piece.

Table 8.3. Standard hardwood and softwood lumber sizes

Standard Softwood Lumber Sizes

Dimension Lumber (used for framing and general construction)*

Nominal Thickness	Actual Thickness	Nominal Width	Actual Width
2"	1-1/2"	2"	1-1/2"
3"	2-1/2"	3"	2-1/2"
4"	3-1/2"	4"	3-1/2"
		5"	4-1/2"
		6"	5-1/2"
		7"	6-1/2"
		8" and wider	3/4" less than nominal

Boards, Factory, and Shop Lumber**

Nominal Thickness***	Actual Thickness	Nominal Width	Actual Width
3/4"	5/8"	2"	1-1/2"
4/4"	3/4"	3"	2-1/2"
5/4"	1-5/32"	4"	3-1/2"
6/4"	1-13/32"	5"	4-1/2"
7/4"	1-19/32"	6"	5-1/2"
8/4"	1-13/16"	7"	6-1/2"
9/4"	2-3/32"	8" and wider	3/4" less than nominal
10/4"	2-3/8"		
11/4"	2-9/16"		
12/4"	2-3/4"		
16/4"	3-3/4"		

* Actual dimensions are specified for lumber after it is surfaced smooth and dried to 19% moisture content

**Actual dimensions are specified for lumber after it is surfaced smooth and dried to 12% moisture content

*** Board thickness are generally designated by quarter inch increments, e.g. 4/4 is I-inch thick.

Standard Hardwood Lumber Sizes*

Nominal Thickness	Actual Thickness	Nominal Width	Actual Width
3/8"	3/16"	up to 8" wide	3/8" less than nominal
1/2"	5/16"	8" and wider	1/2" less than nominal
5/8"	7/16"		
3/4"	9/16"		
1"	13/16"		
1-1/4"	1-1/16"		
1-1/2"	1-5/16"		
1-3/4" and thicker	1/4" less than nominal		

* Actual dimensions are specified for lumber after it is surfaced smooth and dried to 8% moisture content.

Table 8.4. Softwood lumber grades

Use Categories		Grades
Construction Uses -- Dimension lumber used for framing and sheathing		
Stress-Rated	Structural Light Framing -- 2 to 4-inch thick x 2 to 4-inch wide, e.g. 2" x 4" Structural Joists & Planks -- 2 to 4-inch thick x 5-inch wide and wider, e.g. 2" x 6" Timbers -- 5-inch thick and thicker x width greater than thickness plus 2-inch Posts & Timbers -- 5"x5" and larger with width no more than 2" > thickness Stress-Rated Boards -- 3/4 to 4-inch thick x 4" and wider, e.g. 1" x 6"	Select Structural No. 1 No. 2 No. 3
	Light Framing -- 2 to 4-inch thick x 2 to 4-inch wide, e.g. 2" x 4"	Construction Standard Utility
	Stud -- 2" x 4" and 2" x 6" (length of 10-foot or less)	Stud
Non Stress-Rated	Economy Stud -- 2" x 4" and 2" x 6" (length of 10-foot or less)	Economy
	Boards -- 3/4 to 4inch thick x 4-inch and wider	1 Common (Select Merchantable) 2 Common (Construction) 3 Common (Standard) 4 Common (Utility) 5 Common (Economy)
Architectural Uses -- Appearance is more important than strength		
	Appearance Framing -- 2 to 4-inch thick x 4-inch and wider	A (clear) -- stress-rated
	Boards -- 3/4 to 4inch thick x 4-inch and wider	1 Common 2 Common
	Selects and Finish -- Molding, Trim, Cabinets, Flooring etc. (sizes vary depending on intended product)	B & Better C D
Remanufacturing Uses-- Stock for furniture, flooring, molding, doors, boxes, etc.		
	Factory and Shop Lumber (sizes vary depending on intended product)	Select Shop No. 1 Shop No. 2 Shop No. 3 Shop

Table 8.5. Hardwood lumber grades

Use Categories	
Standard Lumber Grades -- based on proportion of clear wood (cuttings)	
Grades	Minimum Requirements
FAS	83.3% clear, minimum board dimensions: 6-inch width, 8-foot length
Select	83.3% clear, minimum board dimensions: 4-inch width, 6-foot length
No. 1 Common	66.6% clear, minimum board dimensions: 3-inch width, 4-foot length
No. 2 Common	50.0% clear, minimum board dimensions: 3-inch width, 4-foot length
No. 3 Common	33.3% clear, minimum board dimensions: 3-inch width, 4-foot length
Construction and Architectural Uses	
Grades	Minimum Requirements
Interior wall paneling	
Natural	91.6% clear, minimum board dimensions: 6-inch width, 8-foot length
Colonial	83.3% clear, minimum board dimensions: 4.5-inch width, 6-foot length
Prime	83.3% clear, minimum board dimensions: 4-inch width, 6-foot length
Custom	tight knots to 1-1/2-in. diam. OK, minimum dimensions: 4-in. width, 6-ft. length
Construction and Utility Boards (primary use is for government specificaitons)	See NHLA Rule Book
No.1 Construction (Utility)	
No.2 Construction (Utility)	
No.3 Construction (Utility)	
Flooring -- Grades established by National Oak Flooring Manufacturers Assoc.	
Clear	Little discoloration or character marks, minimum length is 3-1/2 foot
Select	Slight discoloration and small, tight knots, minimum length is 3-1/2 foot
No. 1 Common	Moderate discoloration and defects allowed, minimum length is 1-1/4 foot
No. 2 Common	Very few limits on defects, minimum length is 1-1/4 foot
1-1/4' Shorts	Short pieces (9 to 18-inch) of the above grades
Bridge, Mine, and Industrial timbers and boards	See NHLA Rule Book
Railway Ties -- Grades estabilished by American Railway Engineers Assoc.	

Table 8.6. Common redwood lumber grades

Use Categories

Landscape and Construction (all sizes): Decks, retaining walls, garden structures, etc.

Grades		Minimum Requirements
Select Heart	---	Sound/tight knots, all heartwood (sapwood corner allowed in 3-inch and thicker)
Select	---	sound/tight knots, sapwood allowed
Construction Heart	---	tight knots and moderate defects, all heartwood
Construction Common	---	tight knots and moderate defects, sapwood allowed
Merchantable Heart	---	all knots and holes to size limits, occasional sapwood on corner
Merchantable	---	all knots and holes to size limits, sapwood allowed

Stress-Graded: 2" x 4" and 2" x 6" sizes for engineered structures

Grades		Minimum Requirements
Deck Heart	---	slight defects, all heartwood
Deck Common	---	moderate defects, sapwood allowed

Architectural: Siding, paneling, trim, cabinetry, millwork, etc.

Grades		Minimum Requirements
Clear Heart	---	Best face is 100% clear, all heartwood
Clear	---	allows 2 small knots (3/4"), sapwood allowed
Heart B	---	moderate defects, all heartwood
B	---	moderate defects, sapwood allowed

Some dimension lumber is available as non stress-graded lumber, which is intended for general construction, or utility uses. This lumber is still graded on the basis of the effect of defects on the expected performance for the intended use, but the rules are less rigorous than the stress-graded rules and the grades do not have design values associated with them. Boards are generally graded as non-stress graded lumber.

- **Architectural lumber** -- is construction lumber that is manufactured to a specific pattern or size for uses where the appearance of the board is the most important property. Siding, trim, molding, and flooring are examples of appearance lumber.

- **Remanufacturing lumber** -- also know as factory or shop lumber, is intended to be used as the raw material for a higher-value manufactured wood product. This lumber is the stock for products such as flooring, furniture, cabinets, molding, millwork, boxes, etc.

  Species with unusual or unique characteristics are often manufactured for uses that capitalize on the unique properties. Examples include redwood, western redcedar, and cypress siding; redwood deck and fence lumber, and Redwood architectural lumber. These species are commonly used for siding, deck construction and architectural uses because of the attractive color and high levels of natural resistance to attack by wood-boring insects and wood decay fungi. Although these are commercial softwood species that are covered by the National Lumber Grading Standards, special rules exist for these higher-value uses. In fact, in todays market most of the lumber of these species is graded for the higher-value uses. For example, even though redwood can be stress-graded for construction uses following the softwood structural grades it is rarely done. Most redwood is graded for landscape, deck, or architectural uses following the rules of the California Redwood Inspection Service. A summary of these rules is presented in **Table 8.6.** .

8.4.1.2. Hardwood lumber grades. Most of the hardwood lumber will be remanufactured into a higher-value product. As such, a hardwood lumber grading system has evolved that is based on how many clear wood (no defects) pieces of various standard sizes can be cut out of a board. These clear wood pieces are referred to as cuttings. The grades are defined by the number of cuttings and the percentage of the board that is clear. These grades, known as the Standard Lumber Grades for hardwood, are presented in **Table 8.5.** . Hardwoods are often used as non-standard lumber for special products. For example, the lumber can be graded for a specific use such as paneling or flooring. Hardwoods can also be manufactured to structural lumber sizes for use in construction. However, there are no structural grading rules that apply to specific hardwood species. The National Hardwood Lumber Association (NHLA) rulebook lists construction grades for oak but these are rarely used, if at all. If a hardwood species is to be used in construction it will likely need the approval of the local building officials. This can be done, but it usually requires the services of a structural or civil engineer to certify that its strength and stiffness are appropriate for the intended use.

8.4.2. Grading Organizations.

There are numerous lumber and wood product grading organizations in the United States. The following is a partial list of those with jurisdiction in the West.

Hardwood Lumber

National Hardwood Lumber Association
PO Box 34518
Memphis, TN 38184
Phone: (901) 377-1818 or (800) 933 0318
Web Page: www.natlhardwood.org

Hardwood Flooring

National Oak Flooring Manufacturers Assoc.
804 Sterick Building
Memphis, TN 38103
Phone: (901) 526-5016
FAX: (901) 528- 7022
Web Page: www.NOFMA.org
E-mail: info@NOFMA.org

Softwood Lumber

Western Wood Products Association
1500 Yeon Building
Portland, OR 97204
Phone: (503) 224-3930
Web Page: www.wwpa.org
FAX: (503) 224-3924

Redwood Inspection Service
405 Enfrente Drive, Suite 200
Novato, CA 94949
Phone:
Web Page: www.calredwood.org
FAX: (415)382-8531

West Coast Lumber Inspection Bureau
Box 23145
Portland, OR 97223
Phone: (503) 639-0651
FAX: (503) 684-8928

For more information it is suggested you contact the appropriate grading agency or manufacturing association. Lumber manufacturers can train their own employees to grade lumber according to these rules, or they can contract with a lumber inspection service. One such service in California is the California Lumber Inspection Service, 5025 Wayland Ave., San Jose, CA 95118 (Phone: (408) 993-1633).

8.5. SUMMARY.

The technology exists to produce lumber and higher-value remanufactured products from urban tree species. The inherent working characteristics of the wood that are related to density, knots, grain deviation, and tree form determine whether the wood can be processed economically. The extra processing steps required to produce the quality demanded by the market place may result in manufacturing costs that are too high. A thorough understanding of the properties of the wood and the manufacturing techniques that minimize defects and maximize value are imperative to succeeding in this business. One of the most crucial steps in the process is drying. Many small start-up sawmills have failed because they didn't understand the importance of drying and how to minimize the drying losses due to excessive drying defects.

Another important consideration for any processing enterprise is to produce consistent quality products. For wood product operations using urban species targeted to niche or specialty markets this usually means a definition of product quality needs to be created. Once defined, in terms of moisture content, size tolerances, surface quality, etc., methods of measuring quality parameters during production should be created. Any materials not meeting the quality standards should be reprocessed to achieve desired quality or marketed as a below grade product. Although it's obvious, it is always a surprise when a producer loses site of the old adage, "unhappy customers are not repeat customers".

In addition to identifying the target market(s), determining the quality and volume needs of customers, and determining the resource availability to meet these needs, it is imperative to prepare a thorough business plan that includes realistic estimates of product value and manufacturing costs. As the size of the operation increases so does the need for more expensive equipment and the overall complexity of the business plan. Assistance in developing business plans can be obtained from various sources including local economic development agencies, and private and public business consultants.

Any urban tree can be processed into a wood product. The question is can it be done profitably. The harder it is the higher the manufacturing costs will be. Can the market bear the cost?

9.0. LITERATURE CITED

Anonymous. 1992. Snatched from the Landfill. Urban Forests Vol 12, No. 4: 12.

Anonymous. 1993. California Dealer Goes into the Woods. Prosales, May/June, p. 2. (Location unknown)

Anonymous. 1996. Answer Book 1996. The California Forestry Association, Sacramento, CA., 80 pp.

Anonymous. 1997. The Portable Sawmill Encyclopedia, 46 pp. Sawmill Exchange, P.O. Box 131267, Birmingham, AL 35213-6267.

Bailey, Lauranne J.. David S. Liebl, Eugene M. Wengert. 1998. Wood Products Value-Added Manufacturing and Finishing: Efficiency, Waste Reduction, and Regulations, Second Edition. University of Wisconsin - Extension Solid and Hazardous Waste Education Center, Madison, WI, 528 pp.

Bean, Pat. 1992. Woodwork Becomes One Man's Cause. Standard Examiner, Monday, August 17, pages 1 and 2B. Salt Lake City, Utah.

Bernhardt, Elizabeth and Tedmund J. Swiecke. 1989. The State of Urban Forestry in California -- Results of the 1988 California Urban Forest Survey. Prepared for the California Department of forestry and Fire Protection. Plant Science Consulting and Research, Vacaville, CA, 68 pp.

Bernhardt, Elizabeth and Tedmund J. Swiecke. 1993. The State of Urban Forestry in California -- 1992. Prepared for the California Department of Forestry and Fire Protection. Plant Science Consulting and Research, Vacaville, CA, 61 pp.

Blanche, A. and H. F. Carino. 1996. Sawmilling Urban Waste Logs: An Income-Generating Option for Arborists. Arborist News, Oct.: 45-48.

Bolsinger, Charles C. 1980. California Forests: Trends, Problems, and Opportunities. USDA For. Serv. Resour. Bull. PNW-89-138, Pac. Northwest For. & Range Exp. Sta., Portland, OR. 138 pp.

Boone, Sidney R., Charles J. Kozlik, Paul J. Bois, and Eugene M. Wengert. 1988. Dry Kiln Schedules for Commercial Woods: Temperate and Tropical. USDA Forest Service. General Technical Report FPL-GTR-57. p 158.

Cesa, Edward T., Edward A. Lempicki, and J. Howard Knotts. 1994. Recycling Municipal Trees -- A Guide for Marketing Sawlogs from Street Tree Removals in Municipalities. Northeastern Area State and Private Forestry. NA-TP-02-94. U.S. Dept. of Agriculture, Morgantown, WV. 52 pp.

Chapman, Mary. 1996. Cheating the Landfill - Wood Waste Turned to Gold. Understory, Winter, Vol 6, No. 1: 1 & 6.

CIWMB (California Itegrated Waste Management Board). 1994. Nonyard Wood Waste Report, Sacramento, CA. 69 pp.

CIWMB. 1995. Nonyard Wood Waste Report - Annual Update, Sacramento, CA. 28 pp.

CIWMB. 1998. Personal communicvation about CIWMB Interim Database.

