AN ABSTRACT OF THE THESIS OF

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Abstract approved

Of the many hardwood species growing in the Pacific Coast states, few are being used for lumber. In this area which produces the nation's greatest volume of softwood products, the lumbering industry generally is not geared to process these scattered hardwoods. A number of the western broad-leaved native and introduced hardwoods seem to have potentially fine properties and working characteristics for school shop use.

While teaching in a forest area, this writer became interested in the utilization of the tree resources of the county, and particularly in making use of the hardwoods growing in the region for supplementary student project materials. In attempting to use these woods, problems invariably arose. These problems were centered around workable methods for tree and wood identification and selection, cutting of pieces into usable forms, and seasoning the wood. Very little valid information in organized form was available for the woodworking teacher, thus the need for such research became apparent.

The purpose of this study was twofold: first, research was made to determine which western trees and larger hardwood shrubs would produce suitable materials for school projects; second, to investigate and then present in the form of a guide, the needed background and methods that would make possible the utilization of these woods in the school shop program.

Eighteen of these trees are described and are included in the appendix. In addition, a supplemental list of others that have been reported usable is included.

The main body of this study deals with the background, the general information, and the methods found most satisfactory for producing seasoned wood from these hardwoods.

By surveying the available literature, interviewing men working with these woods in school shops, small industry, and in forest products research; and by personal experimentation,
it was determined that many of these woods can be cut and seasoned satisfactorily in amounts suitable for school use. Although many woodworking teachers expressed interest in utilizing local woods, they indicated that because of the lack of time, information, and facilities, these woods were being used only slightly in their school shop programs.

In concluding the study, recommendations were made to aid the teacher in solving the problems of identifying and selecting the trees, cutting of large logs and pieces into usable forms, and methods of seasoning and storage.

The essence of satisfactory seasoning, which is the major obstacle in using these hardwoods, is in the understanding of how wood dries and in controlling the removal of the moisture. This is necessary so that as nearly as possible uniform shrinkage can take place. It is the uneven drying and the consequent uneven shrinkage, which causes the majority of losses during the seasoning and storage periods.

It is further recommended that the utilization of these hardwoods be a student-centered activity. No teacher without the interested cooperation of his classes would be able to carry out satisfactorily his teaching duties and the additional work of preparing these woods. This material is being processed for student use and the whole program should be maintained on a teaching-learning basis as an integral part of the woodworking course.
UTILIZING PACIFIC COAST HARDWOODS IN THE PUBLIC SCHOOL INDUSTRIAL ARTS PROGRAM

by

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UTILIZING PACIFIC COAST HARDWOODS
IN THE PUBLIC SCHOOL INDUSTRIAL ARTS PROGRAM

CHAPTER I

INTRODUCTION

Growing in the valleys and canyons of the Pacific Coast states are a large number of hardwoods that have had relatively small utilization for lumber.

In the early days when the West was being developed, the settlers turned to these hardwoods as materials for constructing the tools, implements, and appliances of the home, farm, mine, and small industries of the times. Western hardwood plow and shovel handles cultivated the soil and dug the gold. Tough oaken pack-saddle frames carried supplies far into the hills and river bars, to the mines and to the industries that flourished with mining. Wagon wheels of western hardwoods carried families and their belongings farther and deeper into the vast hinterland, away from the seaports and emigrant roads. Hardwood spokes, tongues, and axles transported the pine timbers of the high Sierras over tortuous roads to the desert mines of the Nevada Comstock Lode and brought back the silver bullion which financed the expansion of the West. Gigantic lumber wagons, whose parts were made of local hardwoods where great strength and wearing qualities were required, brought out of the Northwest and California forests the great firs, pines, and redwood logs felled by saws and axes whose handles were of tough Pacific Hardwoods.

Locally made small wooden boats and larger ships, built partly of
hardwood, explored and then plied regularly the coastal waters and navigable streams, bringing low cost transportation to the interior valleys and to the industries of the coast towns and mills.

In the better homes and hostelries of those earlier days, lovely furniture and cabinets began to appear, painstakingly made of west coast hardwoods by craftsmen who used the western counterpart of the familiar eastern hardwoods.

In the industrial arts of the early West, where iron, steel, and imported eastern woods were little used, local hardwoods were essential to the economy and development of the area. This utilization of a local resource dwindled rapidly as faster, cheaper transportation brought from the East the newly developed things of iron and steel. Mass produced pieces from eastern factories displaced all but a small amount of locally-made western hardwood furniture.

With the pioneering and earlier homesteading period over, and the development of this area booming, the lumber industries were geared to handle only the large coniferous softwoods. Very little logging was done in these minor hardwood species except for fuel, fence posts, tannin, and charcoal. This is the condition that exists to a large extent today.

It is not to be presupposed that a vast natural resource grows here untouched, to be harvested at a good return for ingenuity, work, and investment. That is not the case and definitely not the thesis of this study. It will be pointed out later that there are real obstacles in producing hardwoods that can compete with eastern and foreign woods in variety, quality, quantity, and in the resulting ultimate
selling price. Yet there are both scattered and good stands of hardwoods and larger shrubs throughout the Pacific Coast area which will provide lumber for woodturning, furniture making, and a multitude of other uses for projects in the school's woodworking program.

There are a few native hardwoods of sufficiently high quality that can be processed in adequate amounts to be sold by major hardwood dealers. These are available to school shops and western industries through the usual trade channels. In a survey made in Oregon alone in 1944, it was estimated in a report by Robinson: "... that there are slightly more than 2 1/3 billion board feet of hardwood in Oregon. This total includes trees 11.1 inches and greater diameter breast high (4 1/2 feet above ground), but it does not include such species as cherry, dogwood, or cascara." (56, p.5) This leaves a substantial number of species whose volume exceeds millions of board feet, which at present are not being utilized for lumber. There are sound reasons for this lack of use which now relegates these fine trees to serve only for the minor purposes of shade, fence-posts, and fuel.

Some of these woods are dense and refractory thus they offer seasoning and manufacturing difficulties. The major reason these trees are left in the forest is that the commercial operators are trained and equipped to log only the coniferous trees. These softwoods occur in vast predominance over the western hardwoods. Larger volumes of marketable lumber per tree are produced from the firs, pines, cedars, and other species than from the hardwoods. With the great present demand for the west coast softwoods, few operators care to bother with the smaller, less lucrative hardwoods.
The fact remains, however, that there are hardwoods in the three western states of Washington, Oregon and California. These can produce fine, usable products when properly cut, handled, seasoned, stored, and worked.

From a background of both good and bad experiences with seasoning, storing, and working small amounts of local woods in a high school industrial arts program, the writer is interested in these potentially fine woods and a plan by which they could produce a larger proportion of usable lumber.

The school in which this interest and study was started is located in a mountain county of northern California which is mostly forest land. In both the high school classes and the adult evening classes in furniture construction, there was a real interest in those woods which grew close at hand throughout the county. A number of the adults were particularly interested in woods and woodworking and brought to the school shop, from basements and sheds, pieces of hardwoods; some green, some many years old, to be made into small pieces of furniture. Much of this material proved unsatisfactory because of seasoning defects or insect infestation and there was a lack of suitable machinery for reducing the pieces to usable shapes and sizes.

**Aim of the Study**

There is need for investigation of the possible means of utilizing the hardwoods of the Pacific Coast states that would be available for the industrial arts program. Many of these woods are known to have great potential beauty and utility, yet they are not used extensively
by school shops and industry. A major obstacle preventing their wider usage seems to lie in the great loss of usable wood in the drying process.

The aim of this study was two-fold: first, gathering of worthwhile, accurate information on the availability, seasoning, storing, working characteristics, and uses of as many west coast hardwoods as was feasible; second, to synthesize this information into a form that could be readily used by industrial arts teachers as a referral source.

Sources of Information and Procedures Used in Conducting the Study

The seasoning and uses of these hardwoods is a field where many older woodworkers seem to have their own special recipes for getting the best results. Often these methods are based on hearsay, on groundless tradition, or on scant understanding of wood composition. In some instances these recommendations are contradictory. The lack of readily available, objective information for the teacher of woodworking was one of the factors that started this search for finding if there were practical ways of utilizing these hardwood resources on a small scale for school shop usage. The data for this study were gathered from the following sources:

1. Personal interviews with: wood shop teachers, professional wood technologists and foresters, local craftsmen working with hardwoods, commercial hardwood operators and dealers.

2. Investigations of available literature known to be accurate and applicable.

3. Experiments by the writer with the seasoning, storage, working and application of various uses of certain local hardwoods in the industrial arts program.
Terminology Used in this Study

Since this report deals, with but two exceptions, with western hardwoods, it is well, for the sake of definition, to clarify the term "hardwood" as differentiated from the softwoods. Brown, Panshin and Forsaith make this distinction: (9, p.48)

Commercial woods are divisible into two general classes popularly known as softwoods and hardwoods; these terms are frequently somewhat confusing, for some softwoods such as hard pine (*Pinus palustris* Mill., etc.), are much harder than some of the hardwoods, such as basswood (*Tilia spp.*), and vise versa. They are therefore to be considered as used in a general sense, to indicate a type of wood rather than the physical characteristics of a given wood. The softwoods, otherwise known as coniferous woods, are produced by coniferous and usually evergreen trees such as the pines, spruces, and hemlocks. The leaves are needlelike, linear, awl-shaped or scalelike and the seeds are born either in cones in the axil of a scale, or naked. Since the majority of these trees bear cones, they are placed by the botanists in the Coniferales, or Coniferae, which mean literally "cone bearers". The hardwoods, on the other hand, are obtained from broad-leaved trees such as elm, ash, oak, and poplar, scattered through various plant orders and families. The leaves are broad except in rare instances and are usually deciduous in the temperate zones. Softwoods are sometimes designated as nonporous woods and hardwoods as porous woods. The basis of this classification lies in the fact that the porous woods possess vessels or ducts extending along the grain which appear as pores and are often visible with the naked eye on the transverse surface.

The ensuing three defining chapters were constructed to present the needed background and to bring meaning to the terms used in discussing the problems of identifying these western woods; of their properties, and of their ultimate preparation and usage.
Limitations of this Study

This investigation was bounded by a number of limiting factors some of which appear to suggest a basis for a great deal of further research.

The hardwood trees, both native and imported, growing in the Pacific Coast states are many. It was apparent from the start that only the more common or accessible of the local hardwoods, and a very few of the imported or domesticated species, could be covered by a report of this type. Some of these trees have been described and are included in the appendix.

Lack of time and facilities further restricted this study to the reporting of the work and experiments of others in the methods of procuring, seasoning, handling, and working with these woods. It was necessary to use textbooks and library material for the background information needed to convey the findings to woodworking teachers and others, most of whom know little of basic wood technology.

It was decided that the most satisfactory method of obtaining worthwhile data from industrial arts teachers and other woodworkers would be by personal interview and discussion rather than by the questionnaire method. This too is a limiting factor, because the elements of time, distance, and funds restricted these interviews to a relatively short range. Two areas were covered: central western Oregon, near Oregon State College, and a part of central California. Many of the woodworking teachers and small commercial operators interviewed, though expressing a real interest in using these local resources, have had only meager experiences in actually seasoning and
working with these woods. They were themselves very interested in finding sound information about these native hardwoods.

It was found that industry and research workers have been experimenting over a long period, striving for better methods of utilizing these trees. The best and latest information is in the form of publications from colleges, industry and publicly supported forest products laboratories, including the U. S. Forest Products Laboratory at Madison, Wisconsin and the Oregon Forest Products Laboratory at Corvallis. Botanists and foresters, have studied these western trees for years and have published their objective findings in texts, manuals, periodicals and other literature. For these reasons much of the data upon which this thesis is based has been drawn from reports and library material pertinent to the western hardwoods.

The Need for this Study

If the industrial arts teacher is to grow professionally, to serve better the students he teaches and the community in which he lives, he must constantly learn more of his subject and of the materials with which the industrial arts are concerned. It is becoming realized that education within the school must foster the training of this country's youth, especially in the western states, towards thinking of a fuller utilization and conservation of the area's natural resources.

If it is possible to use these local materials, the school's program will be richer for it. In the few school shops that are using these hardwoods to any extent, students are making fine projects at low cost. They are using good materials suitable for the job. Except for
these local woods they would have to substitute expensive or impractical materials or not attempt the work.

