Problems and Prospects in Drying California Hardwoods for High Quality Usage

by

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INTRODUCTION

Although softwood production and potential in California dwarfs that of timber tree hardwoods, the state has at its disposal a valuable resource in the potential supply of hardwoods as yet largely untapped. With changing economy, the economic necessity for closer utilization of forests and the geographical distance of the west coast from hardwood production centers, there is some interest developing in California in the commercial utilization of some of its 600 billion bd. ft. of hardwoods. At the moment there are, to my knowledge, no regular or consistent producers of California hardwoods for lumber although some use has been sporadically attempted on a very small scale. Currently, madrone and the oaks are being used for charcoal production.

The species with which I am concerned are California black oak (*Quercus kelloggii* Newb), tanoak (*Lithocarpus densiflorus*), which is not a true oak, golden chinkapin (*Castanopsis chrysophylla*), and Pacific madrone (*Arbutus menziesii* Pursh). These species constitute 85% of the hardwood forest potential on commercial timber lands as estimated by the U. S. Forest Service.

TABLE I

Estimated Utilizable Volume of Hardwoods in California

Species	Volume (million bd. ft.)	Diameter Class (per cent) 11" - 20.9"	Greater than 21"
Tanoak	2036	42	58
California black oak	1946	31	69
Pacific madrone	1076	50	50
Golden chinkapin	83	52	48
Others	859		
Total	6000		

Although a variety of problems are associated with their utilization, such as scattered distribution, undercapitalized operations, seasonal production, lack of satisfactory standards, and faulty manufacture. Not the least of the problems are those of being able to economically dry the species to a quality requirements for which they are largely suited such as flooring, furniture, panelling, and some classes of millwork.

It is historical that whenever new species are launched for timber there is always some natural reservation which reacts against acceptance. I believe that there is no exception with California hardwoods.

Again, it is natural in a state where essentially pure stands of softwood lumber is available and conditions lend themselves to large scale operation, that operators look askance at processing hardwoods, which from the nature of their distribution and properties, must be handled on a different scale and with much more critical requirements.

Indeed it does reqmire a revision of thinking in approaching hardwood drying as the problems are on a completely different scale from softwood operation. Here we must think in terms of relatively small operations and concentrate to a much greater degree on processing from the log to the finished product. There is comparatively little leeway allowable if we are to finish with a high quality product.

The sporadic unsuccessful attempts to utilize some of the species in the past can be traced to small unstable operations, poor manufacturing, lack of sufficient standards, promotion, and last, but certainly not least, improper handling and processing.

CHARACTER OF CALIFORNIA HARDWOODS

In general, these species characteristically produce short length logs -- probably more 8'-12' logs than 16' length are available. Chinkapin has the best log form of all these species, while madrone has the poorest. The diameter of merchantable timber trees is distributed as shown in Table I.

Madrone, one of the heaviest of the species, has a density of 45 lbs. per cu. ft. at 12 per cent moisture content. This species has a fine close grain with rich red brown color. Some trees contain a heart which is almost dark red in color. Its general availability is good. It makes an excellent finishing wood and is somewhat similar to eastern cherry.

Black oak is slightly less dense than most of the commercial oaks and in appearance is similar to the widely used northern red oak, but does not contain the red hue and can be of slightly darker color. Its workability is good. Its application would be the same as that in which other oaks are now used.

Tanbark oak, although it is not a true oak, has a very large sapwood content in the log which is a light grey and looks very similar to oak. The color of the wood, when freshly cut, is light but turns to a slightly darker color. Its texture and appearance is similar to the true oaks and its characteristics suggest similar applications.

Chinkapin has the lowest density of the group, and like tanoak, contains a high proportion of sapwood. The appearance and workability of the species should be satisfactory for flooring.

On the question of machining characteristics, there need be no apprehension as these species compare well with popular species such as red oak, maple, walnut, etc., in ability to be planed, shaped, turned, and bored.

I wish to make it quite clear that the problems and difficulties associated with these timbers are mainly concerned with the processing down to the point of remanufacture.

MAJOR DRYING PROBLEMS

The species quoted all come in the category of difficult to dry species. Characteristically they all show to a greater or lesser degree excessive shrinkage or collapse. This is particularly pronounced in madrone with some in chinkapin, tanoak, and to a lesser degree in black oak. This, of course, does result in large volumetric reduction of the finished product. Warping is a problem, most of all with madrone, but is variably serious in all the species; probably least serious in California black oak.

Sensitivity to checking (surface, internal, and end) is pronounced in chinkapin and tanoak. Madrone is the least sensitive to checking.

Some tension wood does occur in these species, but does not appear to be a serious difficulty in drying, apart from some crook.

Chemical and fungal stain can be a problem in wide sapwood species such as tanoak. These troubles are processing troubles and once the timber is dried, do not effect its performance in any way.

GENERAL HANDLING PROCEDURES RECOMMENDED TO MINIMIZE LOSSES

Considering the above characteristics, several general proposals can be formulated which will lead to reduced losses, and in some cases, accelerated drying without degrade.