Clar, C. Raymond. 1959. California Government and Forestry -- From Spanish Days Until the Creation of the Department of Natural Resources in 1927. Published by the Div. of For., Dept. of Nat. Res., State of Calif. Sacramento, CA. 623 pp.

Cohen, David H.; Derek Goudie. 1995. Profile of the California Furniture Industry: Structure, product types and wood use. Forest Products Journal 45(6):31-37.

Davis, E. M. 1962. Machining and Related Characteristics of United States Hardwoods. USDA Forest Service. Technical Bulletin No. 1267. Washington, DC. p. 68.

Dean, William and David S. Evans (editors). 1978. Terms of the Trade, A Handbook for the Forest Products Industry. Random Lengths Publications, Inc. Eugene, Ore. 130 pp.

Environmental Science Associates and Pryde Roberts Carr. 1995. Toward Ensuring Adequate Landfill Capacity. Prepared as part of the Integrated Waste Management Planning Study contract #C1089. San Francisco, CA, 47 pp. plus appendices.

Faison, David. 1997. Certification and Urban Forest Products. Proceedings of the Urban Wood Utilization Workshop, June 13, 1997; Pierce College, Woodland Hills, CA. California Urban forests Council, San Francisco, CA. 11 pp.

Fitch, Martin. 1997. Personal communication, Parks Superintendent, Sacramento, CA.

Hall, Guy H. 1998. The Management - Manufacturing - Marketing of California Black Oak, Pacific Madrone, and Tan Oak, A Practical Handbook on Successful Hardwood Utilization in California and Southern Oregon. Western Hardwood Assoc., Camas, WA, 222 pp.

Herr, Serena. 1993. Harvesting Urban Forests. California Trees - Exploring Issues in Urban Forestry 4 (4): 1-2, 3-4. Quarterly publication of California ReLeaf.

Hessenthaler, George. 1993. The Case for Salvaging “Waste Wood”. California Trees - Exploring Issues in Urban Forestry 4 (4): 1, 3. Quarterly publication of California ReLeaf.

Hessenthaler, George. 1997a. Creating Value Added Products from Urban Forest Wood Waste. Proceedings of the Urban Wood Utilization Workshop, June 13, 1997; Pierce College, Woodland Hills, CA. California Urban forests Council, San Francisco, CA. 11 pp.

Hessenthaler, George. 1997b. Personal communication, Owner, Urban Forest Woodworks, Logan, Utah.

Hoadley, R. Bruce. 1980. Understanding Wood. Tauton Press. Newton, CT. 256 pp.

Howard, James O. 1984. California's Forest Products Industry: 1982. Resour. Bull. PNW-119. USDA, Pacific Northwest Forest and Range Exp. Sta., Portland, OR, 79 pp.

High Sierra RC&D Council. 1997. A Management Handbook for Hardwood Sawmills, Auburn Calif, 61 pp.

Huber, Dean W. and Philip M. McDonald. 1992., California's Hardwood Resource: History and Reasons for Lack of a Sustained Hardwood Industry. Gen. Tech. Rep. PSW-GTR-135. USDA., For. Serv., Pacific Southwest Research Station, Albany, CA. 14 p.

Integrated Urban Forestry, Inc. (1995). Greenwaste Reduction Implementation Plan (GRIP) -- An Urban Forestry Biomass Utilization Project. Laguna Hills, CA. 49 pp.

Lang, Peter. 1997. Personal communication, Owner, The Peter Lang Co., Santa Rosa, CA.

Larson, Tom. (1995). Urban Woods (Utilization of Discarded Urban Trees), Integrated Urban Forestry, Inc., Laguna Hills, CA, 2 pp.

Linquist, Craig. 1998. Personal communication. Service Line Manager, Arbor Care, San Jose, CA.

Lubin, Dorothy Mockus; John R. Shelly. 1995. California Hardwoods and Non-Timber Forest Products Directory of Producers and Suppliers. University of California Forest Products Laboratory. Richmond, CA. p. 91.

McPherson, E. Gregory. 1998. Structure and Sustainability of Sacramento's Urban Forest. J. of Arboriculture 24 (4): 20 pp.

Merwin, Miles. (Date unknown). Custom Sawmillers Process Eucalyptus and Other Hardwoods. (Source unknown), 2 pp.

Meyer, Christopher J.; Judd H. Michael; Steven A. Sinclair; William G. Luppold. 1992. Wood Material Use in the U.S. Wood Furniture Industry. Forest Products Journal 42(5):28-30.

Miller, Paul. 1998. Personal communication, Forest Fire Laboratory,Riverside, CA.

Munns, E.N., Theresa G. Hoerner, V.A. Clennents. 1949. Converting Factors and Tables of Equivalents Used in Forestry. U.S.D.A. Msc. Paper No. 225, Washington, D.C. 48 pp.

NEOS Corporation. (1994). Final Report - Urban Tree Residues: Results of the First National Inventory. Prepared for ISA Research Trust, Allegheny Power Corp., National Arborist Foundation. Lakewood, CO, 65 pp. plus appendices.

Palmer, Janet Holman. 1991. Environmentally Correct Forestry. The Press Democrat, Nov. 6. Santa Rosa.

Pillsbury, Norman and Richard Thompson. 1995. Tree Volume Equations for Fifteen Urban Species in California. Urban Forest Ecosystems Institute, California Polytechnic State University, San Luis Obispo, CA, 45 pp.

Pillsbury, Norman. 1997. Personal communication. Department Head, Natural Resources Management Dept., Cal Poly, San Luis Obispo, CA.

Senerchia, Will. 1997. Personal communication. Mill Manager, Institute for Sustainable Forestry, Piercy, CA.

Shelly, John R. 1995. Quality Processing of California's Hardwoods. Appendix IV in Starting A Cooperative for Hardwoods and Special Forest Products by Deborah Gray and Mahlon G. Lang. September 1995. Center for Cooperatives. University of California, Davis. p 32-38.

Shelly, John R. 1998. Seasoning. Chapter 9 in "The Management, Manufacture, Marketing of California Black Oak, Pacific Madrone, and Tanoak" by Guy H. Hall. Western Hardwood Association. Camas, WA. p 112-131.

Shelly, John R. and Dorothy Mockus Lubin. 1996. California Hardwoods and Non-Timber Forest Products. Final Report, EDA Project No. 07-19-04005. University of California Forest Products Laboratory. Richmond, CA. p. 5.

Shelly, John and William Tietje. 1996. Resource Evaluation for Forest Products, p. 82-97. Guidelines for Managing California Hardwoods, Rangelands, University of California Division of Agrculture and Natural Resources, Publication 3368, Oakland, CA. p. 82-97.

Sherrill, Sam, Carey Sherrill, and Michael Romanos. 1997. The Nuts and Bolts of Turning Waste Trees into Good Wood. Trees to Furniture Program sponsored by Wood-Mizer Products and Popular Woodworking Magazine, Cincinnati, OH. 20 pp.

Sierra Resource Group. 1997. A Management Handbook for Hardwood sawmills, High Sierra Resource Consevation & Development Area, Auburn, CA. 51 pp.

Simpson, William T. 1991. Dry Kiln Operator's Manual. USDA Forest Service, Agriculture Handbook 188. p. 274.

Summit, Joshua and E. Gregory McPherson. 1998. Residential Tree Planting and Care: A Study of Attitudes and Behavior in Sacramento, CA. J. of Arboriculture 24 (2): 18-197.

Tellus Institute. 1991. Disposal Cost Fee Study Final Report. Prepared for California Integrated Waste Management board. Boston, MA, 333 pp.

U.S. Department of Commerce. 1993. 1991 Annual Survey of Manufacturers: Statistics for Industry Groups and Industries, Series M91 (AS)-1. Washington, DC, U.S. Department of Commerce.

U.S. Forest Products Laboratory. 1974. Wood Handbook: Wood as an Engineering Material. USDA Agr. Handbook No. 72, rev., 426 pp.

Watt, Harry W. 1998. Your Sawmill Business -- Sawing for Others. Sawmill & Woodlot Vol 1(2): 6-8, 36.

Wengert, Eugene M. and Luiz Carlos Oliveira. 1985. Solar Heated, Lumber Dry Kiln Designs. Department of Forest Products. Virginia Polytechnic Institute and State University, Blacksburg, VA. p. 91.

Whittier, J., D. Rue, and S Hasse. 1995. Urban Tree Residues: Results from the First National Inventory. Jour. of Arboriculture 21 (2):57-62.

Wise, Warren. 1997. Personal communication. Owner of The Woodsman, Stockton, CA.

Woolf, Jim. 1992. Utah Entrepreneur Sees Treasure in Tree, Has Soft Spot in His Heart for Hardwoods, The Salt Lake Tribune, Saturday, August 8, pages D1 and 4. References.

10.0. APPENDICES

APPENDIX A. - STANDARD LUMBER ABBREVIATIONS [1]

AD	Air dried
ALS	American lumber standard
AV or avg	average
AW&L	all widths and lengths
B&B B&BTR	B and better
BD	board
BD FT bd. ft.	board foot
BDT	bone dry ton
BEV	bevel or beveled
BH	boxed heart
BM	board measure
BTR	better
CC	cubic content
cft. or cu. ft.	cubic foot or feet
CEC	Calif. Energy Commission
CF	cost and freight
CIWMB	Calif. Integrated Waste Management Board
CLR	clear
CM	center matched
Com	common
CTCF	Commercial tree care firms
DF	Douglas-fir
DIM	dimension
Dkg	decking
D1S, D2S	See S1S and S2S
D&M	dressed and matched
D&CM	Dressed and center matdhed
D&SM	dressed and standard matched
D2S&CM	dressed two sides and center matched
D2S&SM	dressed two sides and stand-ard matched
E	edge
EG	edge grain
EM	end matched
FA	facial area
Fac	factory
FAS	firsts and seconds
FBM, Ft. BM	feet board measure
FG	flat or slash grain
FJ	finger joint
FLG, Flg	flooring
FOB	free on board

FOK	free of knots
FRT, Frt.	freight
FT, ft.	foot or feet
FT. SM	feet surface measure
GM	grade marked
Hrt	heart
H&M	hit or miss
IN, in.	inches
ISA	International Soc of Arboicultue
J&P	joists and planks
KD	kiln dried
LBR, Lbr	lumber
LGR	longer
LGTH	length
Lft, LF	lineal foot
LIN, Lin	lineal
M	thousand
MBM, MBF, M. BM	thousand (feet) board measure
MC, M.C.	moisture content
MERCH, Merch	merchantable
MG	medium or mixed grain
Mft.	thousand feet
N/A, NA	not available
NBM	net board measure
NHLA	National Hardwood Lumber Association
No.	number
PAD	partially air dry
Pcs.	pieces
PE	plain end
P1S, P2S	see S1S and S2S
RDM	random
REG, Reg	regular
RGH, Rgh.	rough
R/L, RL	random lengths
RES	resawn
SDG, Sdg	siding
S-DRY	surfaced dry. Lumber, 19% moisture content or more
SEL, Sel	select or select grade
SG	slash or flat grain
S-GRN	surfaced green, lumber 19% moisture content or less.
STD. M	standard matched

SM	surface measure
Specs	specifications
SQ	square
STD, Std	standard
Std. lgths.	standard lengths
STR	structural
S&E	side and edge (surfaced on)
S1E	surfaced one edge
S2E	surface two edges
S1S	surface one side
S2S	surfaced two sides
S4S	surfaced four sides
S1S1E	surfaced one side, one edge
S1S2E	surfaced one side, two edges
S2S1E	surface two sides, one edge
TBR	timber
T&G	tongue and groove
VG	vertical, edge grain
Wt	weight
WTH	width
WWPA	Western Wood Products Association

____

[1]Source: U.S. Forest Products Laboratory, 1974. and others.

APPENDIX B. - GLOSSARY [1]

ACTUAL SIZE. The finished size, specifically of lumber. The minimum sizes to which lumber may be finished or dressed are specified in the American Lumber Standard for softwood lumber and are listed in regional grading rules. Sizes vary by type of product, moisture content at time of dressing and, in some cases by species.* (See Lumber- dressed size.)

AMERICAN LUMBER STANDARDS. American lumber standards embody provisions for softwood lumber dealing with recognized classifications, nomenclature, basic grades, sizes, description, measurements, tally, shipping provisions, grade marking, and inspection of lumber. The primary purpose of these standards is to serve as a guide in the preparation or revision of the grading rules of the various lumber manufacturers' associations. A purchaser must, however, make use of association rules as the basic standards are not in themselves commercial rules.

ANNUAL GROWTH RING. The layer of wood growth put on a tree during a single growing season. In the temperature zone the annual growth rings of many species (e.g., oaks and pines) are readily distinguished because of differences in the cells formed during the early and late parts of the season. In some temperate zone species (black gum and *sweetgum)* and many tropical species, annual growth rings are not easily recognized.

BAND SAW. A saw consisting of a continuous piece of flexible steel, with teeth on one or both sides, used to cut logs into cants and also to rip lumber.*

BASTARD SAWN. Lumber (primarily hardwoods) in which the annual rings make angles of 30^0 to 60^0 with the surface of the piece.

BOARD. A piece of lumber less than two inches in nominal thickness and one inch or more in width.* *(See* **LUMBER.)**

BOARD FOOT. A unit of measurement of lumber represented by a board 1 foot long, 12 inches wide, and 1 inch thick or its cubic equivalent. In practice, the board foot calculation for lumber 1 inch or more in thickness is based on its nominal thickness and width and the length. Lumber with a nominal thickness of less than 1 inch is calculated as 1 inch.

BOLE. The main stem of a tree of substantial diameter, and roughly, capable of yielding saw timber, veneer logs, or large poles. Seedlings, saplings, and small-diameter trees have stems, not boles.

BOLT. (1) A short section of a tree trunk; (2) in veneer production, a short log of a length suitable for peeling in a lathe; (3) raw material used in the manufacture of shingles and shakes.

BOOKMATCHED. Consecutive flitches of veneer from the same log, laid side by side so that the pattern formed is almost symmetrical from the common center line. Used in decorative paneling or woodworking.*

BOW. The distortion of lumber in which there is a deviation, in a direction perpendicular to the flat face, from a straight line from end-to-end of the piece.

BOXED HEART. The term used when the pith falls entirely within the four faces of a piece of wood anywhere in its length. Also called boxed pith.

BURL. (1) A hard, woody outgrowth on a tree, more or less rounded in form, usually resulting from the entwined growth of a cluster of adventitious buds. Such buds are the source of the highly figured burl veneers used for purely ornamental] purposes. (2) In lumber or veneer, a localized severe distortion of the grain generally rounded in outline, usually resulting from overgrowth of dead branch stabs, varying from 1/2 inch to several inches in diameter; frequently includes one or more clusters of several small contiguous conical protuberances, each usually having a core or pith but no appreciable amount of end grain (in tangential view) surrounding it.

BUTT LOG. The first log from the butt end of the tree.*

CANT. (1) A log that has been slabbed on one or more sides. Ordinarily, cants are intended for resawing at right angles to their widest sawn face. The term is loosely used. *(See* **FLITCH.)** (2) A large timber cut from a log and destined for further processing by other saws.