No study has been done of the utilization of western hardwoods in the public school's woodworking program. There seemed a real need for an investigation and reporting of the means of identifying and satisfactorily preparing the wood of these local trees and larger shrubs for student project material.
CHAPTER II

CLASSIFICATION AND STRUCTURE OF HARDWOODS

An understanding of basic wood technology is essential for carrying out practical utilization of the western hardwoods in the school shop program. To make intelligent selections, for example, in the methods of seasoning and storage of lumber, it is certainly important to understand what actually takes place when these woods dry out; for it is converted from a wet, useless substance to a fine useful material or to a defective loss — valueless except for firewood.

As the background of simple metallurgy is needed for a well-rounded course in metalworking, so this understanding of the tree and its wood is necessary for the successful mastery of woodworking. In making use of these local hardwoods, this related information can take on real meaning for the learner.

This chapter presents a background of the factors which go to make up the anatomy and structure of wood. It will introduce and explain the terminology and the structure that must be known for conducting this study and for understanding the results as described in this report.

Classes of Trees

Trees are classified in the plant kingdom under the major headings of the seed-bearing division or the Spermatophytes. This group is divided into two classes: the Gymnosperms, to which the true conifers belong, and the Angiosperms which have two sub-classes. These
sub-classes are the Monocotyledons (one seed leaf, and include the palms, grasses and bamboos), and the Dicotyledons, the broad-leaved hardwoods.

It is with the trees of the latter group that this study is primarily concerned. The emphasis in this background and the explanation of the structure of wood will be restricted to these dicotyledonous Angiosperms, except where a comparison of these hardwoods with the structure of the coniferous softwoods will help to make the study more understandable.

Structure of Hardwoods

The properties of wood which determine its ultimate utilization are dependent on two factors; of primary importance are the varied physical structures, and secondly, its chemical composition which remains about the same at all times. Koehler, in introducing this subject says: (34, p.1)

Except for variation in the small amounts of infiltrated materials, the chemical composition is approximately the same in all kinds of woods; that is, all woods are composed mostly of carbon, hydrogen, and oxygen in definite proportions. The structure, however, varies considerably and is responsible principally for differences in the properties of the different kinds of woods, except insofar as color, odor, durability, extracts that may be made from the wood, and a few other properties are concerned.

The Chemical Composition of Wood

In the WOOD HANDBOOK prepared by the Forest Products Laboratory of the U. S. Department of Agriculture, is given this readily understandable description: (19, p.15)

Wood is composed of about sixty per cent cellulose, twenty eight
per cent lignin, and minor quantities of other materials. Cellulose is a colorless material insoluble in ordinary solvents such as water, alcohol, and benzene. It forms the framework for the cell wall.

Lignin is also insoluble in most ordinary solvents but more or less solvent in dilute alkalies. It constitutes the cementing material that binds the cells together and is mixed with cellulose in the cell walls. Cellulose and lignin are responsible for many of the general properties of wood, such as its hygroscopicity, resistance to corrosion by salt water and dilute acids, and susceptibility to decay. These two major constituents are found in about the same proportions in all species, but in addition there are small quantities of other materials in wood, some of which give certain species or groups of species clear, distinctive characteristics. Color, odor, and natural resistance to decay, for example, comes from materials other than cellulose.

The Cellular Structure of the Tree

The composition of wood is cellular. To understand the hardwoods, and their characteristics, an introduction to the plant cell and to the component parts of wood is needed in developing the ultimate picture of what transpires as wood is cut and seasoned.

The bulk of the tree is composed of long, thin cells, which because of their shape, are called fibers or tracheids. These fibers are massed together longitudinally and aligned with the main axis of the tree giving mechanical support to the tree, and in some hardwoods, serve to conduct sap. From the WOOD HANDBOOK is taken this description: (19, p.14)

Most of the cells in wood are considerably elongated and pointed at the ends, and for that reason are called fibers. The length of wood fibers varies from one-twenty-fifth inch in hardwoods to from one-eighth to one-third inch in softwoods. The strength of wood, however, does not depend on the length of the fibers, but rather on the thickness and structure of their walls.

The newly-formed cells nearest the outside of the tree (sapwood)
Diagrammatic section of a typical hardwood cell section (Courtesy of U. S. Dept. of Agriculture - Forest Service)
are filled largely with living protoplasm. As most of the inner cells (heartwood), which comprise the major core of the tree, do not contain this protoplasm, the wood is physiologically inactive, or dead. (19, p.14) These are matured cells which are filled with water, air, or, in the case of some of the hardwoods, innergrowths known as tyloses.

That the heartwood is "dead" does not imply it is in a stage of decay, but rather that these inner cells have merely ceased their function of maintaining life and growth in their mature stages. This inner structure, which forms most of the volume of the tree, serves to give strength and support to the main stem or bole, limbs, and the crown of leaves.

Parenchyma Cells. A group of cells that occupy a relatively small volume in most woods, but are important to the wood structure, are the parenchyma cells. These serve to store, digest and conduct the tree's food.

This description is given by Adnah C. Newell, late Professor of Industrial Arts, Illinois State Normal University, in the text WOOD AND LUMBER: (43, p.38)

Cells with thin walls of cellulose and provided with simple round or elliptical pits for easy diffusion, usually containing the life-giving protoplasm, and in addition starch, sugar, proteins and oils, are called parenchyma cells. One type is called assimilatory parenchyma and functions in forming with carbon-dioxide certain organic substances; another is storage parenchyma which contains tree foods . . . Placed radially in a tree, such cells form an important part of the medullary rays¹, and are used for storage or conduction of tree foods from the sieve tubes to the cambium or into the newly formed sap-wood.

¹See description of Wood Rays
Wood Rays In both hardwoods and softwoods, strips of cells run at right angles to the fibers, radially in the tree, to conduct sap across the grain. These strips of cells have been commonly known in the past as medullary rays, and may be found under that name in many older texts of woodworking and wood study. More correctly, these are called xylary rays when found specifically in the xylem or woody structure of the tree, but for the purposes of this study they will be referred to as wood rays. This term is accurate and is recommended when presenting related information in the woodworking class.

Koehler says this about wood rays: (34, pp.14-15)

Their purpose is to store food and to conduct sap from the bark to the sapwood, and vise versa. The ray cells and wood parenchyma cells are the only elements which contain protoplasm and are alive in the woody part (heart-wood) of the stem, although other elements function in the life processes.

In our native woods the rays are largest in oak, in which they appear as distinct lines on the cross-section, and as "flakes" on the faces of radially cut lumber. In sycamore and beech they are conspicuous but they are much smaller than in the oak. In other woods they are still smaller, but they can be seen on split radial surfaces as fine strips running across the grain . . .

The medullary rays play an important part in the drying, shrinking, and checking of wood. They also add beauty to some woods and are very helpful in identifying species.

How the Wood Cells are Formed and the Tree Grows

Koehler describes the formation of new life: (34, p.3)

A tree grows by forming new cells under the bark and at the tips of the branches and roots each growing season, thus increasing its diameter, height, and the extent of root system each year. The new cells are formed by the division of certain delicate cells functioning solely for this purpose. The growing region under the bark is known as the cambium. As an initial cambium cell divides, one of the new cells formed grows to larger size and becomes thicker walled, forming either a wood element if the
inner one develops, or a bark element if the outer one develops. The other cell formed by the division of the parent cell does not develop into other tissues, but after increasing in size it again divides producing a wood or bark element and so on always leaving undeveloped cells to continue the process of division.

**Porous and Non-Porous Woods**

Another part of the gross structure that is important in describing these hardwoods is their porous nature. According to Brown, Panshin and Forsaith: "Hardwoods differ from softwoods in possessing pores that are vessels . . .; softwoods are said to be non-porous in the sense that they do not contain vessels." (9, p.170)

When a cross-section of a hardwood is viewed with a hand lens or a low-powered microscope it will show not only the fiber ends but these vessels or pores, known to the botanist and wood technologists as the *tracheal vessels*. These tracheal vessels or pores are cell-fusions serving as tubes for the conducting of water. (55, p.35) They are bounded by the fiber tracheids and the parenchyma cells.

**Ring Porous and Diffuse Porous Hardwoods** Hunt and Garratt, in discussing the pores as a background for the study of the penetration of wood preservatives explain: (29, p.237)

Depending upon the arrangement of the vessels, the hardwoods are generally classified as either *ring porous* or *diffuse porous*. In the former group, which includes the oaks, ashes, hickories, and elms, the pores in the spring wood are usually definitely larger, and in some cases more numerous, than those in the summer wood. In diffuse-porous hardwoods, such as the maples, birches, beach, gums, basswood, and cottonwood, the pores are nearly the same size and more regularly dispersed throughout the growth rings.

**Tyloses** One of the anatomical factors whose presence determines, to a large extent, seasoning and utilization, is the *tyloses* which
occur in the pores of some hardwoods. Newell describes them and their effect on the wood: (43, pp.40-42)

Tyloses are sac-like portions of the parenchyma cells that have pushed through the pits into the lumina or cavities of the tracheids or tracheal vessels.

Practical value of tyloses. Tyloses close up the tracheal vessels and act as plugs to circulation. Woods having tyloses in the tracheal vessels can be filled more easily and successfully by the wood finisher, as the filler remains in the pores more satisfactorily and a more nearly level surface can be secured to apply the shellac and varnish. For the above reason it is easier to fill white oak than red oak.

Water is absorbed quicker in woods of a similar character which do not contain tyloses, other things being equal, especially the specific gravity, wood having no tyloses will water-log and sink sooner than others.

Brown, Panshin, and Forsaith, in their chapter on the minute structure of porous woods, make this observation regarding the effect that the tyloses have on the permeability of hardwoods: (9, p.209)

Profuse tylosic formation inhibits the penetrability but does not necessarily increase its durability, contrary to wide-spread opinion. The white oaks normally have a high tylosic content and are used for tight cooperage. The red oaks, in contrast have few tyloses, so few that it is possible to blow through the wood for some distance along the grain, hence they are not suitable for wine barrels, beer barrels, etc. until after special treatment. Woods with open pores treat best with preservatives.

Growth of Annular Rings

The structure of wood is determined to a large extent by what occurs during the growth cycles of the tree. The WOOD HANDBOOK tells this story: (19, pp.11-12)

Each year, by growth in the cambium, a tree adds a layer of wood on the outside of that previously formed, thereby increasing the diameter and pushing the bark outward. If growth is interrupted each year, by cold weather or dry
seasons, the character of the cells at the end of each year's growth and the beginning of the next is sufficiently different to define sharply the annular layers or growth rings . . . . If the growth of a tree is interrupted during growing season as a result of drought or defoliation by insects, two or even more differentiated rings may be formed in the same season. The inner one in such event usually does not have a sharply defined outer boundary; is called a false ring.

Occasionally, under unfavorable conditions, no growth takes place in parts of a tree trunk, especially in the lower portion. In such case the annular growth layer is incomplete, portions being entirely missing.

Spring Wood and Summer Wood In the trees that live in these Western states, which are a part of the temperate region, seasonal growth is shown in the following manner: (19, p.12)

Each annular ring is divided more or less distinctly into two layers. The inner one, the spring wood, consists of cells having relatively large cavities and frequently thin walls, the outer layer, the summer wood is composed of smaller cells. The transition from spring wood to summer wood may be either abrupt or gradual, depending on the kind of wood and the growing conditions at the time it was formed.

The proportional amount of these denser, darker summer wood growth rings determines to a large degree in most woods, the strength and value of the wood.

Sapwood and Heartwood In discussing earlier the cellular structure of the tree, the make-up of the outer sapwood and the inner heartwood is described briefly. It is important to visualize the differences between these two adjoining tissues for they have distinct characteristics that influence the seasoning and the physical and working properties of the wood.