Material should be cut as thin as possible with respect to final use. Four quarter stock or less, if possible, should be the initial aim as by this means, drying stresses are greatly reduced thus lessening the possibility or extent of surface and initial checks, and also greatly reducing drying time.

Wide flatsawn boards should not be cut and dried. Wide flatsawn boards do tend to check more and cupping can be serious. In general, boards greater than 6" wide are increasingly prone to checking.

Whenever possible, black oak, chinkapin, and tanoak should be edge sawn or the growth rings cut close to 45°. Edge sawn or nearly edge sawn boards, in general, do not check on the wide faces, consequently allowing the use of faster drying schedules. This factor is so important with chinkapin, tanoak, and black oak that consideration of mill design to achieve this objective is warranted.

Logs should be handled quickly from the stump through the mill. Long log storage times will multiply loss from end checking, and also result in strain in the sapwood of these species.

Sawn lumber should be moved quickly from saw to drying process as the initial few days after cutting are critical in the drying process. Long block piled periods should be avoided or end checking and stain can result.

Close sticker spacings of 18" - 2' in confunction with high, weighted stacks should be used to reduce warpings. This is particularly important with madrone.

RECOMMENDED DRYING PRACTICES

1. Combined air drying and kiln drying. Air drying refractory woods results in less collpase and its attendent distortion than kiln drying from the green condition (See Table 2). Also, with species which are temperature sensitive with regard to checking, air drying is to be preferred. At this stage, the indications from the Oregon Forest Products Laboratory and the Madison Laboratory are that tanoak and chinkapin should be air dried to 20-22 per cent. Our own experience with these two species in kiln drying has been limited to one run each on 4/4 flatsawn stock using the mildest oak type schedule. The results were not encouraging. The extent of checking which did occur even under very mild drying conditions indicated that the material is temperature sensitive. Also, it has been reported by the Oregon Forest Products Laboratory that chinkapin, air dried in the summer developed only half as many checks as when kiln dried. Without special treatment these two species would degrade too heavily and be uneconomic to dry from the green by conventional kilning. Air drying time naturally will vary greatly with the local climate and time of the year but will fall between 3-8 months.

TABLE II.

Shrinkage of California Hardwoods

Species	Method of Drying: Standard ASTM Method-to O.D.W.		Method of Drying: Kiln Drying to 8% M.C.	
	Radial	Tangential	Radial	Tangential
California black oak	3.6	6.6	9.5	7.3
Tanoak	---	---	14.7	17.9
Pacific madrone	5.4	11.9	16.	12.
Golden chinkapin	4.6	7.4	18.3	17.6

Good practice in air drying particularly with sheltering, end coatings, top protection, and close stickering will produce the best results with these species.

Kiln drying of these species after the core of the wettest material has reached 30 per cent moisture content offers no special problem.

Our air drying studies on California black oak and Pacific madrone show a lower shrinkage for this material than when it is air dried. Collapse is not very apparent in air dried California black oak, although it can be pronounced in madrone together with severe warping.

Subsequent kiln drying 5/4 air dried California black oak can be accomplished in approximately 5-6 days including two days for equalizing and conditioning. Apart from the first day of drying, when it is well to operate on less than 10°F. W.B.D., the drying conditions are not critical.

2. Combined predrying and kiln drying. As an alternative to the lengthy air drying period and as a compromise with the cost of kiln drying from the green condition, predrying may be a possibility with the less refractory timbers of this group.

Essentially, predrying is kiln drying but without the cost or flexibility of a conventional kiln. In drying the California hardwoods, a minimum of heat is desirable over the greater portion of the drying time so that a predryer installation may have good application for accelerated drying providing humidity control is reasonable. There are, in fact, a number of predrying operations now being done successfully on similar refractory woods elsewhere. Smith of the California Forest & Range Experiment Station has run 4/4 California black oak under conditions simulating predryer operation with good success. In fact, the most desirable kiln schedule will approximate drying conditions which could be attained in a predryer during drying down to 25 per cent moisture content. Species which could be successfully handled by such a drying method are California black oak and Pacific madrone.

Again, no serious problems are involved in kiln drying thoroughly predried lumber at elevated temperatures provided care is taken in establishing a suitable moisture gradient on the first day.

3. <u>Kiln drying from the green condition</u>. Kiln drying of the California hardwoods offers a definite challenge in operational skill. At this stage, only two species of the four discussed offer promise of successful drying without special treatment and these are California black oak and Pacific madrone. These are the species on which most of our hardwood drying work has been concentrated to date.