CANT HOOK. A (hand) tool used to move cants and logs**.***

CASEHARDENING. A condition of stress and set in dry lumber characterized by compressive stress in the outer layers and tensile stress in the center or core.

CAT FACE. A scar on a tree or log, caused by fire or injury to the growing tree.*

CHECK. A lengthwise separation of the wood that usually extends across the rings of annual growth and commonly results from stresses set up in wood during seasoning.

CHIP. A small piece of wood used to make pulp. They are larger and coarser than sawdust.*

CHOKER. A wire rope or cable that is fastened around a log before pulling it to a landing.*

CLOSE GRAINED. *(See* **GRAIN.)**

COARSE GRAIN. *(see* **GRAIN.)**

COLLAPSE. The flattening of single cells or rows of cells in heartwood during the drying or pressure treatment of wood. Often characterized by a caved-in or corrugated appearance of the wood surface.

COMPRESSION WOOD. Wood formed on the lower side of branches and inclined trunks of softwood trees. Compression wood is identified by its relatively wide annual rings, usually eccentric, relatively large amount of summerwood, sometimes more than 50 percent of the width of the annual rings in which it occurs, and its lack of demarcation between springwood and summerwood in the same annual rings. Compression wood shrinks excessively lengthwise, as compared with normal wood.

CORE STOCK. A solid or discontinuous center ply used in panel-type glued structures (such as furniture panels and solid or hollowcore doors).

CROOK. The distortion of lumber in which there is a deviation, in a direction perpendicular to the edge, from a straight line from end-to-end of the piece,

CROSSCUT. Cut with a saw across the width or grain.*

CROSS GRAIN. An area in a piece of lumber in which the grain of the wood is distorted so that it runs across the piece from edge to edge instead of along the length of the piece*.

CULL. (1) A tree or log that is less than 1/3 usable for lumber or plywood because of excessive decay of other defects. (2) Lumber with the lowest quality, with little or no commercial value.*

CUP. A distortion of a board in which there is a deviation flatwise from a straight line across the width of the board.

CUSTOM MILLING. The surfacing or remanufacture of lumber on a contract basis and to order*.

DEBARKER. A machine used to remove bark from logs prior to processing them into lumber or plywood.*

DENSITY. As usually applied to wood of normal cellular form, density is the mass of wood substance enclosed within the boundary surfaces of a wood-plus-voids complex having unit volume. It is variously expressed as pounds per cubic foot, kilograms per cubic meter, or grams per cubic centimeter at a specified moisture content.

DIAGONAL GRAIN. *(See* **GRAIN.)**

DIMENSION. Lumber that is from 2 inches up to, but not including, 5 inches thick, and that is 2 or more inches in width.*

DRY. Wood usually seasoned to a moisture content of 19% or less.

EARLYWOOD. The portion of the annual growth ring that is formed during the early part of the growing season. It is usually less dense *and* weaker mechanically than latewood.

EDGE. The narrow faces of rectangular-shaped lumber. Also used to identify the outside portion of the wide face.*

EDGE GRAIN. *(See* **GRAIN.)**

EDGER. A piece of sawmill machinery used to saw cants after they come off the head rig, squaring the edges and ripping the cants into lumber.*

EDGING. Waste pieces of wood cut by an edger when cutting and squaring lumber from slab or cant.*

ENCASED KNOT. *(See* **KNOT.)**

END GRAIN. *(See* **GRAIN.)**

FACTORY AND SHOP LUMBER. (*See* **LUMBER.)**

FIGURE. The pattern produced in a wood surface by annual growth rings, rays, knots, deviations from regular grain such as interlocked and wavy grain, and irregular coloration.

FLAT GRAIN. *(See* **GRAIN.)**

FLAT-SAWN. *(See* **GRAIN, FLAT.)**

FLECKS. *(See* **RAYS WOOD.)**

FLITCH. A portion of a log sawn on two or more faces-commonly on opposite faces, leaving two waney edges. When intended for resawing into lumber, it is resawn parallel to its original wide faces. Or, it may be sliced or sawn into veneer, in which case the resulting sheets of veneer laid together in the sequence of cutting are called a flitch. The term is loosely used. (See also Cant.)

FORKLIFT. A piece of mechanized equipment used to move units of lumber, plywood, (or logs). Steel blades of "forks" slip under the load, which is then lifted hydraulically, moved to the desired location, and lowered into place.*

FOUR-QUARTER (4/4). A reference to the thickness of lumber that uses a nominal 1/4-inch scale. A "4/4" is a nominal 1 in. thick, "5/4" is 1 1/4 in. thick, "6/4" is 1 1/2 in thick. etc.

FULL SAWN. A grading term used to describe rough lumber that has been cut to standard sizes but has not varied below the standard sawn size as provided in the grading rules.*

GIRDER. A large or principal beam of wood or steel used to support concentrated loads at isolated points along its length.

GRADE. The designation of the quality of a manufactured piece of wood or of logs.

GRAIN. The direction, size, arrangement, appearance, or quality of the fibers in wood or lumber. To have a specific meaning the term must be qualified.

Close-grained wood. Wood with narrow, inconspicuous annual rings. The term is sometimes used to designate wood having small and closely spaced pores, but in this sense the term "fine textured" is more often used.

Coarse-grained wood. Wood with wide conspicuous annual rings in which there is considerable difference between springwood and summerwood. The term is sometimes used to designate wood with large pores, such as oak, ash, chestnut, and walnut, but in this sense the term "coarse textured" is more often used.

Cross-grained wood. Wood in which the fibers deviate from a line parallel to the sides of the piece. Cross grain may be either diagonal or spiral grain or a combination of the two.

Curly-grained wood. Wood in which the fibers are distorted so that they have a curled appearance, as in "birdseye" wood. The areas showing curly grain may vary up to several inches in diameter.

Diagonal-grained wood. Wood in which the annual rings are at an angle with the axis of a piece as a result of sawing at an angle with the bark of the tree or log. A form of cross-grain.

Edge-grained wood. Lumber that has been sawed so that the wide surfaces extend approximately at right angles to the annual growth rings. Lumber is considered edge grained when the rings form an angle of 45^{o} to 90^{o} with the wide surface of the piece.

End-grained wood . The grain as seen on a cut made at a right angle to the direction of the fibers (e.g., on a cross section of a tree).

Fiddlebock-grained wood. Figure produced by a type of fine wavy grain found, for example, in species of maple, such wood being traditionally used for the backs of violins.

Fine-grained wood. *(See* **Close-grained wood.)**

Flat-grained wood. Lumber that has been sawed parallel to the pith and approximately tangent to the growth rings. Lumber is considered flat grained when the annual growth rings make an angle of less than 45^{o} with the surface of the piece. (See Fig. 8.2.-B)

Interlocked-grained wood. Grain in which the fibers put on for several years may slope in a right-handed direction, and then for a number of years The slope reverses to a left-handed direction, and later changes back to a right-handed pitch, and so on. Such wood is exceedingly difficult to split radially, though tangentially it may split fairly easily.

Open-grained wood. Common classification for woods with large pores, such as oak, ash, chestnut, and walnut. Also brown as "coarse textured."

Plainsawed lumber. Another term for flat-grained lumber

Quartersawn lumber. Lumber sawn so that the annual rings form angles of 45 to 90 with the surface of the piece.* Another term for edge-grained lumber. (See Fig. 8.2.-A)

Side-grained wood , Another term for flat-grained lumber.

Slash-grained wood. Another term for flat-grained lumber.

Spiral-grained wood. Wood in which the fibers take a spiral course about the trunk of a tree instead of the normal vertical course. The spiral may extend in a right-handed or left-handed direction around the tree trunk. Spiral grain is a form of cross grain.

Straight-grained wood. Wood in which the fibers run parallel to the axis of a piece.

Vertical-grained lumber. Another term for edge-grained lumber.

Wavy-grained wood. Wood in which the fibers collectively take the form of waves or undulations.

GREEN. Freshly sawed or undried wood. Wood that has become completely wet after immersion in water would not be considered green, but may be said to be in the "green condition."

HARDWOODS. Generally one of the botanical groups of trees that have broad leaves in contrast to the conifers or softwoods. The term has no reference to the actual hardness of the wood.

HEART ROT. Any rot characteristically confined to the heartwood. It generally originates in the living tree.

HEARTWOOD. The wood extending from the pith to the sapwood, the cells of which no longer participate in the life processes of the tree. Heartwood may contain phenolic compounds, gums, resins, and other materials that usually make it darker and more decay resistant than sapwood.

INTERNATIONAL 1/4 SCALE. This log scale, a modification of an earlier rule using a 1/8 in. kerf, is based on an analysis of the loss of wood fiber incurred in the conversion of sawlogs to lumber. It is one of the few rules incorporating a basis for dealing with log taper*.

JOINERY. A term used in Europe to denote the higher grades of lumber suitable for such uses as cabinetry, millwork, or interior trim.*

KERF. The width of a saw cut; this portion of a log is lost as waste when it (the log) is sawn for lumber. The size of the kerf is dependent on saw size, saw type, sharpness, and other factors.

KILN. A chamber having controlled air-flow, temperature, and relative humidity, for drying lumber, veneer, and other wood products.

KNOT. That portion of a branch or limb which has been surrounded by subsequent growth of the stem. The shape of the knot as it appears on a cut surface depends on the angle of the cut relative to the long axis of the knot.

Encased knot. A knot whose rings of annual growth are not intergrown with those of the surrounding wood.

Intergrown knot. A knot whose rings of annual growth are completely intergrown with those of the surrounding wood.

Loose knot. A knot that is not held firmly in place by growth or position and that cannot be relied upon to remain in place.

Pin knot. A knot that is not less than 1/2 inch in diameter.

Sound knot. A knot that is solid across its face, at least as hard as the surrounding wood, and shows no indication of decay.

Spike knot. A knot cut approximately parallel to its long axis so that the exposed section is definitely elongated.

LOG DECK. A pile of logs; a deck in use is called a hot deck, while one where logs are stored for later use is called a cold deck.*

LOG SCALE. A measure of the volume of wood in a log or logs, usually expressed in board feet and based on any of various log scaling rules.

LUMBER. The product of the saw and planing mill not further manufactured than by sawing, resawing, passing lengthwise through a standard planing machine, crosscutting to length, and matching.

Boards. Lumber that is nominally less than 2 inches thick and 2 or more inches wide. Boards less than 6 inches wide are sometimes called strips

Dimension. Lumber with a nominal thickness of from 2 up to but not inducing 5 inches and a nominal width of 2 inches or more.

Dressed size. The dimensions of lumber after being surfaced with a planing machine. The dressed size is usually 1/2 to 3/4 inch less than the nominal or rough size. A 2- by 4-inch stud, for example, actually measures about 1 1/2 by 3 1/2 inches. (See Actual size.)

Factory and shop lumber. Lumber intended to be cut up for use in further manufacture. It is graded on the basis of the percentage of the area that will produce a limited number of cuttings of a specified minimum size and quality.

Matched lumber. Lumber that is edge dressed and shaped to make a close tongued-and-grooved joint at the edges or ends when laid edge to edge or end to end.

Nominal size. As applied to timber or lumber, the size by which it is known and sold in the market; often differs from the actual size, e.g. 2-by-4, 1-by-6. (See also, Dressed size.)

Patterned lumber. Lumber that is shaped to a pattern or to a molded form in addition to being dressed, matched, or shiplapped, or any combination of these workings.

Rough lumber. Lumber which has not been dressed (surfaced) but which has been sawed, edged, and trimmed,

Shiplapped lumber. Lumber that is edge dressed to make a lapped joint.

Shipping-dry lumber. Lumber that is partially dried to prevent stain and mold in transit.

Side lumber. A board from the outer portion of the log; ordinarily one produced when squaring off a log for a tie or timber.

Structural lumber. lumber that is intended for use where allowable properties are required. The grading of structural lumber is based on the strength of the piece as related to anticipated uses.

Surface lumber. Lumber that is dressed by running it through a planer.

Timbers. Lumber that is nominally 5 or more inches In least dimension. Timbers may be used as beams, stringers, posts, caps, sills, girders, purlins, etc.

Yard lumber. A little-used term for lumber of all sizes and patterns that is intended for general building purposes having no design property requirements.

MEDIUM GRAIN. Lumber that exhibits an average of approximately four or more annual growth rings per inch on one end of the piece or the other. The ring count is a measure of the strength of the piece as related to the rate of growth of the tree from which it is manufactured. A piece that averages one-third or more summer wood may also qualify as medium grain.*

MOISTURE CONTENT. The amount of water contained in the wood, usually expressed as a percentage of the weight of the ovendry wood.

NET SCALE. The measurement of a yield of a log after deduction for defects.*

NORMAL MEASURE The nominal or common name sizes of lumber, usually expressed in terms of the nearest inch regardless of actual surfaced, or net, sizes.* (See "lumber" nominal size.)

OVENDRY WOOD. Wood dried to a relatively constant weight in a ventilated oven at 101^{o} to 105^{o} C.

OVERRUN. The volume of lumber obtained from a log in excess of the estimated volume of that log, based on log scale.*

PEAVEY. A tool used in turning logs; it consists of a lever and a moveable curved hook.*

PECKY. Characterized by peck, channeled or pitted areas or pockets as sometimes found in cedar and cypress.*

PITCH. Accumulation of resin in the wood cells in a more or less irregular patch. Classified for grading purposes as light, medium, heavy, or massed.*

PITCH STREAKS. A well-defined accumulation of pitch in a more or less regular streak in the wood of certain conifers.

PITH. The small, soft core occurring near the center of a tree trunk, branch, twig, or log.

PLANK. A broad board, usually more than 1 inch thick, laid with its wide dimension horizontal and used as a bearing surface.

QUARTER MEASURE. A reference to the thickness of lumber, especially select, industrial and board material which utilizes a nominal one-quarter inch scale. Thus, 4/4 is a nominal 1-inch, 5/4 is 1 1/4 inches, 6/4 is 1 1/2 inches, etc.*

QUARTERSAWED. *(See* **GRAIN.)**

RADIAL. Coincident with a radius from the axis of the tree or log to the circumference. A radial section is a lengthwise section in a plane that passes through the centerline of the tree trunk.

RAYS, WOOD. Strips of cells extending radially within a tree and varying in height from a few cells in some species to 4 or more inches in oak. The rays serve primarily to store food and transport it horizontally in the tree. On quartersawed oak, the rays form a conspicuous figure, sometimes referred to as flecks.

REACTION WOOD. Wood with more or less distinctive anatomical characters, formed typically in parts of leaning or crooked stems and in branches. In hardwoods this consists of tension wood and in softwoods of compression wood.

RESAW. To resaw a piece of lumber along its horizontal axis. A bandsaw that performs this operation.

RESAWN LUMBER. Lumber that has been resawn on a horizontal axis to produce two thinner pieces

RING FAILURE. A separation of the wood during seasoning, occurring along the grain and parallel to the growth rings. (See also, Shake.)

RING-POROUS WOODS. A group of hardwoods in which the pores are comparatively large at the beginning of each annual ring and decrease in size more or less abruptly toward the outer portion of the ring, thus forming a distinct inner zone of pores, known as the earlywood, and an outer zone with smaller pores, known as the latewood.

ROUGH. Not dressed or surfaced: the surface texture is the same as when the piece was first sawn or peeled.