Henderson, in describing the heartwood and the sapwood as a background for the seasoning of wood, explains the differences in this way:
Except in a few tree species, every saw-log exhibits two kinds of wood. The core is composed of darker tissue which has a higher infiltration content and is hence generally more durable but not necessarily stronger than the lighter colored wood to the outside; heartwood consists of tissue which is no longer active in promoting the rise of sap in the tree and performs only the mechanical function of insuring strength to the tree stem. The sapwood encircles the heartwood and is lighter in color and generally lighter in weight when ovendried. Structurally there is no difference between sapwood and heartwood with the possible exception of tyloses in the latter, but frequently the sapwood is much richer in moisture while infiltration products are often abundant in the heartwood. Water evaporates from the sapwood quite rapidly and hence it dries quite easily, with few or no seasoning defects. Heartwood, not infrequently, contains less water than the sapwood, but is more difficult to dry and requires a longer time. Where sapwood and heartwood occur in the same board, the difference in the speed of drying and the resulting uneven shrinkage often result in such drying defects as "cupping", "edge-warping", and splitting.
CHAPTER III

ELEMENTS OF THE CHARACTERISTICS AND PROPERTIES OF HARDWOOD

Because of their unique structural and physical properties, the hardwoods are prized for furniture making, interior finish work, sporting equipment, and for many utilitarian purposes such as tool handles, implement parts, and applications where great strength is of importance. The selection and fullest utilization of these woods by the teacher, student, and small mill operator, requires an elemental knowledge of their basic characteristics and the more common defects. The following descriptions will cover briefly the major properties that make these woods desirable, and some of the factors that detract from their value.

Texture and Grain

These terms are used rather loosely in speaking of the size and smoothness of the wood elements, and of the direction of the fibers and structure of the wood.

Texture

Texture is often used synonymously with grain but usually it refers to the size and appearance of the exposed tissue and pores rather than to the annular rings. Brown, Panshin and Forsaith, in differentiating between the two terms, write: (9, p.51)

Texture is concerned with the size and quality of wood elements. To have specific meaning, the term must be preceded by a qualifying adjective. Such expressions as "fine-" and "course-textured", "even-" and "uneven-texture", "harsh-" and "smooth-textured" are frequently encountered in
Grain, as used for wood, has to do with the alignment and sorting of wood elements; the latter is tied up with the width of the annual increments because the sorting is frequently different in wide and narrow rings. Like "texture", the term "grain" must be preceded by an adjective modifier to connote special meaning.

In the coniferous softwoods familiar examples of coarse-textured species are the woods of the sugar pine, white pine, and redwood, whereas the other extreme is represented by the Pacific yew.

In hardwoods, the tangential diameter of the vessels, the size of wood rays, and the number of these per unit of volume, serve best as measures of texture. (9, p.51) The Oregon ash, for example, is coarse-textured, the early or spring wood pores are unusually large in comparison with the pores of the fine-textured Pacific madrone.

"Terms such as "harsh-textured" and "smooth-textured" are expressive of the quality of wood elements — how the wood works and finishes under tools.", is cited by Brown, Panshin and Forsaith. (9, p.51)

**Grain**

Even grain applies to lumber in which there is little contrast between spring and summer wood. Western hardwood species of this type are the Black cottonwood (called by local operators, "bam") and the Bigleaf or Oregon maple.

Uneven grain applies to the lumber in which the summer wood is conspicuous and harder to work, as in the oaks and ashes.

Straight Grain indicates that the fibers of the lumber run parallel to the edge of the board.

Diagonal Grain is produced when straight-grained lumber is not cut parallel with the grain. This is a serious defect which greatly weakens the piece. Diagonal grain is caused by careless sawing, by
using crooked logs, and/or by "the common practice of sawing tapering logs parallel with the center instead of with the bark". (34, p.23)

**Interlocking Grain** or cross grain, means adjacent layers of wood spirally inclined in opposite directions. (34, p.24) This is caused by the fibers spiraling in a given direction for a number of years, then the pitch is reversed for about the same period. "Wood of this type in which the fiber alignment reverses at quite frequent intervals is designated as **interlocked-grained** wood." (9, p.273)

These woods of interlocked grain produce their most eye-appealing surface when the boards are "quarter sawn", but the surfacing or planing of such lumber is most difficult. "When such lumber is properly surfaced these layers reflect the light differently giving the wood a ribbon or stripe effect." (34, p.25)

Two western trees that have characteristically interlocked grain are cottonwood and sycamore, although it occurs in other local woods, especially at the butt. This interlocking grain has a tendency to cause the lumber to twist in drying and storage, but does not weaken timber so much as the diagonal grain.

**Silver Grain** is the term often applied to the wood rays or flakes when seen at right angles to the edge of the grain. Oak and sycamores are quarter-sawn to produce this effect and are beautiful chiefly because of the appearance of the rays.

**Quarter-Sawing of Hardwoods to Produce Figure and the Desired Grain**

Before continuing with the appearance of wood, the methods of
cutting the log to produce the most attractive or functional surface should be described. Nelson C. Brown, professor of Forest Utilization, Syracuse University, describes quarter-sawing and its purpose in the text LUMBER: (10, p.86)

In quarter-sawing, the log is sawed parallel to the wood rays and perpendicular to the annular rings. Quarter-sawn lumber includes all boards whose rings form an angle between 45° and 90° to the widest surface of the lumber. The principal advantages of quarter-sawed lumber as compared to plain-sawed lumber are:

(1) It resists abrasion and wears more evenly as can be seen in flooring.

(2) Some species such as oak and sycamore exhibit a pleasing figure, as in panels.

(3) It takes a finish more evenly.

(4) It does not work or splinter easily and therefore seasons more readily.

(5) It is stronger when used for structural purposes under traverse loads.

(6) There is negligible shrinkage occurring across the width of edge grain pieces when used for flooring.

The principal disadvantage of sawing quartered lumber is that it costs more to manufacture because there is more waste in sawing and more time is required for sawing because of the frequent turning of the log on the mill carriage.

In speaking of the similar manner by which softwoods are cut, the terms familiar to western woodworkers are "vertical" or "edge grain". These are synonymous with "quarter-sawn".

**Figure**

A great deal of space could be used to explain the many variations of figure in the hardwoods. It is this figure that makes the hardwoods
particularly valuable as a source of veneer stock, and gives beauty to the solid lumber.

A number of the Pacific Coast woods produce interesting and very beautifully figured grain, and as such these are a valuable source of veneers for commercial use. The Alfred A. Loeb Company of Portland, Oregon, ships burls and figured-grained logs of local Oregon or Big-leaf maple, walnut, madrone, and California laurel or Oregon myrtle to veneer buyers in Italy, Switzerland, France, and England.

In describing the term "figure", S. J. Record, Dean of the Forestry School, Yale University, makes this distinction: (55, p.92)

"Figure, in the sense used in the timber trade, applies only to lumber that exhibits special and attractive designs in grain and (or) color, whereas the wood technologist generally uses the terms in a broader sense to include all pattern-like arrangement of the tissues."

At the Loeb plant the writer was shown local Bigleaf maple samples of fiddle back mottle, in both the log and the finished sheet of veneer, caused by wavy grain. "This results when the elements undulate in a regular manner without successive layers crossing." (55, p.93) Wavy grain, as its name implies, is used in the manufacture of violins, and is exported for that purpose. Loeb's also had in storage for shipment, logs containing quilted figure, which, according to Brown, Panshin, and Forsaith, "is obtained from selected stock of Oregon maple (Acer macrophyllum Pursh). This figure results from corrugations in the grain which frequently develops in leaning trees and below large limbs". (9, p.277)
These are but a few of the recognized figures of wood; western hardwoods possess these characteristics and many more, to a valuable extent.

Color

Color is one of the factors which gives wood its aesthetic appeal. It is one reason why hardwoods are prized for furniture construction and interior finish work, above all other materials. Color of wood, besides giving interest or beauty, is valuable for identifying these woods.

The sapwood of living trees is light in color, sometimes nearly white, while the heartwood, in the main, is darker; although some of these woods such as cottonwood are of a rather uniform light color throughout.

Black walnut lumber, according to a report of the Forest Products Laboratory at Madison, Wisconsin, is steamed to give uniform color:

(18, p.1)

In commercial practice, black walnut lumber is usually steamed before it is seasoned, mainly to darken the sapwood. Some manufacturers think that it also improves the color of the heartwood. The sapwood of steamed lumber seldom becomes as dark as the heartwood, however, an additional staining is often required in finished products.

Mickelson and Moore, shop instructors of the Eugene, Oregon, High School, color heartwood of "green" walnut used in their shop classes, by covering the pile of walnut boards with sawdust and allowing rain to soak the pile all winter.
Long contact with water will produce color changes in some western hardwood. Koehler points out: (34, p.76)

Oak which has been under water or underground for a long period of time is darker than freshly cut oak. The wood of the California laurel, or Oregon myrtle, is darkened by leaving the logs submerged in crates for a long time.

To the majority of manufacturers, specific woods must, in most cases, have a uniformity of color tone. If other means are not satisfactory in gaining this uniformity, the wood is either bleached or stained accordingly, because neither the producer nor the consumer -- be he commercial operator or student -- would want, for example, a half-light, half-dark walnut table.

The wide variety of color, figure, and texture found in wood is of never-ending interest, for it is these characteristics that give wood its beauty and individuality.

Luster

This is the property of wood that produces a sheen, or gives "life" to the surface, because of the manner that light is reflected from the wood and its contents. Any fine-textured wood can produce a superficially glossy surface by finishing and polishing, but that is not luster. Record makes this comment of luster: (55, p.99)

The finest cabinet woods, regardless of color are characterized by a golden luster that appears to glow beneath the surface . . . Some woods, especially those with considerable parenchyma, may appear dull when held in one position and lustrous in another. The presence of oily and waxey substances may reduce or destroy the natural luster.

Pacific dogwood is a good example of a fine-textured hardwood that exhibits very little luster, while the woods of the Oregon or Bigleaf
maple and the California laurel (Oregon myrtle) have a beautiful natural sheen.

If a hardwood is quarter-sawed the wood will generally reflect more light than if plain-sawed. This is because the "quartered" grain exposes numerous ray flecks which have the ability to reflect light.

**Density and Weight**

**Density**

Density of wood refers to the amount of wood substance in a definite volume. This should not be confused with the weight of the wood which is changeable because of the moisture content and other variables.

Wanaargd, in describing density as one of the factors affecting mechanical properties says: (71, p.153)

The greater amount of wood substance in one wood than in another is reflected in the presence of a larger proportion of cells with thicker walls and smaller cavities, a condition that naturally leads to greater strength on the part of the denser wood.

**Relative Weight of Wood**

The major cause of variety in the weight of wood of a given species is a change in the moisture content. The amount of water will range from four or five percent in kiln dried stock to over 100 percent (by weight) in some "green" timbers. Allowing for the changeability of the water content, woods that have greater dry weight will have the greater strength because of their density. The important factor of
moisture content is more fully covered in the next chapter where drying lumber is discussed.

Other Descriptive Characteristics of Hardwoods

These properties also determine the ultimate use of the wood.

Durability
This is the resistance of wood to decay and fungus infection.

Elasticity
The property of a wood to resist deformation, and thereby to quickly recover its original shape when the deforming forces are removed. This is a requisite for archery bows and implement handles.

Refractory
Hardwoods that are termed refractory indicates that they are hard to season and/or obstinate while working with tools.

Machinability
Those composite properties of a wood which allows it to be worked satisfactorily with high speed cutting edges. Woods that machines well have a resistance to splitting, chipping, binding, and producing fuzzy grain. The wood cuts readily yet is firm under tool pressure, and does not dull or overheat tools quickly.

Growth and its Relations to Strength in the Hardwoods

Ring-Porous Hardwoods
In the summer wood of species such as the ash and oak, the vessels are smaller and have correspondingly narrow, thick-walled fibers, which
makes a very dense substance when compared to the large pores in the spring wood. In ring-porous hardwoods, the more rapid the growth, or the wider the growth rings, the heavier, harder, stronger, and stiffer the wood will be. Although this is generally the case, here again the quality of the summer wood must be considered, together with the conditions under which the material was grown. (71, p.165)

In selecting stock that requires great strength, as would be required for tool handles and ski blanks, the younger, faster growing of "second growth" trees generally should be chosen.

Diffuse-Porous Hardwoods

These trees include such west coast species as alder, maple, and madrone, to mention a few. The pores or vessels are scattered throughout the growth rings of these trees rather than confined to the large pores in the spring wood growth.

There is generally no definite relationship between the rate of growth and the density and strength of their structure. Wangaard (71, p.165) does say, however, that "... a medium rate of growth is usually associated with stronger wood than is very fast or very slow growth".