As a rule black oak has perhaps the least tendency to collapse of all the species in the group, but exceptions will be found to this. The oak, however, is relatively sensitive to the development of surface checking and extreme care is needed to reduce checking development. It is a feature of most of these hardwoods that liability to surface check is highest at the very commencement of drying and that the danger of surface and end checking diminishes with increasing dryness. This pattern is rather different from the behavior of softwoods with which most are more familiar. With California black oak, it became apparent that if checking could be prevented on the first day of drying, then chances of success were high. The dominant factor, then, in kiln drying the California black oak is precise control of drying conditions in the very early stages of the run. The intention would be to depress the potentially fast drying rate at this early stage by using a wet bulb depression of 3-4°F. and a temperature of no more than 110°F. If a kiln is not capable of holding these conditions uniformly, the possibilities of success are not high. If checks do initiate at this stage, almost invariably they will extend deeply into the board at later stages of drying causing bottleneck or honeycomb checks. The question of when to increase the wet bulb depression and dry bulb temperature is important. By using the technique of drying stress analysis it was found that the very small wet bulb depression must be maintained until about 75 per cent moisture content was reached, which ordinarily takes approximately 2-3 days. After that, the wet bulb depression can be increased to 5-6°F. and at a moisture content of 55 per cent rapid and substantial increases in the depression can be made.

To reduce overall warp and the possibility of surface checking, the temperature of drying should not exceed 110°F. until the wettest material reaches 25 per cent moisture content. From then on the drying conditions are much less critical.

As regards stress relief, it should be pointed out that the California black oak is fairly sensitive to stress relief treatments and that 10-12 hours is sufficient at 180°F.

The drying time of such a schedule including equalizing and conditioning amounts to approximately 25 days for 5/4 stock.

As an indication of the amount of drying degrade which results from kiln drying, grading studies on a test run of approximately 4000 bd. ft. of California black oak before and after drying, on a more severe schedule than recommended, showed that drying degrade amounted to $2. per 1000 bd. ft. when translated into cost. More conservative schedules would reduce this amount considerably.

Pacific madrone is considerably more resistant to all forms of checking than any of the other species. The major problem with this species is warp and collapse. Our test runs on this species are not yet completed, but it is apparent that this species will stand considerably more severe drying conditions both as regards wet bulb depression and temperature than the other hardwoods discussed. The extent of warping was not much affected by the drying conditions applied.

Present indications are that 4/4 material of Pacific madrone can be kiln dried in approximately 13-15 days including equalizing and conditioning.

SPECIAL TREATMENTS

As pointed out, one of the major causes of trouble occurring with these hardwoods is their excessive shrinkage or collapse always associated with warping and sometimes with severe checking particularly when drying is accelerated. If collapse could be overcome with these species, much of the difficulty in drying would largely disappear.

There is a method that will largely overcome the excessive shrinkage and warping designated as reconditioning. Reconditioning is a collapse removal treatment which consists of steaming the timber, preferably at a moisture content of about 15 per cent, in live saturated steam at 212°F. The period of steaming is relatively short -- 4-6 hours -- in general, being sufficient. This process has the effect of almost completely removing excessive shrinkage, collapse, and warp and is standard practice in Australia for treating the refractory eucalyptus. The recovery in dimension so obtained is permanent. Our tests on the application of this process to the California hardwoods have been very successful, transforming otherwise useless boards into high quality material. The most successful treatments to date, have been obtained with Pacific madrone where, contrary to previous experience with eucalypts this timber responds to the treatment at 8 per cent moisture content and after having been exposed to temperatures as high as 180°F. Shrinkage of madrone in thickness and width has been consistently reduced from 1/2-1/3 of that without any treatment, and warping has been largely removed.

Similarly, large recoveries have been obtained with tanoak and chinkapin but the conditions of application seem to be more critical than with Pacific madrone. Black oak also shows substantial recovery but because its collapse is less, the results are less striking than for the other hardwoods.

The potentialities for such a process in accelerating the utilization of these woods are great and I firmly believe that adoption of collapse removal treatments will pay handsome dividends.

The reconditioning treatment, however, is not a cure-all and is not of much use if the material is badly checked. In fact, the process will tend to open surface checks so that the need for control over check development still remains. The outstanding need - a method of drying which will prevent the occurrence of collapse during drying-and it is this phase that the University of California Forest Products Laboratory is investigating at the present.

On the question of checking inthese hardwoods, another approach which is worthy of consideration is chemical seasoning in conjunction with kiln drying to obtain accelerated drying. This approach would appear to have merit particularly for check susceptible tanoak and chinkapin. This process, which is not new, consists of dipping or applying a hygroscopic chemical to the lumber. The penetration need not be deep. The chemical, by its vapor pressure, holds the surface fibers at a relatively high moisture content level thus reducing the tendency toward checking, although relatively more severe drying conditions can be applied. Because of the relative impermeability of the hardwoods, most of the treating chemical would be dressed off in manufacturing operations. We have not yet done any work along these lines at the Laboratory, but I suggest this method be considered in your pilot operations.

Looking somewhat more into the future, another field which may hold promise for drying these refractory hardwoods, is the possibility of using completely different drying methods. Work has commenced on solvent seasoning at the California Laboratory and although no studies have yet been done on the drying of hardwoods by this method, plans have been made to begin this work within the next twelve months.

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