ROUGH LUMBER. Lumber that has not been dressed or surfaced, but has been sawn, edged or trimmed.*

ROUNDWOOD. Logs, bolts, and other round sections as that are cut from a tree.*

SAPWOOD. The wood of pale color near the outside of the log. Under most conditions the sapwood is more susceptible to decay than heartwood.

SAW KERF. (1) Grooves or notches made in cutting with a saw; (2) that portion of a log, timber, or other piece of wood removed by the saw in parting the material into two pieces.

SCHEDULE, KILN DRYING. A prescribed series of dry- and wet-bulb temperatures and air velocities used in drying a kiln charge of lumber or other wood products.

SEASONED. Not green; dried to a moisture content not exceeding 19%. Correctly termed dry.*

SEASONING. Removing moisture from green wood to improve its serviceability.

Air-dried. Dried by exposure to air in a yard or shed, without artificial heat.

Kiln-dried. Dried in a kiln with the use of artificial heat.

SELECT. A high-quality piece of lumber graded for appearance.*

SHAKE. A separation along the grain, the greater part of which occurs between the rings of annual growth. Usually considered to have occurred in the standing tree or during felling.

SHOP. Lumber that is graded with reference to its cutting qualities for use in millwork items such as door and window parts. Also, a term used to describe reject sheathing and sanded plywood.*

SIX-QUARTER (6/4). See Quarter measure.

SLAB. A slice of wood cut from a log, a cant.*

SLOPE OF GRAIN. The deviation of the line of fibers from a straight line parallel to the sides of a piece.*

SNAG. Standing dead tree, or portion of a tree from which most or all of the foliage, limbs, etc. have fallen away.

SOFTWOODS. Generally, one of the botanical groups of trees that in most cases have needlelike or scalelike leaves; the conifers, also the wood produced by such trees. The term has no reference to the actual hardness of the wood.

SPECIFIC GRAVITY. As applied to wood, the ratio of the ovendry weight of a sample to the weight of a volume of water equal to the volume of the sample at a specified moisture content (green, air-dry, or oven-dry).

STICKERS. Strips or boards used to separate the layers of lumber in a pile and thus improve air circulation.

SUMMERWOOD. The dense fibrous outer portion of each annual ring of a tree, formed late in the growing period, but not necessarily in the summer.*

SURFACED. Refers to the lumber that has been dressed by planing for the purpose of attaining smoothness of surface and uniformity of size on at least one side or edge.*

SWEEP. The curvature of bend of a log, pole, or piling. It's classified as a defect.*

TANGENTIAL. Strictly, coincident with a tangent at the circumference of a tree or log, or parallel to such a tangent. In practice, however, it often means roughly coincident with a growth ring. A tangential section is a longitudinal section through a tree or limb perpendicular to a radius. Flat-grained lumber is sawed tangentially.

TENSION WOOD. A form of wood found in leaning trees of some hardwood species and characterized by the presence of gelatinous fibers and excessive longitudinal shrinkage. Tension wood fibers hold together tenaciously, so that sawed surfaces usually have projecting fibers, and planed surfaces often are torn or have raised grain. Tension wood may cause warping.

TRIM SAW. A set of saws, usually circular used to cut lumber to various lengths by lowering individual blades to make contact with the lumber as it passes beneath the saws on a moving chain. Trim saws also cut out defects and improve grade recovery.*

TWIST. A distortion caused by the turning or winding of the edges of a board so that the four corners of any face are no longer in the same plane.

VERTICAL GRAIN. *(See* **Grain.)**

WANE. Bark or lack of wood from any cause on edge or corner of a piece.

WARP. Any variation from a true or plane surface. Warp includes bow, crook, cup, and twist, or any combination thereof.

WET-BULB TEMPERATURE. The temperature indicated by the wet-bulb thermometer of a psychrometer.

---

[1]Definitions without an * are from the U.S. Forest Products Laboratory 1974 Wood Handbook. Those with an * are from Terms of the Trade by Dean and Evans (editors), 1974.

Appendix C. The International Log Rule [1] -- Saw Kerf = inch [2]

Diameter	Volume in board feet of logs of indicated length in feet						
(inches)	8	10	12	14	16	18	20
4	---	5	5	5	5	5	10
5	5	5	10	10	10	15	15
6	10	10	15	15	20	25	25
7	10	15	20	25	30	35	40
8	15	20	25	35	40	45	50
9	20	30	35	45	50	60	70
10	30	35	45	55	65	75	85
11	35	45	55	70	80	95	105
12	45	55	70	85	95	110	125
13	55	70	85	100	115	135	150
14	65	80	100	115	135	155	175
15	75	95	115	135	160	180	205
16	85	110	130	155	180	205	235
17	95	125	150	180	205	235	265
18	110	140	170	200	230	265	300
19	125	155	190	225	260	300	335
20	135	175	210	250	290	330	370
21	155	195	235	280	320	365	410
22	170	215	260	305	355	405	455
23	185	235	285	335	390	445	495
24	205	255	310	370	425	485	545
25	220	280	340	400	460	525	590
26	240	305	370	435	500	570	640
27	260	330	400	470	540	615	690
28	280	355	430	510	585	665	745
29	305	385	465	545	630	715	800
30	325	410	495	585	675	765	860
31	350	440	530	625	720	820	915
32	375	470	570	670	770	875	980
33	400	500	605	715	820	930	1045
34	425	535	645	760	875	990	1110
35	450	565	685	805	925	1050	1175
36	475	600	725	855	980	1115	1245
37	505	635	770	905	1040	1175	1315
38	535	670	810	955	1095	1245	1390
39	565	710	855	1005	1155	1310	1465
40	595	750	900	1060	1220	1380	1540
41	625	785	950	1115	1280	1450	1620
42	655	825	995	1170	1345	1525	1705
43	690	870	1045	1230	1410	1600	1785
44	725	910	1095	1290	1480	1675	1870
45	755	955	1150	1350	1550	1755	1960
46	795	995	1200	1410	1620	1835	2050
47	830	1040	1255	1475	1695	1915	2140
48	865	1090	1310	1540	1770	2000	2235

1/ From Munns et al. (1949) Converting Factors and Tables of Equivalents Used in Forestry.

2/ Scale for seasoned lumber with 1/16-inch shrinkage per 1-inch board, and saws cutting a 1/4 inch kerf, or for green lumber, for saws cutting a 5/16-inch kerf. For saws cutting a 1/8-inch kerf add 10.5%.

Formula: $((D^2 X0.22)-0.71D)X0.904762$ for 4-foot sections. Taper allowance: 1/2 inch per 4 lineal feet.

Appendix D. Solid Content of Logs in Cubic Feet [1/]

Length (feet)	Average mid-diameter of logs in inches																	
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
4	0.3	0.3	0.5	1	1	1	2	2	3	3	4	4	5	6	6	7	8	9
5	0.3	0.5	0.5	1	1	2	2	3	3	4	5	5	6	7	8	9	10	11
6	0.3	0.5	1	1	2	2	3	3	4	5	6	6	7	8	9	11	12	13
7	0.3	0.5	1	1	2	2	3	4	5	5	6	7	9	10	11	12	14	15
8	0.5	0.5	1	2	2	3	4	4	5	6	7	9	10	11	13	14	16	17
9	0.5	1	1	2	2	3	4	5	6	7	8	10	11	13	14	16	18	20
10	0.5	1	1	2	3	3	4	5	7	8	9	11	12	14	16	18	20	22
11	0.5	1	1	2	3	4	5	6	7	9	10	12	13	15	17	19	22	24
12	0.5	1	2	2	3	4	5	7	8	9	11	13	15	17	19	21	24	26
13	0.5	1	2	3	3	5	6	7	9	10	12	14	16	18	20	23	26	28
14	0.5	1	2	3	4	5	6	8	9	11	13	15	17	20	22	25	28	31
15	0.5	1	2	3	4	5	7	8	10	12	14	16	18	21	24	27	30	33
16	1	1	2	3	4	6	7	9	11	13	15	17	20	22	25	28	32	35
17	1	1	2	3	5	6	8	9	11	13	16	18	21	24	27	30	33	37
18	1	2	2	4	5	6	8	10	12	14	17	19	22	25	28	32	35	39
19	1	2	3	4	5	7	8	10	13	15	18	20	23	27	30	34	37	41
20	1	2	3	4	5	7	9	11	13	16	18	21	25	28	32	35	39	44
21	1	2	3	4	6	7	9	11	14	16	19	22	26	29	33	37	41	46
22	1	2	3	4	6	8	10	12	15	17	20	24	27	31	35	39	43	48
23	1	2	3	5	6	8	10	13	15	18	21	25	28	32	36	41	45	50
24	1	2	3	5	6	8	11	13	16	19	22	26	29	34	38	42	47	52
25	1	2	3	5	7	9	11	14	16	20	23	27	31	35	39	44	49	55
26	---	---	---	5	7	9	11	14	17	20	24	28	32	36	41	46	51	57
27	---	---	---	5	7	9	12	15	18	21	25	29	33	38	43	48	53	59
28	---	---	---	5	7	10	12	15	18	22	26	30	34	39	44	49	55	61
29	---	---	---	6	8	10	13	16	19	23	27	31	36	40	46	51	57	63
30	---	---	---	6	8	10	13	16	20	24	28	32	37	42	47	53	59	65
31	---	---	---	6	8	11	14	17	20	24	29	33	38	43	49	55	61	68
32	---	---	---	6	9	11	14	17	21	25	29	34	39	45	50	57	63	70

[1/] Adapted from Munns et al. (1949) - Converting Factors and Tables of Equivalents Used in Forestry.

Appendix D. (con't) Solid Content of Logs in Cubic Feet [1]

Length (feet)	Average mid-diameter of logs in inches														
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
4	10	11	12	13	14	15	16	17	18	19	20	21	22	24	25
5	12	13	14	16	17	18	20	21	23	25	26	28	30	32	33
6	14	16	17	19	20	22	24	26	28	29	31	34	36	38	40
7	17	18	20	22	24	26	28	30	32	34	37	39	42	44	47
8	19	21	23	25	27	29	32	34	37	39	42	45	48	50	53
9	22	24	26	28	31	33	36	38	41	44	47	50	53	57	60
10	24	26	29	31	34	37	40	43	46	49	52	56	59	63	67
11	26	29	32	35	37	41	44	47	50	54	58	61	65	69	73
12	29	32	35	38	41	44	48	51	55	59	63	67	71	76	80
13	31	34	38	41	44	48	52	56	60	64	68	73	77	82	87
14	34	37	40	44	48	52	56	60	64	69	73	78	83	88	94
15	36	40	43	47	51	55	60	64	69	74	79	84	89	95	100
16	38	42	46	50	55	59	64	68	73	79	84	89	95	101	107
17	41	45	49	53	58	63	68	73	78	83	89	95	101	107	114
18	43	48	52	57	61	66	72	77	83	88	94	101	107	113	120
19	46	50	55	60	65	70	76	81	87	93	100	106	113	120	127
20	48	53	58	63	68	74	80	86	92	98	105	112	119	126	134
21	51	55	61	66	72	77	83	90	96	103	110	117	125	132	140
22	53	58	63	69	75	81	87	94	101	108	115	123	131	139	147
23	55	61	66	72	78	85	91	98	105	113	121	128	137	145	154
24	58	63	69	75	82	88	95	103	110	118	126	134	143	151	160
25	60	66	72	79	85	92	99	107	115	123	131	140	148	158	167
26	63	69	75	82	89	96	103	111	119	128	136	145	154	164	174
27	65	71	78	85	92	100	107	115	124	133	142	151	160	170	180
28	67	74	81	88	95	103	111	120	128	137	147	156	166	177	187
29	70	77	84	91	99	107	115	124	133	142	152	162	172	183	194
30	72	79	87	94	102	111	119	128	138	147	157	168	178	189	200
31	75	82	89	97	106	114	123	133	142	152	162	173	184	195	207
32	77	84	92	101	109	118	127	137	147	157	168	179	190	202	214

[1] Adapted from Munns et al. (1949) - Converting Factors and Tables of Equivalents Used in Forestry.

APPENDIX E. Lumber Board Foot Volume for Different End Dimensions

Thickness (T) and width (W) (inches)	T x W[1] / 12	Lumber length (ft.)									
		6	8	10	12	14	16	18	20	22	24
		Contents in board feet									
1x1	0.083	0.5	0.7	0.8	1.0	1.2	1.3	1.5	1.7	1.8	2.0
1x2	0.166	1.0	1.3	1.7	2.0	2.3	2.7	3.0	3.3	3.7	4.0
1x3	0.250	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
1x4	0.333	2.0	2.7	3.3	4.0	4.7	5.3	6.0	6.7	7.3	8.0
1x5	0.417	2.5	3.3	4.2	5.0	5.8	6.7	7.5	8.3	9.2	10.0
1x6	0.500	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0
1x8	0.667	4.0	5.3	6.7	8.0	9.3	10.7	12.0	13.3	14.7	16.0
1x10	0.833	5.0	6.7	8.3	10.0	11.7	13.3	15.0	16.7	18.3	20.0
1x12	1.000	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0
2x2	0.333	2.0	2.7	3.3	4.0	4.7	5.3	6.0	6.7	7.3	8.0
2x3	0.500	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0
2x4	0.667	4.0	5.3	6.7	8.0	9.3	10.7	12.0	13.3	14.7	16.0
2x6	1.000	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0
2x8	1.333	8.0	10.7	13.3	16.0	18.7	21.3	24.0	26.7	29.3	32.0
2x10	1.667	10.0	13.3	16.7	20.0	23.3	26.7	30.0	33.3	36.7	40.0
2x12	2.000	12.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0	44.0	48.0
3x4	1.000	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0
3x6	1.500	9.0	12.0	15.0	18.0	21.0	24.0	27.0	30.0	33.0	36.0
3x8	2.000	12.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0	44.0	48.0
3x10	2.500	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0
3x12	3.000	18.0	24.0	30.0	36.0	42.0	48.0	54.0	60.0	66.0	72.0
4x4	1.333	8.0	10.7	13.3	16.0	18.7	21.3	24.0	26.7	29.3	32.0
4x6	2.000	12.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0	44.0	48.0
4x8	2.667	16.0	21.3	26.7	32.0	37.3	42.7	48.0	53.3	58.7	64.0
4x10	3.333	20.0	26.7	33.3	40.0	46.7	53.3	60.0	66.7	73.3	80.0
4x12	4.000	24.0	32.0	40.0	48.0	56.0	64.0	72.0	80.0	88.0	96.0
6x6	3.000	18.0	24.0	30.0	36.0	42.0	48.0	54.0	60.0	66.0	72.0
6x10	5.000	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0
6x12	6.000	36.0	48.0	60.0	72.0	84.0	96.0	108.0	120.0	132.0	144.0
8x8	5.333	32.0	42.7	53.3	64.0	74.7	85.3	96.0	106.7	117.3	128.0
8x10	6.667	40.0	53.3	66.7	80.0	93.3	106.7	120.0	133.3	146.7	160.0
8x12	8.000	48.0	64.0	80.0	96.0	112.0	128.0	144.0	160.0	176.0	192.0
10x10	8.333	50.0	66.7	83.3	100.0	116.7	133.3	150.0	166.7	183.3	200.0
10x12	10.000	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0	220.0	240.0
12x12	12.000	72.0	96.0	120.0	144.0	168.0	192.0	216.0	240.0	264.0	288.0

1/Cross-sectional area. For board foot volumes of any length board, multiply the T X W/12 value times board length; e.g. board foot volume of a “2 X 4” that is 15 ft. long is:

Board foot volume = 0.667 X 15 ft. = 10.0 bd. ft.