Defects Not Caused by Seasoning

Sound logs, boards, and burls are selected for use before the seasoning or drying process takes place, thus most of the defects which cause trouble and loss will be seasoning defects. These will be covered in Chapter IV in discussing seasoning problems. Non-seasoning defects
that affect these hardwoods should be mentioned to give an understanding of their prevention.

**Powder-Post Beetles (Lyctus)**

There are a number of insects whose larvae produce "powder-post" defects in wood. The most widely distributed and prevalent of these belong to the genus *Lyctus*.

This powder-post beetle attacks mainly the starchy sapwood of the seasoned hardwoods, but will readily infest the heartwood. Hunt and Garrett write: "The larvae or grubs of these insects bore through the wood for food and shelter, leaving the undigested parts of the material in the form of a fine powder." (29, p.66) Powder-post damage is most frequently found in ash, hickory, oak and California laurel, although cherry, elm, maple, poplar and black walnut are subject to attack. (9, p.340)

Eggs are laid on the outer pores or vessels, and the grubs tunnel through the wood thriving on the starch of the dry parenchyma cells, especially in the sapwood. As one infested piece can contaminate and make valueless a whole lumber stock if left unattended, it is essential to take measures against this pest. Sherrill makes these recommendations: (61, pp. 30,31)

Material once attacked by this insect is usually damaged beyond repair. The best action to take once a lumber storage area has been infested is to empty the storage, trim off all the visibly infested pieces and dispose of them. Before putting the lumber back in storage, it may be saturated with kerosene or orthodichlorobenzine. Kiln drying of 180 degrees F. will destroy all stages of the powder post beetle. Preventative measures to take against infection are:

1. Inspect stored hardwoods regularly.
2. Burn all infected pieces and useless sapwood material.

3. Classify all lumber as to kind, quality (heartwood or sapwood), and age, pile these classes in separate piles.

4. Utilize or sell the oldest stock on hand.

5. Inspect all new stock going into storage.

6. Use only heartwood sticks in piling lumber.

At the industrial arts department of the Eugene, Oregon, High School, Mickelson and Moore have used local hardwoods extensively for a number of years. They make a practice of painting the Oregon myrtle and other stock, subject to the Lyctus beetle, with a water solution of sulphur and lime, a method which has proved very satisfactory.

About twenty years ago in the wood shop of the Industrial Arts department at Oregon State College, the stored hardwood lumber, particularly a quantity of ash, was found to be riddled by this beetle. These were brought in by a shipment of infested myrtle wood.

According to Professor George Cox, head of the department of Industrial Engineering and Industrial Arts, the entomology department was consulted on the problem and they recommended the following measures which were carried out: the badly infested parts or pieces were destroyed; the remaining sound stock was heated in a dry air kiln at 180° F. for a rate of one hour for each inch of thickness per board; and the floors cleaned of any of the "powder" from the worm holes, as it contains the eggs of the powder post beetle. Following these measures, the storage loft was fumigated with carbon bisulphide and the "clean" lumber was sprinkled thoroughly with insect powder.
Over the years, this treatment has been given to the hardwood stock three times with good results.

Now, before the lumber is stored, each piece is sprayed with a water solution of DDT, then liberally sprinkled with a powder containing DDT. By treating the lumber methodically in this manner, the valuable hardwoods have been freed of infestation.

Infection Defects Caused by Fungi

These are molds, stains, and decay, each requiring moisture for their growth and are developed in sound timber by lack of precaution in yarding, drying, and storage. Avoidable defects such as these will be covered after a discussion of the wood-moisture relationships.

Tension Wood

An abnormal wood is produced on the upper side of leaning trunks and in large limbs of hardwood trees. Material from these members is designated as tension wood. (9, p.287) It, and the compression wood formed on the underside of the branches of softwoods, is called "reaction wood".

Brown, Panshin, and Forsaith cite from research workers experimenting with this reaction wood: (9, pp.293-294, 297)

Tension wood frequently machines differently than normal wood... Marra found that tension wood in hard maple tended strongly to result in "woolly" surfaces traceable to the tracts of gelatinous fibers... In shaping blocks, Marra experienced considerable difficulty in sawing; the saw frequently pinched making the operation difficult... In lumber from tree species with dark heartwood, tension grain can be distinguished in the heartwood by its silvery sheen along the grain. This is traceable to tracts of gelatinous fibers in the early wood which cause the abnormal wood to stand out from the duller and generally darker normal wood. The contrast is much less striking in the sapwood but, in
this also, the tension wood can be detected by its more pronounced silvery luster with the proper angle of light.

**Brashness**

Brashness is an important defect in wood where strength is desired. Brashness is an abnormal condition in wood that permits it to break suddenly and completely across the grain, at a stress at which a normal piece of the same wood would not fail. (9, pp.297-298)

Brashness gives no sign of failure before breaking sharply, especially under shock, and for that reason is very objectionable. It is often characterized by low density and in some cases may be caused by prolonged high temperatures during kiln-drying.
CHAPTER IV

SEASONING AND STORAGE OF WESTERN HARDWOODS

The cellular structure of all living trees is saturated with water, which begins drying and working out of the wood as soon as the tree is cut. At all times the wood attempts to reach the same moisture content level as that of the air which surrounds it. It is essential for this water to leave the wood for only dry lumber has value to the woodworker. During this seasoning or drying-out time and ensuing storage period, the bulk of the defects of these hardwoods are developed.

An understanding of the factors that affect the wood during this process and a knowledge of how wood dries is basic to carrying out practical utilization methods of these local woods.

Factors That Affect Seasoning

Seasoning Defined

As all wood is wet when it is freshly cut from a growing tree, its moisture content must be lowered before the wood is fit to use. Eyres, gives the British Standards Institute definition of seasoning, and then further describes the action of the drying and seasoning as: (17, p.51)

A process involving the reduction of the moisture content in a timber towards or to an amount suitable for the purpose for which it is to be used (drying). In other words, it is a process of bringing the timber into a condition in which it will more or less remain stable after manufacture.

Seasoning does infer that, in addition to the "setting" of the cell walls consequent upon drying, there is also an exhaustion of surplus starch content and therefore, less
likelihood of insects and fungi being attracted. The practice of allowing oak logs to lie with their bark on will result in reduction of the starch content by the remaining live cells in the wood feeding on it, even though no appreciable drying can start to take place.

The terms "drying" and "seasoning" are synonymous. They are used interchangeably by nearly all the references.

Moisture in Wood

Water is contained in wood in two ways. These are: "free" water and "bound", "imbibed" or "hygroscopic" water. "Free" water is held in the cell cavities and intercellular spaces. "Bound" water is contained within the cell walls. (3, p.2) It is this water contained in the cell wall that maintains "green" wood in a swollen condition. When the tree is cut and the log is exposed to air, the free water leaves the exposed ends by evaporation. When the free water is completely gone from this outer area, the bound water can begin to leave the cell wall, and as this occurs the cell shrinks. That is the way wood dries, progressively, from the outside layer to the next layer of cells.

It is important to realize that the free water must be removed first before any of the bound water can leave. When water leaves the cell walls, shrinkage of the cell must take place. The essence then for seasoning any wood is in controlling the removal of the moisture content so that as nearly as possible, uniform shrinkage can take place.

"Uneven drying and uneven shrinking are the cause of perhaps 90 percent of the losses occurring in seasoning, whether it be out in the yard or in the dry kiln." (26, p.13) That stage of drying where the
Characteristic shrinkage and distortion of flats, squares, and rounds as affected by the direction of the annual rings. The dimensional changes shown are somewhat exaggerated.
shrinkage of the cell walls begins, is the stage called the fiber saturation point of wood.

**Fiber Saturation Point** Henderson, in discussing the moisture contained in wood says: (26, p.12)

When wood dries the free water is first to evaporate and after it has all left and only the water in the fiber walls remains, we have reached what is termed the Fiber Saturation Point. This amount varies from 20 to 30 per cent of the dry weight of the wood, depending on the particular species and in practice we use 25 per cent as the saturation point.

**The Shrinkage and Swelling of Wood** In describing the control of drying defects, Baker and Espanas point out that: (3, p.2)

The shrinkage or swelling of wood is directly proportional to the amount of water lost or gained below the fiber saturation point. Because of the complex structure of wood, its shrinkage is not equal in all directions and even in a given direction, the shrinkage is not equal because of variations in structure, especially with respect to density. In normal wood, shrinkage along the grain is negligible, while shrinkage along the annual rings (tangential shrinkage) is greatest ... Shrinkage across the annual rings (radial shrinkage) is approximately one-half to two-thirds of the tangential shrinkage. In general, shrinkage is greater in woods of higher density, whether of the same or different species.

Variations of shrinkage cause seasoning defects to occur as the wood dries. Many of the potentially valuable western hardwoods have high density, and thus considerable shrinkage takes place while reducing the moisture content to a satisfactory point where there will be no change in its size and shape during final working and ultimate use. Therein lies a major problem of utilizing these local timber resources.

**Moisture Content** The low percentage of water in relation to
the dry weight of wood is the essential factor for a minimum amount of shrinkage and swelling of the wood cells, and for a reduction of the defects incurred by this cellular change. "An air-dried board containing 12 to 15 per cent of moisture has shrunk one-half of its total possible shrinkage. A kiln dried board of about 8 per cent moisture has been reduced by approximately three-fourths of its entire possible shrinkage." (43, p.127)

It is customary to express the moisture content of wood as a percentage of the oven-dry weight. The following formula quoted by Brown, Panshin and Forsaith, is used to determine moisture content and percentage of the weight of drying lumber. (9, p.60)

\[
\text{wt. of the wood before oven-drying} - \text{wt. of the oven-dry wood} \times 100 \\
\text{wt. of oven dry wood}
\]

Bateson expresses the formula in these words: (4, p.7)

The initial weight minus the dry weight represents the amount of moisture which has been evaporated. The weight of the moisture originally present divided by the dry weight of wood multiplied by one-hundred gives the moisture content per cent.

The moisture content of wood is affected both by the original water still in the cells and the amount of moisture "picked up" by the wood from the surrounding air. Both air and wood are hygroscopic, that is, they have the ability to hold water. "Dry wood will absorb moisture from damp air, and wet wood will give up some of its moisture in comparatively dry air." (34, p.42) This action takes place in all wood relationships and ultimately assumes a point known as the
"equilibrium moisture content". (3, p.3)

Relative Humidity In describing the influence of moisture content of air on the drying of lumber, Henderson says: "Since the drying power of air is dependent upon the amount of water it can continue to absorb until saturated, we are only concerned with its relative humidity." (26, p.15) Relative humidity is the actual percentage of water vapor in the air as compared to air that is fully saturated.

The Seasoning of Western Hardwoods for School Use

The aim of all lumber seasoning is to reduce the moisture content within the wood structure to a stable point where there is a minimum of shrinking and swelling. At the same time it is imperative to prevent the many defects caused during the drying out and shrinking process.

Lumber to be used for outside rough construction obviously does not need the lowered moisture content that is necessary for fine furniture and interior panelling. For projects that are to be built in a warm shop and to be used in homes and heated buildings, a low, uniform moisture content is vital to keep joints from opening up, to keep fits tight, and to prevent checking and warping caused by further shrinkage.

Mathewson, advocates these moisture percentages for seasoned lumber: (37, p.266)

Recommended moisture content for various wood items at time of installation. (percentage of oven-dry weight)

Interior finish woodwork and soft wood flooring - 8%

Hardwood flooring - - - - - - - - - - - - - - - - - - - - - - - - - - 7%
Siding, exterior trim, sheathing and framing — — — 12%

Ross, while telling of the seasoning requirements for Oregon myrtle says: "... it is a general rule that wooden articles for interior use have a moisture content of 6-8%." (57, p.3)

Except in cases where a lumber dealer handles kiln dried local hardwood such as alder and maple, it will be necessary for the school to season its own stock by air drying. It may be possible in some situations to have the pieces kiln dried. While kiln drying is very desirable, it is often not available to the schools of most western localities so the seasoning of locally gathered materials frequently must be done by a long period of air drying.

It is possible to reduce the moisture content by air drying, of even the denser woods whose thicker cell walls make for slow curing. In Henderson's interesting history of kiln drying, he speaks of the method the woodworker employed long before the kiln was used:

(26, p.107)

He early discovered that if he brought his wood into his workshop where air conditions were warmer and drier than out of doors, they dried in less time and the subsequent shrinkage much reduced. This slow and antiquated process of drying is resorted to still to some extent even in this country. We have, however, many splendid cabinet and musical instruments constructed centuries ago, as examples of fine workmanship in which correct seasoning played a very important part.

There are a number of publications written to aid the person who wishes to season small quantities of lumber. Any teacher of woodworking will find these very readable and helpful even if they are just to guide him in storing lumber and understanding wood more fully. References to a number of these sources are included in the
Edmund F. Rasmussen, of the Forest Service, Forest Products Laboratory at Madison, Wisconsin, writes in the introduction to a short instructive bulletin on A METHOD OF SEASONING SMALL QUANTITIES OF LUMBER: (54, p.1)

Green lumber can be seasoned to the necessary dryness for the purpose by combining outdoor air seasoning with subsequent further drying in a heated room. Studies at the Forest Products Laboratory show that, while this method is essentially simple, it is not without pitfalls for the inexperienced handler of green wood. Unless certain precautions are observed, such defects as checking, warping, and splitting may occur. If reasonable care is exercised, however, well-seasoned lumber can be obtained by the method.

Good seasoning results are dependent on a number of factors that the teacher and his shop classes can control. "Among these are the size of the lumber to be dried, the use of end coatings to retard end drying, proper piling, and other practices." (54, p.1)

Sizes of Lumber for Best Seasoning

Rasmussen makes these pertinent points that must be kept in mind while considering the seasoning methods and the ultimate articles for which the lumber will be used: (54, p.2)

Thin, narrow lumber dries much more rapidly with fewer seasoning checks than does thick, wide lumber. Warp, however, is increased. Thick planks or timbers containing the pith of the tree, commonly called box-heart timbers, are very difficult to dry without checking. Wide boards are more likely to surface check than narrow boards. Thick boards are also more susceptible to checking than thin boards. To obtain fast drying with a minimum of seasoning defects, the lumber should be cut into boards of about the thickness and widths required for final use, with due allowance for shrinkage and warp.
It is common practice for the manufacturers of Myrtlewood products in southern Oregon and northern California, to rough-out "green" stock for lamps, bowls and novelties to within one-quarter to one-half inch of the desired finished dimension. These blanks are then set aside to season until they are dry enough for use. This practice was observed in the shop of Charles Ward of Eugene, Oregon, where he had many blanks being dried. These ranged from small objects such as roughed-out salt and pepper shakers to large blanks for trays and gunstocks.

J. M. Stewart, in charge of the woodshop of the Oregon Forest Products Laboratory, found when working with Pacific madrone that one-inch lumber not over eight inches in width when cut, produced the best working characteristics and had less degrade due to seasoning. Very fine broad surfaces, such as needed for table tops, can be built-up by machining and gluing the narrower boards of madrone together. This method is recommended for those native hardwoods that are refractory and dense.

End Coating Wood for Prevention of End Checks

J. S. Mathewson, in his article on the seasoning of lumber published in the INDUSTRIAL ARTS AND VOCATIONAL EDUCATION magazine, discusses the movements of moisture in wood: (37, p.267)

A general knowledge of the movement of moisture in wood enables one to understand the seasoning process. . . . moisture tends to distribute itself evenly through the wood, moving from the moist to the drier areas . . . losing moisture through the end grain more rapidly than through the side grain. Temperature and humidity at the surface of the wood are controlling factors.

Because end-cuts dry out and check quickly, waste caused by this checking can be reduced by covering the exposed portion of freshly cut
logs and lumber. Coverings can be made by tacking metal or wooden cleats on the ends, or by coating the ends with a water resistant sealer. The most practical way of covering the exposed timber ends for small lots in the school shop is to paint them with a liquid end coating. This coating can easily be applied by dipping or brushing. The requirement for end coating materials for air drying is that they be water resistant, and must not be easily removed either during handling or by the action of the air and water vapor within the wood.

Here are some recommended coating materials that can be used in the school shop:

**Hot Coating Material**

"Paraffin" is described by McMillian of the Forest Products Laboratory at Madison, Wisconsin: (39, p.4)

Paraffin has long been used to coat specialty items that are to be air seasoned. It is effective in one thick coat, can be applied at low temperatures (135° - 150° F.) and adheres well to wood ... It is moderate in cost; material to coat 100 square feet of end area can be bought for $2.50 to $3.00.

**Cold Coating Materials**

McMillian in discussing cold coating says: (39, p.7)

The use of paints, drying oils, and asphalt varnishes as end coatings, sometimes with little regard to their effectiveness, has been long practiced by the lumber industry. Ordinary paints and varnishes are too thin for end coating unless several coats are applied.

"Aluminum paints" L. D. Espanas, of the staff of the Oregon Forest Products Laboratory, in discussing the end coatings that could be used in the school shop, said that aluminum paint made a very satisfactory seal against excessive loss of moisture. Referred to again,
McMillian reports: (39, pp.9-10)

The effectiveness is due to the leafing that occurs when the flat particles come to the surface and pack themselves closely together in the outer layers of the vehicle... The effectiveness of aluminum paint is influenced by the vehicle used. With ordinary bronzing liquids, their effectiveness is not very great. One of the best vehicles is a phenolic resin, tung-oil varnish.

Piling Procedures

The location of the drying pile for the industrial arts program is an individual problem for each school. The seasoning can take place in outdoor piles, or in open or closed sheds or rooms. An ideal situation for a school would be to have the lumber dried in an enclosed, well ventilated shed or room adjacent to the dry lumber storage. If a lack of facilities require that the lumber be initially yard dried, it must later be brought indoors and stacked in a warm room to bring the moisture content to the desired percentage.

The most satisfactory school lumber drying arrangement observed while making the study was at the Eugene, Oregon, high school. This school has dried local woods satisfactorily for a number of years. Its shop layout provides a covered drying shed outside of the lumber room. The shed is boarded up on three sides and has a broad-mesh screen front to provide adequate air circulation. The hardwood stock is left in the shed for varying periods of time ranging from many months to several years, depending on the size of the pieces. Later the boards are brought into the warm lumber room to complete the seasoning process.

This type of set-up does not involve a great deal of expense and a similar one could be developed by most schools. The savings made by
bringing good hardwood lumber to the students at low prices would soon make up for the cost of such a drying shed. Whatever the situation, there are certain essentials that should be understood for the satisfactory seasoning of these local woods.

Circulation  Circulating air in the pile is of great importance in drying lumber. J. S. Mathewson outlines these principles that govern the procedures for piling lumber: (35, p.22)

The movement of air in a lumber pile is the result of two general types of circulation. Horizontal circulation is caused primarily by local wind currents. Vertical circulation on the other hand is an internal movement produced by evaporation and the resulting differences in temperature throughout the pile.

Horizontal circulation can be regulated to some extent by variations in drying-yard layout, in foundation construction, and by piling methods.

Vertical circulation in a lumber pile is of utmost importance. As the green stock in the pile dries, the evaporation uses up heat, which is taken from the air in contact with the stock. This air, on becoming cooler and consequently heavier, tends to drop towards the bottom of the pile. Methods of pile construction should therefore, be designed to facilitate an unobstructed flow of this damper, heavier air from the pile. To obtain the maximum benefit from vertical circulation, it must be adequate entirely across the pile from one side to the other. This means that adequate air channels, well distributed, are essential.

For outdoor piling of hardwoods, where a shed or a covered structure is not available, the pile should be arranged and stacked in a manner similar to that shown by the drawings on page 46 furnished by Mr. Leif Espanas, of the Oregon Forest Products Laboratory.

Shed dried lumber, according to Henderson, (26, pp.62-63) is likely to be more free from checking, splitting, and warping because it dries more slowly and evenly. If a shed or room is available, the same
SUGGESTED PILING METHOD FOR AIR SEASONING OREGON HARDWOODS

PLACE WEIGHTS ON ROOF OR TIE DOWN

2' TO 4' BETWEEN PILES

1" TO 2" BETWEEN BOARDS

PILE 6' WIDE

PITCH FORWARD 1" PER FOOT OF HEIGHT

1" x 2" STICKERS ON 2' CENTERS

TIMBER FOOTINGS AND ALL WOOD FOUNDATION MEMBERS SHOULD BE HEARTWOOD OF DURABLE SPECIES OR TREATED TO PREVENT DECAY

GROUND LINE
procedures given for outside piling apply. "It is not necessary, however, to slope the pile from front to rear to provide a forward pitch. Furthermore, individual pile roofs will not be needed, but it would be well to place some weights on the top of the piles to reduce warping." (54, p.3)

Methods of air drying Oregon myrtle recommended by Charles R. Ross can well be applied to the seasoning of other dense, refractory species of the western hardwoods: (57, p.2)

... The conventional method of piling green lumber for air drying will provide the most rapid seasoning. Dry, decay-free stickers 1-1 1/2 inches thick by 1 1/4-1 1/2 inches wide should be placed 18-24 inches apart between each course of lumber. The pile should be well elevated on a rigid foundation. Protection from the elements, particularly hot, dry air currents, is very necessary. Adequate weighting of the pile to assist in keeping the boards flat is a good practice. Protection can be afforded by a roof of low grade lumber built over the pile, by partial enclosure, by battening the pile with rough boards, or by all three methods. A simple system of wire and turnbuckles or blocks of iron or concrete placed on top of the pile can provide the necessary top weight and keep the boards flat. It seems to be the practice among Myrtlewood operators to repile air seasoning lumber one or more times during the seasoning period in order to control the spacing between boards and consequently the rate of drying. The value of the material would seem to justify this care.

Stickers The strips or boards separating the layers of lumber are called stickers or crossers. Their size, placement, and moisture content are important for drying lumber to the best advantage. They may be separated into two classes; stock stickers and special stickers. Peck explains their differences: (51, p.11)

Stock stickers are boards of the same kind of lumber that makes up the pile, but are generally of narrower widths. ... Special stickers may be made from any species, but should preferably be of heartwood. ... Special stickers should be at least thoroughly air dry in order to minimize blue
stain, decay and checking in the lumber they support.

The use of green stock stickers for drying shop project hardwoods is poor practice. "If green stickers are used, the portions of the boards in contact with them dry out more slowly and thus increase the danger of stain and decay-fungus development, and at the same time, of setting up shrinkage stresses that may result in checking."

(51, p.11)

The illustration on page 49 shows the use of stock stickers being used in drying Black cottonwood and Golden chinquapin at the Bond Manufacturing company of Irving, Oregon. This lumber was being dried for use as push-broom blocks.

Control of Drying Rates Because wood does not dry uniformly and shrink evenly, it is necessary to control the rate of drying in the pile to minimize seasoning defects. Being able to accurately control the rate at which the moisture content is lowered, is a major advantage of kiln drying.

Here, briefly outlined by Rasmussen are some methods for controlling the rate of air drying and minimizing checking in the pile:

(54, p.4)

(1) Decrease spacing between piles; (2) Decreased width of vertical flues; (3) Increased width of pile; (4) Thinner stickers; (5) Avoiding the use of stock for stickers (narrow dry, special stickers are less conducive to checking); (6) and piling stock in a cool room having a high relative humidity.

Immersion in water or in bogs and storage in damp places helps prevent too rapid drying and the consequent checking of newly cut logs and sawn lumber. Hardwood sawmill operators, myrtlewood artisans, and
Black cottonwood and Golden chinquapin at the Bond Manufacturing Company, Irving, Oregon. This shows the use of stock stickers in a neatly stacked pile.
home craftsmen in California and Oregon coastal regions, where hardwoods are cut and used, practice these methods of control.

The Alfred A. Loeb Company of Portland, at the suggestion of an English burl buyer, now stores its burls and figured-grained logs awaiting shipment to Europe in a deep covered pit. It was found that this simple method greatly reduced the checking and other degrade that had occurred when the stock was stored in sheds.

In speaking of local methods for controlling the rate of drying Oregon myrtle, Ross gives this information that would apply to the seasoning of any hardwood: (57, p.2)

Current practices in air seasoning large pieces of Oregon myrtle vary greatly. Burying the material in the ground and under piles of moist sawdust, piling in dark damp basements and in caves, and even complete immersion in water for long periods of time have been practiced. Any method which does not promote some drying defeats the purpose of seasoning. Claims are made that many unusual treatments such as those mentioned "age" or "condition" the material, imparting to it desirable characteristics of color and sheen when finished. The limited information available makes it impossible to support or contradict claims for the value of these "conditioning" techniques. It is known, however, that Oregon myrtle is not resistant to decay when placed in contact with the ground and that if left unobserved for any period of time is very likely to become infested with decay organisms and wood destroying insects.