APPENDIX F. Wood Density as a Function of Specific Gravity and Moisture Content [1/]

Moisture content of wood (%)	Density in pounds-mass per cubic foot when the specific gravity[2] is ---										
	0.30	0.34	0.38	0.42	0.46	0.50	0.54	0.58	0.62	0.66	0.70
0	20.4	23.3	26.3	29.7	32.7	36.1	39.3	43.0	46.3	49.9	53.6
4	21.1	24.0	26.9	30.2	33.4	36.7	39.9	43.5	46.9	50.5	54.1
8	21.6	24.8	27.7	30.8	34.1	37.4	40.8	44.2	47.5	51.0	54.6
12	22.1	25.2	28.7	31.6	34.7	37.9	41.3	44.7	48.1	51.5	55.0
16	22.5	25.7	28.9	32.1	35.2	38.6	41.9	45.2	48.5	52.0	55.5
20	23.1	26.2	29.4	32.5	35.9	39.1	42.4	46.0	49.0	52.4	55.9
24	23.8	26.6	30.0	33.2	36.4	39.7	43.0	46.4	49.5	52.9	56.3
28	24.0	27.3	30.7	33.7	36.9	40.2	43.5	46.9	50.1	53.3	56.6
32	24.7	28.0	31.3	34.6	37.9	41.2	44.5	47.8	51.1	54.4	57.7
36	25.5	28.9	32.2	35.6	39.0	42.4	45.8	49.2	52.6	56.0	59.4
40	26.2	29.7	33.2	36.7	40.2	43.7	47.2	50.7	54.2	57.7	61.2
44	27.0	30.6	34.1	37.7	41.3	44.9	48.5	52.1	55.7	59.3	62.9
48	27.7	31.4	35.1	38.8	42.5	46.2	49.9	53.6	57.3	61.0	64.6
52	28.5	32.2	36.0	38.8	43.6	47.4	51.2	55.0	58.8	62.6	66.4
56	29.2	33.1	37.0	40.9	44.8	48.7	52.6	56.5	60.4	64.2	68.1
60	30.0	33.9	37.9	41.9	45.9	49.9	53.9	57.9	61.9	65.9	69.9
64	30.7	34.8	38.9	53.0	47.1	51.2	55.3	59.4	63.4	67.5	71.6
68	31.4	35.6	39.8	44.0	48.2	52.4	56.6	60.8	65.0	69.2	73.4
72	32.2	36.5	40.8	45.1	49.4	53.7	58.0	62.3	66.5	70.8	75.1
76	32.9	37.3	41.7	46.1	50.5	54.9	59.3	63.7	68.1	72.5	76.9
80	33.7	38.2	42.7	47.2	51.7	56.2	60.7	65.1	69.6	74.1	78.6
84	34.4	39.0	43.6	48.2	52.8	57.4	62.0	66.6	71.2	75.8	80.4
88	35.2	39.9	44.6	49.3	54.0	58.7	63.3	68.0	72.7	77.4	82.1
92	35.9	40.7	45.5	50.2	55.1	59.9	64.7	69.5	74.3	79.1	83.9
96	36.7	41.6	46.5	51.4	56.3	61.2	66.0	70.9	75.8	80.7	85.6
100	37.4	42.4	47.4	52.4	57.4	62.4	67.4	72.4	77.4	82.4	87.4
110	39.3	44.6	49.8	55.0	60.3	65.5	70.8	76.0	81.2	86.5	91.7
120	41.2	46.7	52.2	57.7	63.1	68.6	74.1	79.6	85.1	90.6	96.1
130	43.1	48.8	54.5	60.3	66.0	71.8	77.5	83.2	89.0	94.7	100.5
140	44.9	50.9	56.9	62.9	68.9	74.9	80.9	86.9	92.9	98.8	104.8
150	46.8	53.0	59.3	65.5	71.8	78.0	84.2	90.5	96.7	103.0	109.2

[2] Based on mass when ovendry & volume at tabulated moisture content (above 30% M.C.).

[1/] Adapted from U.S. Forest Products Laboratory, 1974. Wood Handbook. Note: density values at moisture contents 28% and below have been adjusted for specific gravities based on oven dry weight and volume at the indicated moisture contents (Fig. 3-4 in Wood Handbook).

APPENDIX G. WOOD DENSITY AND SPECIFIC GRAVITY FOR VARIOUS TREE SPECIES [1/]

Species	Weight/ft^3 (lbs)		Weight/MBF (lbs.)	Specific gravity*	
	Green	Air dry**		Air dry**	Green
Red alder	46	28	2,330	0.41	0.37
Oregon ash	46	38	3,160	0.55	0.50
Aspen	43	26	2,170	0.38	0.35
Birch	57	44	3,670	0.63	0.57
Incense cedar	45	NA***	NA	NA	0.35
W. red cedar	27	23	1,920	0.33	0.31
Black cottonwood	46	24	2,000	0.35	0.32
Douglas-fir	38	34	2,830	0.48	0.45
American elm	54	35	2,920	0.50	0.46
White fir	46	27	2,250	0.38	0.36
W. hemlock	41	29	2,420	0.42	0.38
Western larch	48	36	3,000	0.52	0.48
Black locust	58	48	4,000	0.69	0.66
Honey locust	61	NA	NA	NA	0.60
Evergr. magnolia	59	35	2,920	0.50	0.46
Bigleaf maple	47	34	2,830	0.48	0.44
Red oak (E.)	64	44	3,670	0.63	0.57
White oak (E.)	63	47	3,920	0.67	0.59
Lodgepole pine	39	29	2,420	0.41	0.38
Ponderosa pine	45	28	2,330	0.40	0.38
Sugar pine	52	25	2,080	0.36	0.35
Redwood	50	28	2,330	0.40	0.38
Sweetgum	50	34	2,830	0.49	0.44
Sycamore	34	34	2,830	0.49	0.46
Black walnut	38	38	3,170	0.55	0.51

*Assume a green volume and 12% moisture content. ***Not available.

**Air dry is assumed to be at 12% moisture content.

[1/] Adapted from the 1955 Forestry Handbook (Forbes, 1955).

APPENDIX H. Green Log Weight as a Function of Mid-log Diameter, Log Length, and Density

Mid-log		Log length (ft)														
Diam (in)	Area (in^2)	5					15					25				
		Weight/cu. ft. (lb)					Weight/cu. ft. (lb)					Weight/cu. ft. (lb)				
		25	35	45	55	65	25	35	45	55	65	25	35	45	55	65
6	0.20	25	35	45	55	65	75	105	135	165	195	125	175	225	275	325
8	0.35	44	61	79	96	114	131	184	236	289	341	219	306	394	481	569
10	0.55	69	96	124	151	179	206	289	371	454	536	344	481	619	756	894
12	0.79	99	138	178	217	257	296	415	533	652	770	494	691	889	1,086	1,284
14	1.07	134	187	241	294	348	401	562	722	883	1,043	669	936	1,204	1,471	1,739
16	1.40	175	245	315	385	455	525	735	945	1,155	1,365	875	1,225	1,575	1,925	2,275
18	1.77	221	310	398	487	575	664	929	1,195	1,460	1,726	1,106	1,549	1,991	2,434	2,876
20	2.18	273	382	491	600	709	818	1,145	1,472	1,799	2,126	1,363	1,908	2,453	2,998	3,543
22	2.64	330	462	594	726	858	990	1,386	1,782	2,178	2,574	1,650	2,310	2,970	3,630	4,290
24	3.14	393	550	707	864	1,021	1,178	1,649	2,120	2,591	3,062	1,963	2,748	3,533	4,318	5,103
26	3.69	461	646	830	1,015	1,199	1,384	1,937	2,491	3,044	3,598	2,306	3,229	4,151	5,074	5,996
38	4.28	535	749	963	1,177	1,391	1,605	2,247	2,889	3,531	4,173	2,675	3,745	4,815	5,885	6,955
30	4.91	614	859	1,105	1,350	1,596	1,841	2,578	3,314	4,051	4,787	3,069	4,296	5,524	6,751	7,979
32	5.59	699	978	1,258	1,537	1,817	2,096	2,935	3,773	4,612	5,450	3,494	4,891	6,289	7,686	9,084
34	6.31	789	1,104	1,420	1,735	2,051	2,366	3,313	4,259	5,206	6,152	3,944	5,521	7,099	8,676	10,254
36	7.07	884	1,237	1,591	1,944	2,298	2,651	3,712	4,772	5,833	6,893	4,419	6,186	7,954	9,721	11,489
38	7.88	985	1,379	1,773	2,167	2,561	2,955	4,137	5,319	6,501	7,683	4,925	6,895	8,865	10,835	12,805
40	8.73	1,091	1,528	1,964	2,401	2,837	3,274	4,583	5,893	7,202	8,512	5,456	7,639	9,821	12,004	14,186

Weight of any length log of the above mid-diameter can be determined by multiplying mid-log area (in^2) X log length (ft) X log density (lb/ft^3).

EXAMPLE: Determine the weight of a log 12 in. in diameter, 12 ft. long, and weighs 45 lb/ft^3.
Log weight = 0.79 in^2 X 12 ft. X 45 lb/ft^3 = 426.6 lb.

APPENDIX I. -- Phone Numbers of County Landfills Contacted in Green Waste Utilization Study

County	FAX Number	Contact	Page Number	Received FAX
Alameda	(714) 834-4110*		1	
Amador	(209) 223-6260		4	
Amador	(209) 223-2208		5	
Butte	(503) 796-0305		8	
Calaveras	(209) 754-6664		11	yes
Colusa	(916) 458-3035		12	
Contra Costa	(510) 223-1591		15	
Contra Costa	(510) 313-8904		16	
Contra Costa	(510) 682-1096		17	
Contra Costa	(415) 781-2635	Phylis	23	
Del Norte	(707) 465-1300		27	
Fresno	(209) 262-4466		34	
Glenn	(916) 934-6533	Scott	40	yes
Glenn	(916) 865-3680		41	
Humboldt	(707) 442-7485		42	
Humboldt	(707) 668-4402		44	
Humboldt	(707) 764-4396		45	yes
Imperial	(619) 352-1217		49	
Imperial	(619) 348-2714	Bruce/Joy	62	yes
Inyo	(619) 873-5599		64	
Kern	(805) 862-8901		76	yes
Kern	(805) 762-7696		90	yes
Kings	(209) 386-0629		101	yes
Kings	(209) 582-2757		103	yes
Lake	(707) 263-7748		107	
Los Angles	(818) 243-9369		117	
Los Angles	(805) 274-4289	Craig	118	
Los Angles	(310) 692-2941		119	yes
Los Angles	(818) 969-1529		120	
Los Angles	(805) 945-2269		124	
Los Angles	(805) 257-5730		125	
Los Angles	(310) 510-0244		130	
Los Angles	(805) 248-6415		135	
Los Angles	(818) 965-9569	Julia	143	
Los Angles	(310) 464-3572		144	yes
Los Angles	(818) 252-3239		146	
Madera	(209) 665-2307		149	
Marin	(415) 898-1354		151	
Marin	(415) 663-9034		152	
Mariposa	(209) 966-2828		154	
Mendocino	(707) 463-5474		155	
Mendocino	(707) 468-3427		158	

Mendocino	(707) 443-9572		159	
Mendocino	(707) 463-6204	Rick	164	yes
Mendocino	(707) 459-1562		165	
Merced	(209) 722-7690		170	
Merced	(209) 827-7006		172	
Modoc	(916) 233-3132		174	
Monterey	(408) 755-4958		189	yes
Monterey	(408) 754-2837	Chuck	192	
Monterey	(408) 384-3567		193	yes
Napa	(707) 253-4545		195	
Napa	(707) 963-7641		196	
Orange	(714) 834-4110		200	
Orange	(714) 841-4660		204	
PLacer	(916) 889-7599		207	
Placer	(916) 587-4244		208	yes
Plumas	(916) 832-5418		210	
Plumas	(916) 283-6323		211	
Riverside	(909) 275-1334		214	yes
Sacramento	(916) 875-6767	John	238	
Sacramento	(916) 731-5826		245	
San Bernardino	(909) 386-8646		264	
San Bernardino	(619) 326-4780		279	
San Bernardino	(619) 255-8799		307	
San Joaquin	(209) 468-3078		323	yes
San Luis Obispo	(805) 238-4704		327	
San Luis Obispo	(805) 549-9036	Kim	330	
San Luis Obispo	(805) 475-2211		333	
San Mateo	(818) 504-6490		334	
San Mateo	(415) 342-8132		336	
Santa Barbara	(805) 681-4051		342	
Santa Barbara	(805) 928-6632		344	
Santa Barbara	(805) 736-5347		345	yes
Santa Clara	(415) 962-8079	Julie	347	
Santa Clara	(408) 842-5664		348	
Santa Clara	(408) 730-7286	David	349	
Santa Clara	(415) 852-9289		350	yes
Santa Clara	(408) 262-2871		352	yes
Santa Clara	(408) 263-2393		353	yes
Santa Clara	(408) 779-5165	Brian	354	
Santa Cruz	(408) 429-3420		356	
Santa Cruz	(408) 763-4065		357	
Santa Cruz	(408) 336-3955		358	
Shasta	(916) 347-7056		363	
Shasta	(916) 225-5667	Patrick	366	yes
Sierra	(916) 289-3620		368	
Siskiyou	(916) 964-3175		370	
Siskiyou	(916) 842-4836	Robert	371	yes
Siskiyou	(916) 842-8288	Roger	372	

Solano	(707) 448-1257		382	
Solano	(510) 233-1591	Larry	386	
Sonoma	(707) 792-0416		390	
Stanislaus	(209) 538-1852		409	
Stanislaus	(209) 538-1825		410	
Tehama	(916) 385-1189	Garry	412	
Tehama	(707) 443-9572		413	
Tulare	(209) 730-6290		417	
Tuolumme	(209) 533-5698		429	yes
Ventura	(805) 579-7482		434	yes

*Area codes may have changed since this list was created.

APPENDIX J1. LANDFILL SURVEY COVER LETTER

Cal Poly
California Polytechnic State University
San Luis Obispo, CA 93407

Agribusiness Department
(805) 756-5027

Urban Tree Waste Survey

Hello, my name is Marianne Wolf. I am a professor at California Polytechnic State University, San Luis Obispo, and a member of a team that has received a grant from the California Department of Forestry and Fire Protection to study urban tree waste. The study examines the existing conditions and future potential of urban tree waste that could be manufactured into solid wood products.

The research team would greatly appreciate it if you would take a few minutes to complete this questionnaire. Your facility is one of a small group of waste disposal operations that is being contacted for initial information. Any suggestions that you have to improve this questionnaire is appreciated. The goal of this research is to contact all disposal operations in California. We also plan to contact government agencies, arbor companies, firewood operators, and others. Do you have any suggestions for other pertinent contacts?

Utilizing the larger limbs and tree trunks for valuable products would not only reduce the amount of green waste that goes to disposal sites, it would also provide a much greater economic return for this material than from current disposal methods (e.g. chipping, mulching, firewood, ect.). To achieve this goal, the volume of green wood waste must first be quantified. After the volume is quantified, manufacturing plants will be identified as well as markets for wood recycled from green wood waste.

The purpose of this questionnaire is to quantify the size of the green wood waste resource. For economical lumber production, green wood should be a minimum of 12 inches in diameter and 4 feet long. Smaller diameter material can be used, but less efficiently.

Please fax this survey to Dr. Marianne Wolf at 805-756-5040. If you have any questions, my phone number is 805-756-5027.

once again, thank you very much for your time and help.

Sincerely,
Dr. Marianne Wolf
Associate Professor

APPENDIX J2. LANDFILL SURVEY QUESTIONNAIRE

Urban Tree Waste Study

Name of Landfill ______________________________ Date _____________
Name & Title ________________________________
County ______________________________________

1. a. How much waste did your landfill receive in 1996? ______________(Specify Units)
   b. Out of that total, what percentage was Green Waste? ________________________

2. a. The list below describes a number of ways Green Waste may be utilized at your facility. Please circle all of the ways green waste has been utilized in the past year at your facility in column 2A.
   b. Now, please indicate approximately what percentage of green waste is utilized in each of the following ways at your facility in column 2B.

	Col. 2A	*Col. 2B(%)*
Directly to landfill	-1	_____
Landfill cover	-2	_____
Mulch	-3	_____
Soil amendments	-4	_____
Sold to Co-Generation plants for electricity	-5	_____
Diverted to other uses without processing	-6	_____
Lumber production (logs)	-7	_____
Incinerated	-8	_____
Firewood	-9	_____
Other (specify)	-10	_____

NOTE: For the following questions, <u>Green Wood Waste</u> is that which can be characterized as wood and not as leaves, roots or twigs.

2. c. Do you charge for <u>Green Wood Waste?</u>
   Yes .... -1
   No .... -2

2. d. If Yes, please explain.

____

____

2. e. Please think of your total Green Waste, of the total Green Waste, what percentage is <u>Green Wood Waste?</u> ________________ Percent

2 f. Please think of your Green Wood Waste, what percentage of your total Green Wood Waste is in each of the following size categories?

Less than 6 inches in diameter	________
6 to 11 inches in diameter and less than 4 feet long	________
6 to 11 inches in diameter and 4 feet long or longer	________
12 inches or greater in diameter and less than 4 feet long	________
12 inches or greater in diameter and 4 feet long or longer	________

3. a. Are there requirements or restrictions concerning Green Wood Waste at your landfill facility?

Yes .... -1

No .... -2

If No, please skip to question 4.

b. If Yes, please explain. ____

________ ____

4. In a typical year, approximately what percentage of the total annual Green Wood Waste do you receive at your facility in each of the following months?

	%		%
January	________	July	________
February	________	August	________
March	________	September	________
April	________	October	________
May	________	November	________
June	________	December	________

5. To the best of your knowledge, please approximate the percentage which is closest to the amount of Green Wood Waste that is being diverted from your landfill. (Please Circle)

0% .... -1
20% .... -2
40% .... -3
60% .... -4
80% .... -5
100% .... -6

6. a. The following is a list of potential recipients of Green Wood Waste. Please circle the number under column 6A which refers to the recipients of Green Wood Waste in your region.

b. Now, please estimate the proportion of Green Wood Waste which is received by each group listed below. Write the proportion in column 6B.

	Col. 6A	*Col. 6B(%)*
Public/State Agencies	-1	______
Arborists	-2	______
Private Homeowners	-3	______
Firewood	-4	______
Other	-5	______
Don't Know	-6	

7. Which of the following species has your landfill received in the past three years?

Monterey Pine .... -1
Redwood .... -2
Cedar .... -3
Douglas Fir .... -4
Monterey Cypress .... -5
California Bay .... -6
Acacia .... -7
Walnut .... -8
All Species .... -9
Not Sure .... -10
Other .... -11

8. If a business existed that utilized Green Wood Waste in the production of a recycled wood product, how likely would your landfill be to develop a Wood Waste diversion program?

Certainly will divert Wood Waste .... -4
Probably will divert Wood Waste .... -3
Might divert Wood Waste .... -2
Probably will not divert Wood Waste .... -1
Will not divert Wood Waste .... -0

9. Please attach a schedule of your various dumping fees.

Thank you again for participating in this survey. Your assistance is essential to the success of this study. Once again, the fax number is 805-756-5040. We appreciate your time.

Sincerely,

Dr. Marianne Wolf

APPENDIX K. -- Total Waste and Number of Active Landfills by County for 1994 [1]

County	County Waste 1994 (%)	Total Waste 1994 (T)	Population 1994 (No.)	County Population (%)	Active Landfills 1995	Page Number
Alameda	6.427	2,182,315	1,347,930	4.217	3	1 to 3
Alpine	0.000		1,161	0.004		
Amador	0.059	19,939	33,189	0.104	3	4 to 6
Butte	0.537	182,497	201,028	0.629	3	7 to 9
Calaveras	0.074	25,025	37,635	0.118	1	10 to 11
Colusa	0.000	0	17,765	0.056	2	12 to 14
Contra Costa	1.429	485,148	868,600	2.718	7	15 to 25
Del Norte	0.036	12,257	28,808	0.090	1	27
El Dorado	0.202	68,448	144,002	0.451	1	28
Fresno	1.934	656,739	755,184	2.363	7	29 to 39
Glenn	0.047	25,060	26,500	0.083	2	40 to 41
Humboldt	2.279	94,707	126,856	0.397	5	42 to 48
Imperial	0.440	149,527	135,675	0.425	10	49 to 63
Inyo	0.025	8,392	18,900	0.059	7	64 to 71
Kern	2.848	627,584	617,004	1.931	18	72 to 99
Kings	0.276	93,655	114,191	0.357	5	100 to 106
Lake	0.087	29,628	56,507	0.177	1	107 to 108
Lassen	0.052	17,626	29,331	0.092	7	109 to 115
Los Angles	35.544	12,068,712	9,230,599	28.881	29	116 to 148
Madera	0.262	88,869	105,695	0.331	1	149 to 150
Marin	0.986	334,698	242,476	0.759	2	151 to 153
Mariposa	0.038	12,740	16,033	0.050	1	154
Mendocino	0.163	55,263	84,805	0.265	10	155 to 169
Merced	0.549	186,432	198,807	0.662	4	170 to 173
Modoc	0.009	2,984	10,424	0.033	4	174 to 182
Mono	0.010	3,232	11,179	0.035	6	183 to 188
Monterey	1.271	431,402	370,905	1.161	6	189 to 194
Napa	0.575	195,199	118,246	0.370	2	195 to 198
Nevada	0.000	0	87,172	0.273	0	199
Orange	8.754	2,972,474	2,596,511	8.124	5	200 to 206
Placer	0.619	210,088	200,057	0.626	2	207 to209
Plumas	0.040	13,617	21,010	0.066	4	210 to213
Riverside	4.479	1,521,801	1,357,443	4.247	20	214 to237
Sacramento	3.108	1,055,200	1,130,363	3.537	6	238 to 247
San Benito	0.092	31,102	40,952	0.128	7	248 to 254
San Bernardino	4.331	1,470,511	1,591,780	4.980	39	255 to 311
San Diego	7.356	2,497,670	2,687,987	8.410	9	312 to 320
San Francisco	0.000		751,732	2.352		
San Joaquin	2.005	680,937	521,481	1.632	5	321 to 326

[1] Source: Adapted from Environmental Science Associates and Pryde Roberts Carr (1995), *Toward Ensuring Adequate Landfill Capacity.*

APPENDIX K. -- Continued

County	County Waste 1994 (%)	Total Waste 1994 (T)	Population 1994 (No.)	County Population (%)	Active Landfills 1995	Page Number
San Luis Obispo	0.543	184,463	231,340	0.724	6	327 to 333
San Mateo	2.483	843,011	686,537	2.148	4	334 to 338
Santa Barbara	0.813	276,015	391,641	1.225	7	339 to 346
Santa Clara	4.238	1,439,083	1,587,768	4.968	6	347 to 355
Santa Cruz	0.656	222,592	238,936	0.748	4	356 to 361
Shasta	0.649	220,501	163,170	0.511	4	362 to 367
Sierra	0.008	2,641	3,442	0.011	1	368 to 369
Siskiyou	0.063	21,229	45,553	0.143	9	370 to 380
Solano	1.135	385,344	373,923	1.170	6	381 to 389
Sonoma	1.292	438,606	438,606	1.321	12	390 to 408
Stanislaus	0.226	76,756	412,676	1.291	2	409 to 410
Sutter	0.000		73,144	0.229	0	411
Tehama	0.128	43,597	54,695	0.171	3	412 to 414
Trinity	0.028	9,368	13,779	0.043	2	415 to 416
Tulare	0.990	336,089	350,616	1.097	7	417 to 427
Tuolumme	0.082	27,950	52,899	0.166	3	428 to 431
Ventura	1.932	655,978	708,168	2.216	3	432 to 439
Yolo	0.457	155,109	150,813	0.472	2	440 to 441
Yuba	0.347	117,928	63,510	0.199	5	442 to 446

1/ Source: Environmental Science Associates and Pryde Roberts Carr (1995), *Toward Ensuring Adequate Landfill Capacity.*

APPENDIX L. ARBORIST SURVEY QUESTIONNAIRE

Arborist Survey

1a. Company name ____

1b. County of operation ____

2. Approximately how many trees do you remove or trim in a typical year? ___________

3. Of the work you do in a typical year, what percentage is:

Whole Tree Removal	__________%
Tree Trimming	__________%
Other	__________%
Total	100%

4. Of the work you do in a typical year, what percentage of the trees are removed or trimmed in each of the following months?

	%		%
January	__________	July	__________
February	__________	August	__________
March	__________	September	__________
April	__________	October	__________
May	__________	November	__________
June	__________	December	__________

5. Of the trees you remove or trim in a typical year, what percentage do you:

Cut into pieces	__________%
Chip	__________%
Other ______________________ (Please Specify)	__________%
Total	100%

NOTE: For the following questions, **wood waste** is that which can be characterized as wood and not as leaves, roots or twigs.

6a. Approximately how many cubic yards of wood waste do you generate in a typical month and in a typical year? (Please answer in the space provided below)

Cubic Yards of wood waste in typical month ___________

Cubic Yards of wood waste in typical year ___________

6b. Typically how much of the total wood waste that your operation generates is:

	Percent
less than 6 inches in diameter	____________________
6 to 11 inches in diameter	____________________
12 inches or greater in diameter	____________________

7. How do you dispose of your **<u>chipped</u> wood waste** ?

	Percent
Leave at location	________
Taken to the landfill	________
Taken to green waste recycle center	________
Sell for mulch	________
Other	________
Total	100%

8. Which compensation do you receive or pay for disposal of your chipped wood waste? Please circle the number that applies to your operation. (For example, if you pay when you take wood waste to the landfill please circle 2 under the Pay column. If you don't pay or receive payment, then leave the row blank.)

	Receive	Pay
Leave at the location.............................	1	1
Taken to the landfill..............................	2	2
Taken to green waste recycle center.......	3	3
Sell for mulch.......................................	4	4
Other..	5	5

9a. How do you dispose of your **<u>unchipped</u> wood waste** ?

	Percent
Leave at the location	________
Taken to the landfill	________
Taken to green waste recycle center	________
Sell to cogeneration plant	________
Sell to sawmill for lumber production	________
Sell for firewood	________
Other	________
Total	100%

9b. Which compensation do you receive or pay for disposal of your **unchipped** wood waste? Please circle the number that applies to your operation. (For example, if you pay when you take wood waste to the landfill please circle 2 under the Pay column. If you don't pay or receive payment, then leave the row blank.)

	Receive	Pay
Leave at the location............................	1	1
Taken to the landfill..............................	2	2
Taken to green waste recycle center.......	3	3
Sell to cogeneration plant......................	4	4
Sell to sawmill for lumber production.....	5	5
Sell for firewood.............................	6	6
Other..	7	7

Questions 10a and 10b refer only to the large wood waste that you generate.

10a. How do you handle **large wood** ?

Cut into pieces	_________%
Chip	_________%
Other ________________________ (Please Specify)	_________%
Total	100%

10b. Of the **large wood** you cut into pieces, into what sizes do you typically cut the wood?

Firewood (16-18 in.)	________%
Quartered	________%
3-4 ft. length	________%
Log lengths (>8 ft.)	________%
Total	100%

11. Of the trees you remove or trim in a typical year, what percentage of the total **wood waste** is typically generated by:

Private Homes	______________%
Businesses	______________%
Government Agencies	______________%
Other	______________%
Total	100%

12. Do you own a chipper............................ Yes........................No

13. What is the largest diameter that your chipper can handle?

Diameter______________

14. Do you own a crane................................ Yes........................No

15. If you own a crane, what are its uses? Please describe briefly.

____

____

____

16. What would encourage you to send your wood waste to a sawmill operation?

Compensation..1

Convenience..2

on-site pick up...3

Other...4

17. If a local sawmill operation were available to mill your wood waste, what would you need to be paid:

to deliver the material to the sawmill operation? $________/yard.

if it were picked up by a sawmill operation at the site of removal? $______/yard.

18. Would you be willing to pay to have someone come pick up the wood waste?....Yes.....No
If, yes how much would you be willing to pay? $______/yard.