Myrtle wood is often solid or close piled to retard the rate of drying and to develop the growth of mold that produces an unusual coloration. (57, p.2)

**Achieving the Needed Low Moisture Content**

As was stated previously, project lumber for cabinet making and other interior work must have a moisture content of from six to eight per cent. Air drying at outside humidities and temperatures in the
regions where these hardwoods grow, even in covered buildings, will not produce this essential low moisture content.

An example of the need for thoroughly dried lumber was told by an old cabinet-maker and woodworker, the father of Raymond F. Chrony of the Scio Planing Mill at Scio, Oregon. In filling an order for a number of fine tables he used Bigleaf maple and Oregon white oak boards that had been well stacked and "dried" in a barn for a number of years. After completing the tables, the exposed wood dried further, allowing the joints to open up and the members to warp and start to crack making the order a total loss.

The son, R. F. Chrony, has built in conjunction with the planing and sawmill, a new kiln for drying hardwood. It is considered by Espanas to be an excellent example of a small kiln. In it maple can be reduced to a seven per cent moisture content in eleven days.

There are very few of these small well designed kilns for the drying of hardwoods. In most instances the wood shop teacher, who wishes to use these woods in his program will have to "finish off" air dried lumber in a warm interior over a long period to time.

The British wood technologist, R. G. Bateson, concludes the chapter on Timber Drying and the "Small Man" by making this encouraging statement: (4, p.92)

Though his drying will take longer, and he will be unable to handle wet timber without air-seasoning it first, the small man equipped with some form of warm store and operating it intelligently can produce thoroughly seasoned timber, which may be used without fear of shrinkage or warping in the best class of construction.
A number of authorities tell of the methods and the time required to reduce air dried stock to a desirable moisture content for interior work. The following statements should serve as a guide for the ultimate seasoning procedure.

Rasmussen, in a report from the Forest Products Laboratory in Wisconsin, writes: (54, p.4)

Lumber that is to be dried to a low moisture content, for example to the 6 or 8 per cent required for interior trim, flooring, furniture, or novelties, should first be air dried to a moisture content of about 20 per cent or less and then repiled in a heated room to attain further drying. The temperature in this room should be maintained approximately 20° F. above the outside temperature at all times of the year. Because many variables, such as size, species, initial moisture content, and climatic conditions, affect the drying rate, it is impossible to state the period of time required to bring the lumber to a moisture content of 20 per cent.

The school boiler-room where the heat might be the mentioned 20° higher than the outside temperature, is not recommended for drying out these hardwoods. This warning is given by Bateson (4, p.91) who says, "A boiler room immediately suggests itself, but would probably be unsuited in winter as the temperature would be too high, whereas it would be perfectly suitable in summer."

Bateson tells also of some of the seasoning defects that can be incurred by placing moist lumber near too much heat: (4, p.98)

Some even go so far as to stack timber over a boiler or other hot situation, but this practice is dangerous. Partly because drying may be too rapid and cause hardening and splitting may result, and partly because if left overlong the timber will become too dry, so that swelling will occur when it is put into use.

A suggested location for the ultimate seasoning of the school's shed-dried lumber that has been reduced to a 20 per cent moisture
content, would be the upper portion of a well ventilated, inside storage loft or lumber room. Here the temperatures will be constantly higher than at the floor level and with time and periodic inspection, should produce lumber with the desired moisture content.

Methods of Measuring the Moisture Content of Seasoning Wood  There are simple methods by which a shop instructor can determine, for practical purposes, the moisture content of these seasoning hardwoods. By following one of these suggested practices, the grief caused by attempting to build projects of unseasoned lumber can be eliminated.

A method suggested by the Forest Service, Forest Products Laboratory bulletin, A METHOD OF SEASONING SMALL QUANTITIES OF LUMBER is this: (54, p.5)

... mark a line across several of the widest boards with a carpenter's square. Measure the width of each board along this line to the nearest 1/64 inch and record the measurement on the board. Pile the lumber on stickers in a room heated approximately 200° F. above outdoor temperatures. Measure the width of the marked boards from time to time over a period of 3 months or more. When no further shrinkage in their width can be detected, the lumber is roughly at a moisture content of about 7 or 8 per cent.

One of the most accurate ways of knowing the percentage of water still in the lumber is to cut off a small test sample 6 to 9 inches from the end of a board that is taken from the middle of the stack. Then by using accurate scales, as might be found in the school's science laboratory, weigh the sample carefully and then place the piece in an oven set at 212° F. and leave it there until the sample will dry no more (when weight remains constant). By following the formula for finding the moisture content stated on page 38 the percentage can readily be found.
Length of Drying Time

Because of the many variables, it is impossible to give definite drying times and schedules for the air-drying of these Pacific coast hardwoods as they would be accomplished in the school shop program. In making the survey of the drying period of these hardwoods, the majority of the instructors in the woodworking shops of the Willamette Valley who were interviewed felt that about a year of drying for each inch of thickness for most woods was satisfactory.

A. C. Newell makes these generalities about the length of the drying time: (43, p.107)

The length of time required for seasoning of wood varies greatly depending upon the dimensions of the stock. Doubling the thickness of a board more than doubles the drying period. A ten-inch timber requires more than twenty times as long as a one-inch board in drying, consequently large timbers require several years for drying out the moisture from the interior of the piece which is not much affected by the daily changes in humidity of the air.

In talking of one of the western woods Ross gives this information: (57, p.3)

One rule of thumb places the seasoning period of Myrtlewood stock at about one year per inch of thickness. Thus about four to six years are needed to season the slab form of material. The exact time will depend upon the prevailing seasoning conditions in any given area.

Defects in Hardwoods Caused by Drying Stresses and Fungi

Seasoning defects and fungus damage are combined in this section for they share these common determinants: moisture content, relative humidity, and temperature.
Particulars of these defects are given so that they may be identified in the drying pile or the storage room. Preventative steps can then be taken to deter their occurrence; and with this knowledge to avoid the use or purchase of lumber made worthless by these defects.

**Defects Caused by Improper Seasoning Conditions**

The hardwoods, because of their greater complexity of cellular structure, are, to a large degree, more affected by shrinkage during drying than the softwoods.

Brown, Panshin, and Forsaith explain the effects of shrinkage stresses which lead to defective wood in the drying process:

(9, p.310)

Unfortunately, as wood continues to dry below the fiber saturation point, the shrinkage is not equal in all directions. This situation is explained by the fact that xylary tissue is a complex cell aggregate composed of different kinds of cells some of which are aligned vertically in the standing tree, others horizontally and radially. The shrinkage of wood along the grain is negligible (Compression and tension woods are an exception to this rule in that they shrink appreciably along the grain); across the grain, it shrinks about twice as much in the tangential direction as radially. This inequality in shrinkage in three directions at right angles sets up strains which are unavoidable and which, if they become too great, cause actual fractures in the tissue.

**End Splitting, End Checking and Surface Checking** These are cracks, either small or large, where the grain has pulled apart and opened up. They are caused by permitting the moisture content of the surface to become so much lower than that of the interior, that the surface tension stresses exceed the maximum strength of the wood in tension at right angles to the length of the fibers. (3, p.7)
This splitting and checking can be avoided by a judicious use of liquid coatings, proper sticking, shading, and covering practices.

**Warping** This term is used to describe any distortion from the true plane that may occur in a piece of wood during seasoning. (9, p.313) The major forms of warping are bowing, crooking, cupping, twisting, and diamonding. The drawing on page 36 will help to recall the effects of distortion caused by unequal shrinkage of lumber cut from different parts of the log. A considerable amount of the natural tendency of wood to warp can be overcome by care in piling and uniform drying. The arrangement of the fibers as in interlocked grain, the size and shape of the piece, all are factors that affect the warping of lumber.

"Bowing" is the deviation from a straight line measured on the flat side of the board. It can be avoided by supporting the boards well during drying.

"Crooking" refers to the deviation from a straight line when measured on the edge of the board. This is caused by an excessive longitudinal shrinkage near one edge. It causes stresses in lumber that pinch the saw when ripping or crosscutting.

"Cupping" appears most noticeable in wide boards, and when viewed from the cross-section assumes a trough-like shape. The cup will bend towards the center of the log (see page 36). Brown, Panshin and Forsaith explain how cupping occurs: (9, p.314)

There are two primary causes for cupping, viz., (1) the more rapid drying of one face than the other and
(2) the discrepancy between radial and tangential shrinkages which causes one side of the piece to shrink more than the other.

"Twist" is the bending of a board about a diagonal axis; consequently, it throws the four corners of a plank out of a plane. Twist is caused by cross or irregular grain, spiral grain in the log from which the board was cut, as a result of uneven drying, "or because of inherent stresses in the standing tree". (9, p.314)

"Diamonding" is caused by the differences between radial and tangential shrinkage. These stresses force squares or stock with a near equal width and thickness to warp out-of-square or assume a diamond-shape when viewed from the end section.

Casehardening An undesirable characteristic of wood that is developed by unequal shrinkage, caused by too rapid drying, is that of casehardening. Baker and Espanas define and explain it in these words: (3, p.6)

Casehardening is defined as a condition in which uniformly dry lumber contains stresses such that the outer wood layers are in tension. This is a perfectly normal state, occurring in air seasoning and kiln drying, produced by the tension set established in the exterior wood layers early in the drying period. Casehardening is objectionable if lumber is to be resawed, patterned, planed deeper on one side than the other, or fabricated in other ways that will upset the balance of stresses existing prior to such alteration. If stresses are not relieved before these operations are performed, the resulting products become distorted.

Henderson says "casehardening is evidenced by the appearance of surface checking and excessive warping and twisting during the drying process. The after effects of casehardening are the pulling out of shape of the boards after they are resawn or surfaced and the
splitting at holes and mortises." (26, p.116)

Collapse occurs often if too rapid drying is attempted. Collapse can be recognized by a shrunken or a washboard-like appearance on the surface of the plank.

H. D. Tiemann in discussing the cause and significance of collapse states: (67, p.169)

These effects are not caused by the shrinkage of the cell wall, but are due to the drawing together of the sides of the cells by an enormous tension force set up in the free-water, due to capillary phenomena.

Collapse occurs among several hardwoods growing in this area; particularly in some of the oaks, in the eucalyptus, and in the tanoak, making them real seasoning problems. Too rapid drying of the species of these trees must be avoided. This collapsed state of the cells greatly weakens the structure of the wood.

Honeycombing is interior checking that takes place as the fibers separate along the wood rays during the drying process. "The most common causes of honeycombing are the internal stresses that develop in hashearding and collapse." (9, p.319)

Blue Stain—A Fungi Caused Defect

Sap stain or "blue stain" occurs on the surface and interior of the sapwood and is caused by the growth of a mold-like fungi. This discoloration, while it does not affect the strength of the wood structure, does make it unsuitable for projects that are to have a natural finish.
If precautions are not taken, blue stain will start to spread readily in the log during the warm months immediately after the tree is cut. This means that the log must be stored in a pond or sawn into lumber and proper drying methods used immediately. This stain requires warm weather and a high moisture content in the wood or air. Action will stop under cool and dry conditions.

In large scale hardwood milling, the boards are dipped to prevent the staining until the lumber can be dried to a moisture content low enough to kill or prevent its growth.

In working with small lots of lumber the following practices are advocated:

(1) Separate the courses in the drying pile with narrow dry stickers. If there is not space between the boards or if broad stock stickers are used blue stain will invariably set in.

(2) Keep the drying pile or seasoned lumber storage in a dry, well ventilated place.

Storage of Western Hardwoods in the Wood Shop

The storage problem rightfully belongs in this section concerned with the moisture content of wood and the effects of the drying out of this moisture in lumber, for as Bateson states in the opening paragraph of the chapter devoted to the behavior of seasoned timber:

(4, p.93)

However dry it may be, and whatever means are employed to dry it, timber remains a hygroscopic substance. It is always striving to attain equilibrium with the air surrounding it. If it is moved from a dry situation to a damp one it will absorb moisture and swell, if it is moved back to the dry situation it will lose moisture and shrink.
Position of Lumber Piling

If the teacher is fortunate enough to be consulted by the administrator and architect in planning the layout for his new shop, or if he has the space in his present shop so that he can determine the position of the lumber storage racks, he will have a choice of stacking the lumber vertically or horizontally.

**Vertical Storage** This is the least desirable of the two methods and should only be chosen when horizontal space is not available. It does have the doubtful advantage of taking less floor space. The major drawback is the air temperature variation between that of the floor and of that near the ceiling. Soon this will cause a constant variation of moisture content of the opposite ends of the lumber. This produces uneven shrinkage throughout the entire length of the boards.

Also, when lumber is stacked on end it does not have the advantage of the horizontal pile where weight of boards is concerned. Piled one on the other each board helps to hold the shape of the under boards and prevents warping during the constant shrinking and expansion that takes place.

Other disadvantages of end piling are that periodic inspection for defects is difficult, and the tendency for the unsupported boards leaning against the wall is to take a permanent curved "set" or bow.

**Horizontal Storage** By enumerating the disadvantages of vertical storage, the advantages of this more desirable method have been partially described. This system is better for reducing the final moisture content of lumber and for storage of thoroughly seasoned air and kiln-
dried stock. These hardwoods stored at different heights in a rack will have varying moisture contents, but each piece will be uniformly dry providing there are no drafty doors, windows or heating elements near one end of the pile.

End coatings can be easily applied if necessary to prevent checking. The Emerson Hardwood Company of Portland makes a practice of end coating their seasoned hardwoods in flat racks with common barn paint as prevention against end checking during storage and for use as identification. This method could be practiced in any school shop wishing to store the seasoned local hardwoods.

In the booklet SOME EFFECTS OF STORAGE ON SEASONED LUMBER, Mathewson and Rasmussen conclude this about storing kiln dried lumber which would be equally applicable to maintaining thoroughly dried air seasoned lumber of a low moisture content. (37, p.4)

Preferably, kiln-dried lumber should be stored in closed, heated sheds in which the equilibrium moisture content is controlled. If such sheds are not available, storage in the upper part of a closed or partially closed shed in which the temperature is slightly higher than the outside temperature is desirable.

Experimental Seasoning of Western Hardwood Species

Mention should be made of the research work now being done by the forest products laboratories at Corvallis, Oregon, and at Madison, Wisconsin, in determining methods for kiln drying certain western hardwoods. This work has been of an experimental nature, but generally the results and the drying schedules developed are believed to be satisfactory for drying these woods. As was stated, there are few west
coast kilns that are in the business of drying hardwoods, but it is known that these species are no harder to cure than some of the dense eastern hardwoods that are used extensively. It seems fair to conclude that if the lumbering industry turned to making more intensive use of these hardwoods, they could be processed satisfactorily in well designed and operated kilns.

In a report of kiln-drying green samples of one-inch California laurel, Pacific madrone, tanoak and Golden chinquapin at the Forest Products Laboratory at Madison, Wisconsin, Torgeson made these conclusions: (69, pp.7-8)

Laurel, madrone, tanoak and chinquapin are sufficiently refractory to require considerable care in seasoning. To dry them green from the saw, a kiln must be so equipped as to provide good control of temperature and relative humidity and a brisk rate of air movement through the loads. Poor operation during the initial stages of drying would be sure to result in excessive degrade, particularly in the tanoak and chinquapin. . . . The possibility of success in kiln drying laurel and madrone green from the saw is very good.

The probability that preliminary air seasoning might be less conducive to seasoning defects than kiln drying green stock from the board was investigated to the extent of drying some tanoak and chinquapin boards under temperatures and relative humidities that simulated, in a general way, desirable air-seasoning conditions. . . . Although only a few pieces were dried, the indications were that the amount of collapse and honeycomb was less than which occurred under temperatures more usual in kiln operation.

These are a few statements made in the conclusions of an Oregon Forest Products Laboratory report written in 1950: (46, p.32)

(1) Because of the high occurrence of various seasoning defects and the long kiln drying time involved, the chances of kiln drying green tanoak on a commercial scale satisfactorily are poor.
(2) The occurrence of the various seasoning defects can be held to a sufficiently low level by carefully and thoroughly air seasoning in the summer months and then kiln drying. Using this procedure, the prospects for seasoning tanoak on a commercial scale seems good.

An experimental project working on the seasoning of madrone was completed and this is part of the conclusion: (46, p.33)

The results of the study indicate that equally good results are obtainable either by kiln drying green from the saw or by kiln drying after preliminary air seasoning. Surface checks, honeycomb, and collapse are not serious. The major loss in the drying of madrone, which appears to be the result of warping can be reasonably well controlled. A kiln schedule for one-inch lumber was derived.

The results of these investigations are reported on when they are completed. This information on the best methods for seasoning and dry-kiln schedules that are determined, will be available and may be obtained by writing to these laboratories.

An interesting seasoning method, not yet commercially feasible, has been patented by the Western Pine Association, this is the "solvent seasoning" process.

Dr. Arthur B. Anderson of the Wood Chemistry department of the School of Forestry at the University of California, had worked with the Western Pine Association in the development of this method. When interviewed at the Berkeley campus, he explained that green boards are placed in a sealed chamber and subjected to streams and vapor of hot acetone. The moisture is driven out of the wood with a minimum of stress resulting; because the shrinkage is fairly uniform. There is very little loss of the solvent as it is captured by
condensation. Anderson showed thoroughly dried samples of native hardwoods that exhibited few seasoning defects. An outstanding example was a one-inch thick cross section cut from the end of tanoak log. It was free of all cracks and showed no indications of warp or collapse.

The Oregon Forest Products Laboratory worked with the same process. In giving the reasons for conducting this experimentation, the report said: (46, p.35)

Chinquapin and tanoak are extremely difficult to dry by ordinary means. Solvent seasoning conceivably could replace customary methods of drying some species and items of wood, and it offers the possibility of additional revenues from extractives obtained in the process.

* * * * *

When the teacher understands these changes that occur as wood dries and is able to recognize the defects that can take place during seasoning and storage, he will be able to cope with the problems of utilizing the western hardwoods.
CHAPTER V

ACQUIRING AND CUTTING OF HARDWOODS FOR SCHOOL USE

The task of cutting hardwoods to suitable size for school shop use is the major obstacle in the utilization of local woods, because schools invariably lack suitable facilities for cutting logs into usable forms.

Major Factors Preventing School Use of Local Hardwoods

As the survey of school shops using western hardwoods progressed, it became evident that these woods were being used little because of these factors:

1. Lack of machinery to cut and shape the wood to usable forms
2. Not sufficient time to gather, cut, and process these hardwoods.
3. Absence of seasoning information
4. Inadequate storage for logs and drying lumber

It was encouraging to find that a lack of interest was only a minor factor in the limited use made of these hardwoods. The majority of teachers were eager to learn about and use all of the materials which would enrich the shop program.

Tools and Equipment for Cutting Hardwoods to Usable Forms

The majority of the machinery observed in the woodworking and the general shops of Oregon and California schools was adequate only for handling ready cut lumber. Typical power equipment was the light,
eight to twelve inch table saws with electric motors of one-half to one horsepower; and light-duty band saws with wheels ranging from twelve to eighteen inches. Some schools had surface planers, but most of the smaller schools whose shops were of the general type, were equipped for surfacing lumber with only small, four to eight inch jointers.

These power tools are satisfactory for making the usual school woodworking projects, but are not designed to mill small logs or to square-up round stock. Squaring limbs and small logs is usually an unsafe practice with this type of equipment. The responsible teacher would seldom allow the student to perform such an operation; consequently, when this work is done, it is the responsibility of the instructor to perform it. Not only is the practice unsafe, it is hard on the machinery, and it takes the teacher away from his class.

Freshly cut hardwoods are wet and have a tendency to bind while being sawed. Often logs, limbs, and rough pieces contain rock, gravel, nails, and staples. Under these conditions, light saw blades designed for precision cabinet work quickly become dull, and are made dangerous from overheating. Motors become overheated under such abnormal loads and the whole process is upsetting to classroom routine. For these reasons, most of the interviewed teachers stated that they would hesitate to saw anything but clean, dry, dimensioned lumber.

It is obvious that under these conditions the working of the "green" hardwoods into usable boards, squares, and slabs must be done with equipment other than the usual school shop facilities.
The school instructors and woodworkers who were using minor Pacific hardwoods stated that they acquired this material in the following ways: buying the lumber or slabs from mills located in hardwood areas; cutting the logs into slab form lengthwise by chainsaw; by ripping thick boards to size by "two-man" saws in shop built sawbucks and jigs.

The first source, that of buying the material is obviously the most convenient, but this is an outlet available only to schools in areas where hardwoods are being cut commercially. From prices quoted by small saw mill owners in Eugene, Oregon, and Marysville, California, the approximate current rate for having hardwood logs custom-sawn is thirty dollars per thousand board feet.

The second method of sawing -- the use of the versatile chainsaw -- is used extensively by those cutting hardwoods for sale. This method holds a real possibility for school shop usage in reducing hardwoods to workable forms. Lumber can be ripped from logs and larger limbs by having a chainsaw operator cut them in school-built holding devices. Also, chainsaws may be rented in most areas and the sawing can be done by the more advanced students.

In a number of industrial arts shops where there were local hardwoods used occasionally for small projects, the classes reduced short lengths to workable sizes by sledgehammer, wedges, and axe. This crude method is suitable for "getting-out" stock for lathe turning and small pieces for projects, but inadequate for producing furniture lumber.
Selection of Trees for Cutting

The choice of wood is determined by a number of factors: the shop's need; interest in wood; knowledge of the tree; facilities for cutting; transportation of the wood to the school; and availability of the tree.

The condition of the tree must be recognized. Only sound, living trees or previously cut stock free of insect, fungus, and seasoning defects should be considered.

Cutting Seasons

It was found that some of the hardwood operators contacted preferred to cut the trees in the fall when the "sap was down" and before the rain made roads impassable. From the literature studied, there was no verificative evidence to show that lumber cut in the fall or winter was easier to season and utilize than late spring or summer-cut wood. Logs and lumber cut in the heat of summer are more subject to severe drying and shrinking, consequently more warping and splitting can take place. Too, during the warm months logs and lumber are more subject to fungus stain and insect infestation.

Trunk and Limb Wood

The wood of the lower trunk of the tree produces the best lumber and, if possible, should be employed if there is equipment available. This main bole of the tree produces the straight grained lumber; it is composed mostly of the desirable heartwood, often has the most figure, and contains the most knot-free lumber.
Where adequate cutting tools are lacking and the heavy trunk wood cannot be transported, limb wood can be used. It is less desirable for it is often crooked; and this makes it harder to obtain long, straight grained pieces. Limb wood contains a large proportion of the lighter colored sapwood which for many uses would be undesirable, for it is more susceptible to blue stain and insect damage during the seasoning period. If limb wood is used, only those large limbs that grow vertically should be chosen, for leaning limbs and trunks produce the undesirable tension wood. (9, p.293)

Acquiring of Wood for Shop Projects

In the majority of schools, it was found that only supplemental use was being made of these western woods. For this reason, there were no set policies and little planned class participation for acquiring stock of this type for the program. Much of this material was brought to the school in short lengths by the students, or the teacher had obtained them from trees felled nearby, or had found them in his travels. In one instance, the teacher had personally purchased burl stock during his summer travels and sold it to his students.

Some schools in areas that produce hardwoods often purchase rough unseasoned lumber from the sawmill. This gives the instructor the opportunity of selecting the stock most suitable for his class use.

On occasions people of the community offered standing trees and pieces of fine hardwood to the school. It was this writer's experience to have the University of California Agricultural Extension Agent bring
in lengths of local woods to the high school industrial arts department. The Extension Agent was interested in determining if these little used hardwoods could be successfully seasoned and utilized.
CHAPTER VI

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

SUMMARY

Of the many hardwood species growing in the Pacific Coast states, few are being utilized for lumber. This is understandable, for in this area the stands of usable hardwoods are sparse and scattered and the region produces the nation's greatest volume of softwood timber products. Because, generally, the west coast lumbering industry is not geared to process hardwoods, the hardwood lumber used in the school shop is shipped predominantly from the eastern United States with certain amounts coming from foreign sources. A number of the western broad-leaved native and introduced hardwoods seem to have potentially fine properties and working characteristics.