19. Which of the following species has your business serviced or removed in the last three years?

Monterey Pine .... -1

Redwood .... -2

Cedar .... -3

Douglas Fir .... -4

Monterey Cypress .... -5

California Bay .... -6

Acacia .... -7

Walnut .... -8

All Species .... -9

Not Sure .... -10

Eucalyptus... -11

Other .... -12

Thank You Very Much For Your Time

APPENDIX M - SMALL, CUSTOM SAWMILL OPERATIONS IN CALIFORNIA [1]

Company	Products	Species	Kiln Info	Phone No.
Jack Boone Jack Boone & Assoc. 16281 Boone Sta. Fort Bragg, CA 95437	Lumber.	Tanoak, chinkapin.	Drying: Dry kilns not available (N/A).	707-459-0730
Kevin Clement True Dimension Mobile Sawmilling P.O. Box 1745 Gerogetown, CA 95634	Lumber, cuts logs.	CA black oak, pine, fir.	Drying: Proprietor operates kilns for George-town CCC.	530-333-4385
Jeannie Danialson Oak Run Lumber Co. Oak Run, CA	Lumber, floor-ing.	CA black oak, pine, fir.	Drying: N/A.	530-472-1484
Wayne De Lisle Wayne De Lisle Enterprises Pike City Rd., Alleghany Star N. San Juan, CA 95960	Lumber, floor-ing.	CA black oak, CA white oak, madrone, CA walnut, burl.	Drying: N/A.	530-288-3406
Neil Elmer Mendocino Hardwoods 9300 Gibson Lane Potter Valley, CA 95469	Lumber, furn-iture.	CA black oak, tan oak madrone, CA & OR white oaks, blue oak, alder, CA walnut, OR ash, interior live oak, laurel, sycamore, chinkapin.	Drying: Small solar kiln. Custom dries lumber.	707-743-1297
Robert Erickson Robert Erickson Wood-Working 17790 Tyler Foote Rd. Nevada City, CA 95959	Lumber, furn-iture, arts & crafts. Will saw lumber for others.	CA black oak, tanoak, madrone, alder, CA walnut, Pacific yew, urban trees e.g. elm, sycamore.	Drying: Dry kilns on site.	530-292-3777
Fred Frank Hidden Springs Tree Farm 3615 Ardilla Ave. Atascadero, CA 93422	Logs, planta-tion growing at this time.	CA white oak, CA walnut.	Drying: N/A.	805-466-2220
Matthew Galt West Coast Hardwoods, Inc 14 th & M St. P.O. Box 4869 Arcata, CA 95518	Lumber, cut stock, flooring, moulding/mill-work	CA black oak, CA white oak, madrone, tanoak, alder.	Drying: Kilns on site. Custom kiln dries lumber.	707-825-8113
Carol Grice LaRue Conversions P.O. Box 463 Mendocino, CA 95460	Lumber, mill-work/moulding Portable mill operators.	Madrone, pine, fir, redwood.	Drying: N/A.	707-928-5003
Michael Henwood Mission Woods Co. 6735 Harmmonton-Smarts-ville Rd. Marysville, CA 95901	Lumber, furn-iture.	CA walnut, sycamore	Drying: Air dries lumber.	530-639-2400

Company	Products	Species	Kiln Info	Phone No.
Charles Hinsch Old Mill Farm P.O. Box 463 Mendocino, CA 95460	Lumber, arts & crafts, furniture, cabinetry.	CA black oak, CA white oak, madrone, tanoak, alder, beech, chestnut, burr oak.	Drying: N/A.	707-937-0244
David Hirch Hirch Vineyards 45075 Bohan-Dillon Rd. Cazadero, CA 95421	Logs & lumber, not in production yet.	Tanoak, fir, redwood.	Drying: N/A.	707-847-3409
Royce Johnson Royce Furniture P.O. Box 1212 Kings Beach, CA 96143	Lumber, millwork/moulding, & crafts, cabinetry, furniture. Will saw for others.	Madrone, CA walnut, pine fir, anything locally available.	Drying: Air dries lumber.	530-56-3275
Peter Lang[2] Peter Lang Co., The 3115 Porter Creek Rd. Santa Rosa, CA 95404	Lumber, burls, veneer logs, crafts.	Madrone, CA walnut, English walnut, laurel nutmeg, chinkapin.	Drying: N/A.	707-579-2551
Kelley Murphy P.O. Box 873 Alta, CA 95701	Lumber, cuts log.	CA black oak, white fir, pine, Douglas-fir, cedar.	Drying: N/A.	530-389-2750
Pamela Parker Motherwoods P.O. Box 837 Willits, CA 95490	Lumber, millwork/moulding flooring.	Tanoak, madrone.	Drying: N/A.	707-459-3438
Dave Parmenter[2] Calif. Hardwood Producers Inc. 1980 Grass Valley Highway Aurburn, CA 95603	Lumber, millwork/moulding flooring, burls slabs, turning blanks.	CA black oak, CA white oak, madrone, tanoak, alder, maple, CA walnut, elm, bay, sycamore, English walnut, catalpa, urban woods.	Drying: N/A.	530-888-8191
Steve Sayers CDF-Boggs Mtn. Demonstration State Forest P.O. Box 839 Cobb, CA 95426	Stumpage, oak sprouts, brush.	Ca black oak, canyon live oak, manzanita.	Drying: N/A.	707-928-4378
Don Seawater[2] Pacific Coast Lumber San Luis Obispo, CA 95401	Lumber, custom milling, Adirondack chairs.	Oak species, redwood, Monterey pine & cypress, red gum eucalyptus, CA walnut, sycamore.	Drying: N/A.	805-543-5533
Don Scott Don Scott Lumber 16281 Sages Rd. Nevada City, CA 95959	Lumber, millwork/moulding logs.	CA black oak, CA white oak, madrone, tanoak, CA walnut, any softwood.	Drying: Air dries all lumber	530-292-3192

Company	Products	Species	Kiln Info	Phone No.
Tim Taylor Pacific Firewood 4700 Trout Gulch Rd. Aptos, CA 95003	Lumber, furn-iture, veneer, cabinetry, flooring,	Any hardwoods in the Watsonville area.	Drying: N/A.	831-722-963
Warren Wise[2] Woodsman, The 1814 McClellan Way Stockton, CA 95207	Lumber, mill-work.	CA walnut, myrtle, chestnut, redwood, sycamore, maple, gum, olive.	Drying: Custom drying of domestic & exotic woods.	209-931-3293

[1]Information from John Shelly, U.C. Forest Products Laboratory, Richmond, Calif.

[2]Custom mill operations covered in Section 5.3. Small Sawmills Cutting Urban Sawlogs.

APPENDIX N. - DEALING WITH EMBEDDED METAL[1]

Metal and other foreign material in street tree sawlogs must be removed or the log should not be sold as a sawlog.

B. Metal and Other Foreign Material in Street Trees

One of the primary reasons why demand for street tree sawlogs has been low in the past is because of metal and other foreign material sometimes found in the logs. The reputation of these logs having metal in them (i.e., nails, wire, spikes, or even car parts) is common among sawmillers.

As depicted in these pictures, metal found in street trees comes in all shapes and sizes.

The problem of metal in street tree logs can be over-come by scanning the logs with a metal detector and removing any metal that is found.

Metal can become a serious problem during log sawing because it dulls and/or damages saw blades and sawmill equipment. It can also be a safety hazard for workers in a mill because of flying debris when a blade hits large metal objects.

The best way to correct this problem is to scan logs for metal before they go through the sawing process. Standard metal detectors are normally adequate. When metal is discovered, it must be removed. If large quantities of metal are detected in a log, it should not be sold as a sawlog. If a metal-laden log is shipped as part of a load to a sawmill, it will probably be the last load you ever sell to that particular mill.

APPENDIX N. - CONTINUED

Following a thorough visual inspection of the sawlog, use a metal detector to carefully scan for metal hidden within the log.

Normally, most metal is located within the first four to six feet of a street tree. This is the section of the tree which people use for hanging signs and securing fencing for yards or pastures. This is also the section that children like to pound nails into. Consequently, butt logs need to be screened more carefully than logs which come from higher up in the tree.

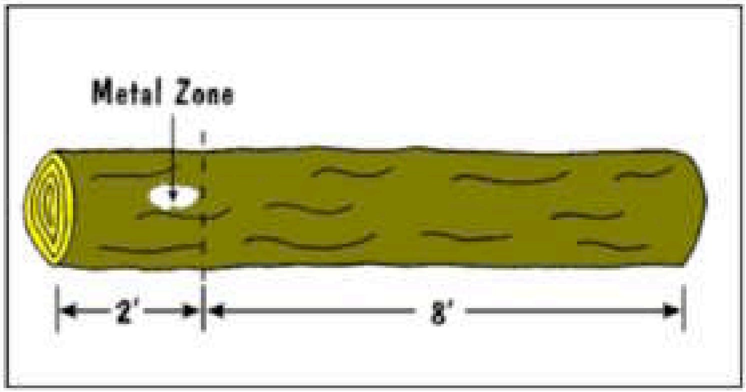
Typical metal detection techniques include a visual inspection and scanning of logs with a metal detector.

Typical metal detection techniques include a visual inspection of the log surface for metal objects like wire and protruding nails, as well as any discoloration which normally appears as a black/blue stain on the end of the log. Following a thorough visual inspection, a careful scan with a metal detector is needed.

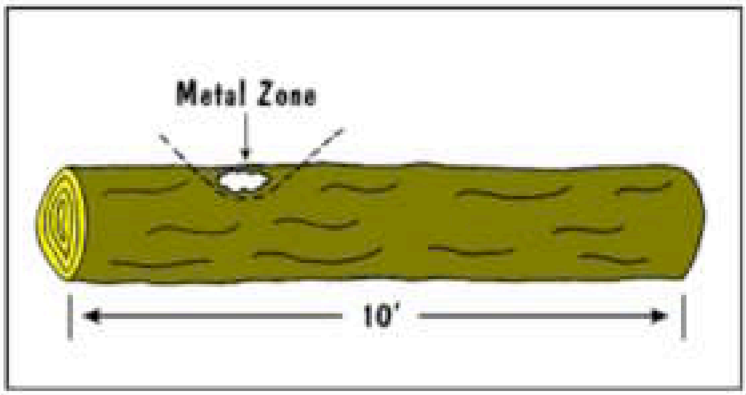
The discoloration on the end of this log indicates the presence of metal near the stained area.

APPENDIX N. - CONTINUED

When metal is seen or detected, appropriate steps are needed to remove it. If metal is located at the end of the log, that part can be sawn off (Illustration 1). If metal is detected toward the middle of the log near the surface, then the section containing the metal can be removed (Illustration 2). Caution is needed to avoid injury. See Appendix A for chainsaw safety procedures. If you do not feel comfortable removing the metal, then mark the area with paint and let the log buyer know it contains metal.



<u>Illustration 1</u>: Remove the end section of the log which contains metal. You do not want to remove too much "good" wood beyond the metal, yet at the same time, you do not want to hit the metal with the chainsaw. If you are uncomfortable removing the metal, let your log buyer show you how.



<u>Illustration 2</u>: Remove metal in this area provided that it is not too deep in the log. If metal is located in the first several inches of the log, removal of it will not affect the volume or quality of lumber produced from the log because this section is usually cut off in the sawing process.

Safety comes first. To avoid injury, use extreme caution when removing metal.

Depending on where the metal is located and how deep it is in the log, a determination must be made as to whether it is worth removing (Illustration 3). If it isn't, the log should be classified unusable as a merchantable sawlog. It may be best, for the first couple of sales, to discuss these marginal logs with the log buyer.

Metal detectors vary in size, cost, and capability. Some detectors not only tell you where the metal is, but also its depth. If a municipality wants to test the sawlog market initially, a metal detector could be borrowed for log scanning.

APPENDIX N. - CONTINUED

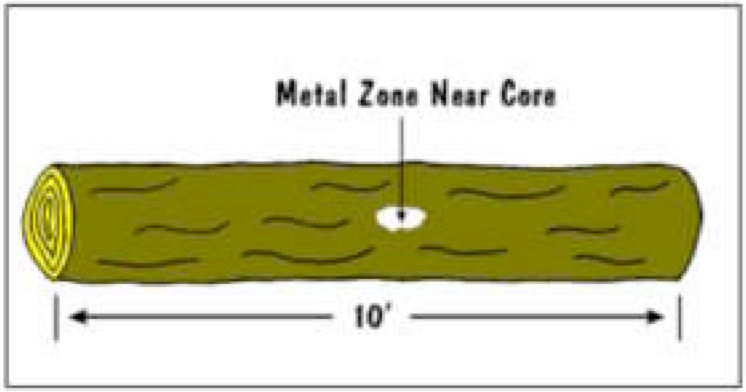


Illustration 3: When metal is located near the core of the log, removing it would drastically reduce the volume of lumber that could be sawn from the log. Leaving it could cause considerable damage to sawmill equipment. These types of logs having metal should be clearly marked (see below) and discussed with the log buyer or processed into firewood.

After several successful sawlog sales, a metal detector could be purchased specifically for scanning logs. Basic metal detectors range in price from $250 to $500.

Listed below are some metal detector manufacturers that can be contacted for specific details:

Fisher Research Laboratory
200 W. Willmott Road
Los Banos, CA 93635
Phone: 209-826-3292
FAX: 209-826-0416

Tesoro Electronics, Inc.
715 White Spar Road
Prescott, AZ 86303
Phone: 602-771-2646
FAX: 602-771-0326

Garrett Electronics, Inc.
1881 W. State Street
Garland, TX 75042-6761
Phone: 214-494-6151
FAX: 214-494-1881

White's Electronics, Inc.
1011 Pleasant Valley Rd.
Sweet Home, OR 97386
Phone: 503-367-6121
FAX: 503-367-2968

The metal object in this log has been clearly marked to indicate its presence.

Metal detectors like the one in this photo can be purchased from many retail outlets.

Other foreign material which is sometimes found in street tree logs is cement and car parts. Any non-wood material within a log poses serious problems to sawmill operators and equipment in the sawmilling process; therefore, every precaution needs to be taken to ensure that sawlogs are free of foreign materials. This effort alone could make or break the concept of a municipality merchandising logs to a sawmill.

[1]Cesa et al. (1994)

APPENDIX O. - RMDZ LOAN INFORMATION[1]

RECYCLING MARKET DEVELOPMENT
REVOLVING LOAN PROGRAM

SUMMARY

PROGRAM OVERVIEW

The Recycling Market Development Revolving Loan (RMDRL) Program provides **direct loans** to businesses that use postconsumer or secondary waste material to manufacture new products. To be eligible to apply for a loan, the business must be located in designated **Recycling Market Development Zone**.

Local governments may apply for funds to finance public works infrastructure which directly supports businesses that use postconsumer or secondary waste material.

USE OF FUNDS

- Equipment Purchases
- Real Property Purchases
- Working Capital
- Leasehold Improvements
- Refinance Onerous Debt

RATES, TERMS & FEES

Each eligible business or local government agency may borrow up to **50% of the cost of a project**, up to a **maximum of $1,000.00**

The maximum term of a loan is **10 years**; the loan term is based on the useful life of the asset(s) being financed.

The Board may consider a subordinate collateral position to a primary private lender.

Interest rates are **fixed** for the term of the loan, and are set by the Board semi-annually. Check with your Zone Administrator for the current rate.

A nonrefundable **application fee of $300.00** is due at time of application submittal. **A loan origination fee of three percent of the loan** will be charged upon loan closing. The loan fee may be financed.

FILING LOAN APPLICATIONS

Loan applications are accepted on a continuous basis.

APPENDIX O. - CONTINUED

RECYCLING MARKET DEVELOPMENT REVOLVING LOAN PROGRAM

*PROGRAM OBJECTIVES**

Preamble: In marketing the Recycling Market Development Revolving Loan Program, staff shall target businesses and projects which would best serve to achieve the program objectives adopted by the Board.

Objective #1

Maximize the effectiveness of the Recycling Market Development Revolving Loan Program as a market development tool by targeting projects which use material normally disposed in solid waste landfills as recycled feedstock to manufacture recycled-content end-products, or otherwise increase demand for secondary materials which directly support achievement of local waste diversion goals from solid waste landfills. Manufacturing, as described, does not include the clean up of nonhazardous contaminated soil.

Objective #2

Support the Board's current Market Development Plan by giving priority consideration to projects which utilize the Board's priority materials and divert the greatest tonnage. ***The Board's priority materials are mixed waste paper, compostable materials, high density polyetheylene, mixed plastics and construction and demolition materials.***

Objective #3

Support the integrated waste management hierarchy by promoting in order of priority: 1) source reduction; 2) recycling and composting; 3) environmentally safe transformation and environmentally safe land disposal.

To achieve this objective, the Board shall:
a. Give priority lending consideration to source reduction projects which satisfy objectives 1 and 2 above; and

b. Give lowest lending priority to alternative daily cover and transformation projects, and limit funding of such projects to those which:

i. Produce value-added products;
ii. Are not detrimental to current or future efforts to increase source reduction, recycling or composting of the project's material type;
iii. Do not, in aggregate, exceed 10% of all loan funds to be awarded during any annual loan funding cycle.

*** The Recycling Market Development Revolving Loan Program objectives are periodically updated by the California Integrated Waste Management Board**

APPENDIX O. - CONTINUED

RECYCLING MARKET DEVELOPMENT
REVOLVING LOAN PROGRAM

APPLICATION PROCESS

A. Pre-Application

A potential applicant should first contact the Recycling Market Development Zone Administrator or one of the Board's Regional Credit Managers for the Loan Program to receive an overview of the loan program, discuss the proposed project, and arrange a pre-application meeting to discuss project eligibility and readiness prior to submittal of an application.

B. Application Process

Step 1 An applicant must submit two (2) complete copies of the loan application and supporting documents with original signatures. **The application must be accompanied by a nonrefundable application fee of $300**.

Step 2 Within 10 days of application submittal, staff will complete a preliminary review to determine application completeness and eligibility and send a letter which state one of the following:
(a) That the application is incomplete, or that the Applicant is ineligible for a loan, and specify the steps, if any, which the Applicant may take to correct identified deficiencies; or
(b) That the Applicant is eligible for a loan, the application is complete, and shall be evaluated by the Board staff; or
(c) That based upon an analysis of the financial information provided an other credit information , the Applicant does not meet the credit standards for the program and will not be recommended for approval. Appeal procedures will be included in the letter.

Step 3 For applications meeting criteria (b) above, staff will then complete an analysis of the application and prepare a credit analysis. As a result of staff's review, additional information may be required. The analysis will outline staff's recommendation, including project description, project cost, proposed financing, diversion tonnages, job creations, loan amount, loan terms, and any special loan conditions.

Step 4 Applications which met the following criteria will be recommended to the Loan Committee;
(a) the Applicant is creditworthy; and
(b) Cash flow and collateral are appropriate for the requested loan amount; and
(c) the Applicant has adequately demonstrated the appropriateness of the loan for use in the project.

APPENDIX O. - CONTINUED

RECYCLING MARKET DEVELOPMENT REVOLVING LOAN PROGRAM

APPLICATION PROCESS

Step 5 Each application which meets the criteria listed in Step 4, will be presented by staff to the Loan Committee. The Loan Committee will review the staff analysis on the loan request and either approve as submitted, approve with modifications, or deny the loan request.

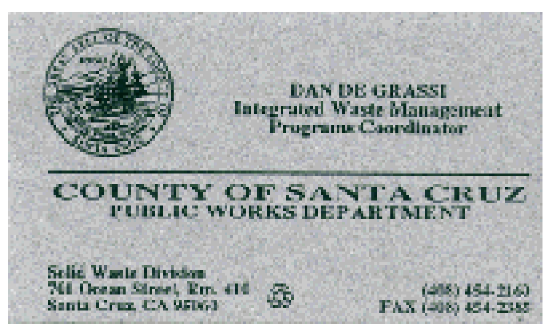
Step 6 The Loan Committee will submit a list of recommended projects to the Market Development Committee.

Step 7 The Market Development Committee will evaluate and rank projects according to the current program diversion priorities. The current diversion priorities may be obtained by contacting the Board's loan staff.

Step 8 After the Market Development committee reviews the application, the Market Development Committee will submit a recommendation for loan approval to the Board. The Board will review staff and Committee recommendations, and will make the final determination on loan approval or denial. If the Board denies an application, the applicant may request reconsideration by following the program's appeal process. If the Board approves a loan, a loan commitment letter setting forth the terms and conditions of the loan will be issued to the Applicant for the Applicant's acceptance.

Step 9 After the Applicant has accepted the loan, loan closing documents will be prepared. Loan closing must take place within 90 days of Board approval.

Step 10 Loan funds will be disbursed in accordance with the terms of the loan agreement.



[1]Information provided by Dan DeGrassi

APPENDIX P. - SCORE INFORMATION

Facts For Small Business From

SCORE®

The Service Corps of Retired Executives Association

Providing:

- *Confidential Counseling*
- *Training and Workshops*
- *Business Information*
- *Business Management Help*

CALL: 1-800-634-0245
or your nearest SCORE Chapter

A. QUESTIONS TO ASK YOURSELF BEFORE GOING INTO BUSINESS:

1. Is my product or service different from others already in my market area?
2. Do I have the right kind of business experience?
3. Can I prepare a credible, detailed business plan for the first three years?
4. Am I able to take responsibility?
5. Am I a good organizer?
6. Am I ready to put in the long hours that might be necessary?
7. Am I ready to stick to it even during the rough times?
8. Do I have the support of my immediate family?
9. Do I have adequate resources and credit— and maybe a little bit more?
10. Is my health up to the tasks ahead?

B. QUESTIONS TO ASK YOURSELF IF ALREADY IN BUSINESS

1. Is my sales volume higher than a year ago?
2. Am I making money from my business?
3. Is my inventory the right size and balance?
4. In terms of business, is my family protected if I should die?
5. Where will technology take my business in 5-10 years?
6. Are my customers satisfied?
7. Is my location improving or deteriorating?
8. Arc my accounts payable due before my receivables arrive?
9. Do I have a business plan?
10. Should I expand

C. STEPS IN PREPARING AND SECURING A LOAN

1. A detailed description of the business you plan to start: include product or service, market, start-up costs, equipment, working capital, inventory (see also section H).
2. Explain your experience and capabilities and those of your associates.
3. Prepare a financial estimate of your own resources, those of associates and how much you need to borrow.
4. Try to project cash flow for the first three years of business. Show how you will use the business to payback your loan.
5. What collateral can you, your associates, and your family come up with to secure your loan?
6. Review your loan package with a SCORE counselor.
7. Review your loan package with your loan officer. Show your proposal and projections, ask for a direct loan. If turned down, ask to have the bank make the loan under SBA Guaranteed Loan Program.

D. SMALL BUSINESS INDUSTRIES CREATING THE MOST NEW JOBS*

1 Eating and Drinking Places
2 Offices of Physicians
3 Computer and Data Processing Services
4 Nursing and Personal Care Facilities
5 Trucking and Trucking Terminals
6 Miscellaneous Business Services
7 Outpatient Care Facilities
8 Machinery, Equipment and Supplies
9 Residential Care
10 Mailing, Reproduction and Steno Services

E. FASTEST GROWING SMALL BUSINESS INDUSTRIES*

1 Outpatient Care Facilities
2 Medical and Dental Laboratories
3 Mailing, Reproduction and Steno Services
4 Automotive Rental (without drivers)
5 Electrical Repair Shops
6 Computer and Data Processing Services
7 Railroad Equipment
8 Residential Care
9 Offices of Physicians
10 Sporting Goods, Toys, Hobby Goods

The lists for D and E are taken from the most recent data available; however, the compilation of such specific data is time consuming. This data is for the period Dec. 1988-Dec. 1989. While this data may have implications for the present, a person

considering starting or buying a similar business should consider the local economy, competition, location and other factors contributing to the success of a business venture. A free consultation with an experienced SCORE counselor can provide important information in this regard.

G. PRINCIPAL TOPICS OF SCORE WORK SHOPS

1. Pre-Business Planning
2. Accounting and Finance
3. Marketing
4. Sales
S. Women's Business Ownership
6. Veteran's Business Ownership
7. International Trade
8. Expansion
9. Taxes and Tax Accounting
10. Franchising

H. 10 STEPS TO HELP YOU PREPARE A BUSINESS PLAN

1. RESEARCH: Get as much info on your proposed business as possible—from talking to those already in business, from the library,trade associations or trade publications, local and federal agencies.
2. PROJECTIONS: The more you know about your business, the more accurately you can make projections of sales and potential profits for the first year—but preferably for the first three years.
3. CAPITAL: Accept the fact that it always takes more money than you anticipated; have enough working capital on hand and backup resources in case the new business does not prosper as you had anticipated.
4. COMPETITION: Study them carefully; they have been there and experienced what you are about to discover.
5. LOCATION: Remember the real estate adage: location, location, location. If you can't go to your customer, your customer must come to you. So it's either prime location or lot of advertising.
6. IMAGE: What kind of public image do you want to create with your service, merchandise, quality, decor, packaging, personnel, vehicles, ads, pricing?
7. RECORDS: Complete, accurate records are . needed for tax purposes, your bank account and most important, for your own guidance. You might fool others for a while, but you should not fool yourself.
8. PROFESSIONAL HELP: In addition to SCORE counseling, rely on a competent lawyer, accountant and banker. It's also important to have a good insurance broker and marketing professional.
9. BUYING: Knowing what, when and where to buy and how to gauge inventory can make or break you. It allows you to conserve working capital, reduce obsolescence, meet and beat the competition.
10. PROFIT: This is the bottom line for which you are going into business. Make sure that all expenses are accounted for, including your own living costs, possible losses, shrinkage, unseen costs such as fringe benefits and taxes. Then add a legitimate profit to your risk. If the profit does not come out right, perhaps you should rethink the idea of...

GOING INTO BUSINESS!

DON'T UNDERESTIMATE THE VALUE OF A BUSINESS PLAN. A well researched business plan can make or break your loan application—even your business! A review of your plan with a SCORE counselor before you visit your banker can mean the difference between acceptance and rejection. And it will cost you nothing.

I. SCORE HAS:

1. Free, confidential counseling from 13,000 experienced business professionals from a myriad of backgrounds.
2. 380 chapter locations around the country.
3. An additional 380 branch locations for added convenience of suburban or rural dwellers.
4. Counseled over 3 million clients since 1964.
5. Workshops covering basic and advanced business topics.

SCORE, the Service Corps of Retired Executives Association, is funded by the U.S. Small Business Administration. For further information, please write:

The National SCORE Office
409 Third St. SW
Washington, DC 20024
Or call: 1-800-634-0245

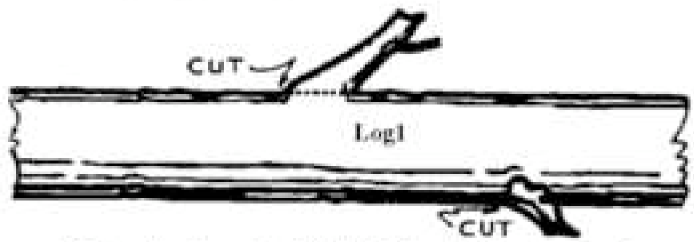
The Service Corps of Retired Executive association (SCORE) is partially funded by the U. S. Small Business Administration (Cooperative Agreement No. SB-2m-00042). The support given by the U. S. Small Business Administration through such funding does not constitute an express or implied endorsement of any of the cosponsors' or participants' opinions, products or services.

NSO 90001 Rev 10/91

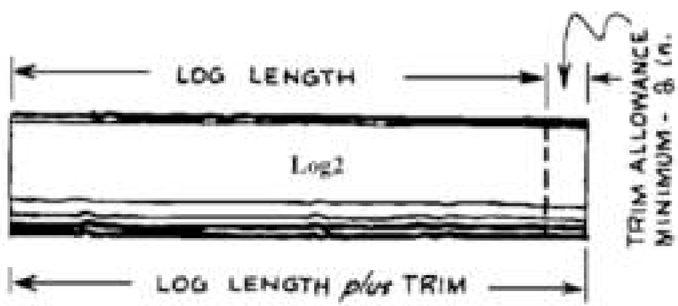
APPENDIX Q. - MANUFACTURING LOGS[1]

Appendix B: Proper Log Manufacturing

The illustrations below show methods for properly manufac-turing sawlogs which will be processed into standard lumber products. They are from <u>More Money for Your Logs When Properly Cut</u>, by W.G. Stump, USDA Forest Service, North-eastern Area, State & Private Forestry, Upper Darby, PA.

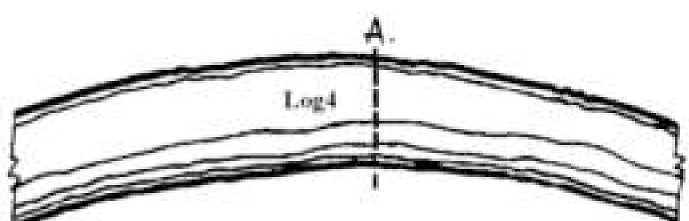


Logs with handles do not roll. Cut limbs off close to log for easier handling.



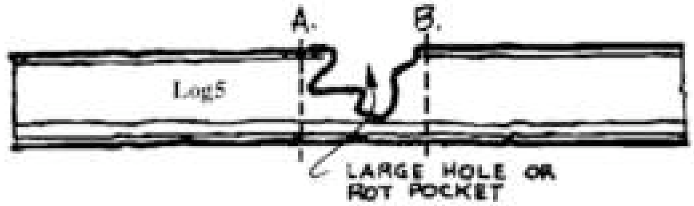
Always cut logs at least 2" longer. This is called trim allowance. Check with buyer before cutting logs to be sure of required trim allowance.

Log should be cut in back of crotch at A.

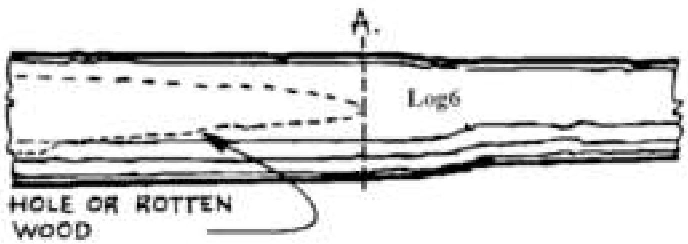


Cut at A. to reduce or eliminate sweep in log.

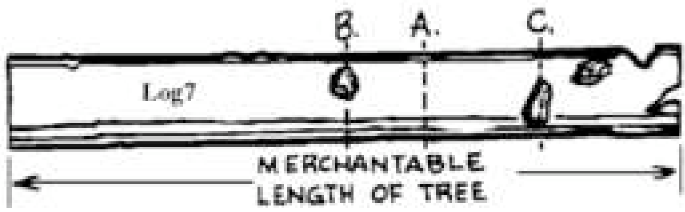
APPENDIX Q. - CONTINUED



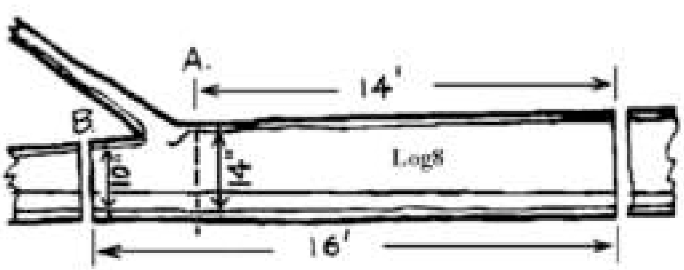
Make 2 logs. Cut at A. and B. if each log can be made 8 feet or longer.



Cut at A. to avoid loss of footage.



Keep logs as free from defects as possible. Do not cut at A. Cut at B. and C. to make 2 clear logs.



Cutting at A. instead of B. yielded an additional 50 board feet of lumber.

[1]Cesa et al. (1994)