Resourceful teachers have always made use of materials at hand, consequently industrial arts teachers of this western area are bringing in pieces of locally gathered hardwoods to their classes. Students are using small amounts of these local woods for supplemental project material, which brings added interest to their work and gives more meaning to units of related information.

While teaching in a lumbering area of California, in a district far from hardwood lumber dealers, this writer became interested in the utilization of the tree resources of the county. In attempting to use these local woods, problems invariably arose. These problems were
centered around obtaining workable methods of seasoning, cutting logs into usable forms, and tree and wood identification and selection.

Attempting, at that time, to find practical answers to these problems, it was found that little specific and valid information in organized form was readily available to the woodworking teacher. The need for research in this field became apparent.

This study is the outcome of such research. It has as its basic intent the development of an instructive guide for better school shop usage of these little used hardwoods.

The essential background data needed to conduct the study was drawn from the findings of wood technologists who were interviewed, from library readings, and from published reports of research workers and teachers in the field.

A defining of the factors of growth and structure of hardwoods, together with the major characteristics and properties of their wood is needed as a basis for a better understanding of the selection, seasoning, and the ultimate usage of the various woods.

Seasoning is often a major obstacle in successfully converting these trees to good lumber after cutting. Knowledge of how hardwoods dry; knowledge of the defects incurred during the seasoning period so that they may be recognized and avoided; and an understanding of proper storage during the seasoning process is needed by the teacher if he is to utilize to good advantage these woods.

To gain specific information about the western hardwoods and their utilization in school shops and by small industries, additional
sources were investigated. Woodworking teachers, teachers of tree identification, commercial hardwood operators and dealers, furniture manufacturers, and wood craftsmen were interviewed. The available literature of the field was studied. From these sources were determined those hardwood trees and larger shrubs of the Pacific Coast whose wood held probable worth for student project work. A description of some of these useful trees is included in the appendix as a guide for those who wish to identify these hardwoods.

The utilization methods practiced by small commercial operators and school shops were evaluated and reported. The described findings include methods of: selecting the trees and logs; cutting the "green" stock to usable forms; practical seasoning and storage methods; the means by which students and teachers acquire these hardwoods; and their ultimate usage in the school shop program.

CONCLUSIONS

There are some of the many Pacific Coast hardwoods which can be used satisfactorily for project material in the industrial arts program of this area.

These hardwoods are found growing in many regions of the states of California, Oregon, and Washington. They may be located and identified by referring to any of the fine texts written on the trees and shrubs of the western United States.

Usable hardwoods are not merely limited to forest trees, for often those introduced for shade and ornamental use and many of those
planted for their fruit and nuts will produce fine hardwood stock suitable for school use.

Although many woodworking teachers expressed interest in utilizing local hardwoods, it was discovered that these woods were being used little because of these factors:

1. Lack of suitable machinery to cut and shape the wood into usable forms
2. Absence of seasoning information
3. Insufficient time to gather, cut, and process these hardwoods
4. Inadequate storage for logs and drying lumber

When the instructor can observe commercial practices and avails himself of the published information on small scale methods of selection and cutting of hardwoods, he will be better prepared to cut these trees and rough pieces to usable forms with local equipment which is available to the school.

The major obstacle, that of seasoning these woods, can be achieved with an understanding of: how wood dries and a knowledge of the requirements for producing thoroughly cured lumber. Fine project material can be produced in small quantities by air drying if methods used to prevent irregular shrinkage and the accompanying seasoning defects are carefully practiced.

Proper storage facilities, and a knowledge of the storing of drying and seasoned lumber is needed for the ultimate utilization of these hardwoods. These are essential, for wood will constantly seek to maintain an equilibrium with the moisture content of the surrounding
It is desirable that seasoned lumber be horizontally piled, in a well ventilated storage room, where the temperature remains the same or slightly higher than the shop class area.

It was concluded from evaluating this study that if this utilization program is to succeed, there must be active pupil participation. This pupil activity should include learning about and participation in the selecting, cutting, and seasoning of these local resources.

RECOMMENDATIONS

Cutting, Seasoning, and Storage Practices Applicable to School Use

These suggestions may prove helpful for the industrial arts class in the initial cutting; and for drying and storing small amounts of local hardwood to produce and maintain a low moisture content.

1. Trees and large pieces may be reduced to workable size by these means; (a) cut to length and thickness with rented chainsaws, (b) buck logs to length using large cross-cut saws and then split lengths with sledgehammer, wedges, and axe, (c) simple power saws can be designed and student-built for sawing short lengths to slabs and rough lumber, (d) large logs may be custom-sawn in areas where hardwood logging is done.

2. Attempting to season whole logs or lengths of large limbs by air drying is not recommended. In drying small rounds, the bark should first be removed to prevent insect infestation and the entire piece should be covered with a moisture resistant coating.

3. Cut, or have the hardwoods custom-sawn into the best assortment of the smallest dimension stock that will be usable for projects, allowing for shrinkage and finishing.

4. Coat the exposed ends of the thicker lumber, logs and burls with paraffin, aluminum paint, oil and white lead, tar and asphalt mixtures, or commercially prepared gloss-oil mixtures.
5. Air dry freshly cut lumber in raised piles protected from the sun and rain by a rough board roof, shed, or well ventilated building. Seasoned, special stickers of uniform thickness should be placed about two feet apart, and in each course the stickers placed vertically one above the other. The pile should be weighted or stoutly tied down to keep the boards flat and straight while drying out.

6. Control of the rate of drying to prevent excessive cracking and warping in the dense refractory woods can be accomplished by: (a) piling the board and thicker slabs in a cool moist place such as a basement, (b) use of thinner stickers, (c) soaking dense hardwoods in a strong salt brine solution from 30-90 days before slow air drying, (d) packing the green planks in sawdust during the early drying stages, (e) weighting or binding the pile down to minimize warping.

7. Reduce the moisture content of the partially dried hardwoods to a final 6-8 per cent by seasoning them over a long period of time in a well ventilated room where the heat is maintained at about 15°-20° F. above the outside air temperature.

8. Check the moisture content percentage for readiness of use by the comparative weighing or the comparative measuring methods.

9. Seasoned lumber is best stored in well ventilated, horizontal piles, in storage rooms where the temperature is about that of the shop class area. Inspection for powder-post beetle infestation in the seasoned lumber should be made regularly.

10. It is felt by this writer, as well as other teachers, that the utilization of these hardwoods should be a student-centered activity. This activity should include the learning about and the gathering and processing of these woods with the teacher acting as a director or guide. No teacher without the interested cooperation of his classes would be able to carry out satisfactorily his teaching duties and the additional work of procuring, cutting, seasoning, and storing these woods. This material is being processed for student use and the whole program should be maintained on a teaching-learning basis as an integral part of the woodworking course.
BIBLIOGRAPHY


APPENDIX A

SOME WESTERN HARDWOODS DESCRIBED FOR SCHOOL SHOP UTILIZATION

The identification of some western hardwoods, their general location, and their uses is presented here as a short guide. It is recommended that those wishing further information about West Coast woods refer to any one of the excellent texts on western tree identification listed in the bibliography of this report.

It was not within the scope of this study to include every western hardwood shrub and tree whose wood is of use to the woodworker. Collectively, though, these trees cover all areas of the Pacific Coast States, and eighteen are included. Emphasis was placed on the more prevalent and/or larger trees; those producing enough lumber for projects bigger than small souvenir pieces or novelties.

The following trees have been carefully studied and their woods found to have properties valuable to the school’s woodworking classes.

The accompanying illustrations are reproduced by permission of the Forest Service, United States Department of Agriculture. (41)
RED ALDER (Alnus rubra)

Growing along creek beds and moist areas of the Coast Range, the Red Alder is found often in dense stands with other water-loving trees, the willows and cottonwoods.

Common Names in Use

Alder, Western alder, Oregon alder, Red alder

Distinguishing Characteristics

According to Jepson, "Red Alder has a chalky white trunk with black patches. It looks like a white post that a boy with muddy feet might have tried to climb". (30, p.47) The oval-shaped leaves are notched or toothed; the undersides are a whitish color. A small cone contains the nut.

Red alder grows to a sizable tree; attaining a height of ninety feet and a trunk girth of two and one-half feet. The bole is long and clean.

Distribution

It is found in the coastal mountains and valleys of western Washington, Oregon, and as far south as Santa Barbara in California.

Characteristics of the Wood

This is the leading hardwood of the Pacific northwest. Its lumber is stocked by major hardwood dealers, and can be recommended for school use because of its workability, appearance, and comparatively low cost.

The wood is whitish when first cut, but ages to a light brown with a reddish tinge. It is close grained, light in weight, and moderately strong. The pores are small and diffused with the growth rings
distinct. There is little difference in appearance of the heartwood and sapwood. The grain is pleasing though not figured.

Alder is a moderately soft hardwood that machines well and holds glue and nails securely. It takes a smooth finish and is readily stained and painted.

**Uses**

Used extensively in general furniture manufacture, Red alder is suitable for millwork, and for manufactured products, such as handles, clothespins, and toys. Because of its moderate shrinkage and its gluing ability, it is used also for veneer core stock. In the school's finishing room alder-made projects may be finished in a number of ways. The natural color of the wood may be retained by simply varnishing or lacquering, or they may first be bleached or stained to give an added surface interest.
WHITE ALDER (*Alnus rhombifolia*)

Like the larger, more important Red alder, the White alder is a moisture lover and is found along creek bottoms.

Sudworth gives this comparison between the White and Red alder:

(66, p.263)

Similar in general appearance to the red alder, from which it is probably not distinguished by laymen. It differs from the latter tree in having thin, conspicuously scaly, brown bark; the scaly bark extends considerably higher up on the stem than that of red alder, which is commonly unbroken and smooth.

Common Names in Use

Alder, California alder, Western alder, White alder.

Distinguishing Characteristics

The White alder is much like the Red alder except that it is usually a smaller tree. The leaves differ from the latter species in that they have fine, sharp pointed teeth and the edges do not curl under.

Distribution

White alder ranges from the eastern Cascades of Washington and Oregon, southward through southern California in the Coast Range. It is found on the western slopes of the Sierras. It will be noticed from the map of its distribution that it is not found in coastal regions of the northwest as is the Red alder.

Characteristics of the Wood

The tree is composed largely of sapwood which is nearly white when freshly cut, but darkens on exposure. Both the dry sapwood and
heartwood are a pale yellowish-brown color. Jepson reported this:
"The wood is light, brittle, and coarse-grained. . . ." (30, p.85)
If any figure is noticeable, it is usually irregularly formed. This
wood is similar in its appearance and working characteristics to that
of the Red alder, but is lighter in weight, and was reported harder
to season.

Uses

Wood of this alder was found to be little used in school shops
and has no commercial usage for lumber. Yet, according to Gibson:
". . . white alder ought to be suitable for nearly every purpose for
which red alder is used". (22, p.592)
WHITE ALDER

_Alnus rhombifolia_

MILES

100  200
OREGON ASH (Fraxin us ore ona)

Oregon ash is at the present time one of the top four commercially important native hardwoods of the West; the others being Red alder, Oregon White oak, and the Bigleaf maple. Growing widespread in river bottoms of the west coast states, it can provide the school program with a light, very tough, and elastic wood.

Common Names in Use

Ash, Water ash, Oregon ash

Distinguishing Characteristics

The leaves are deciduous, compound, and the leaflets are in pairs. The seed is single and like the maples it is winged and grows in dense clusters. The typical ash is from twenty-five to fifty feet in height. Some of the largest trees will measure thirty inches DBH (diameter breast high).

Distribution

This tree is found growing among the cottonwoods, sycamores, and other water loving trees along stream banks, swales, and moist flats in valleys. It ranges from British Columbia south into southern California at elevations up to 2000 feet. Wherever a stream meanders there is a good chance of locating this tough wood. It is interesting that this tree which requires so much moisture has a close relative, the Modesto ash, that thrives in hot, arid zones. This latter tree is being planted extensively for shade and ornamental use the length of California's central valley highways.
Characteristics of the Wood

The sapwood is nearly white while the heartwood is a light greyish-brown or yellowish. Ash is a ring-porous wood; its growth rings are very distinct. It is called coarse grained in the trade. Ash is strong, hard, and stiff. This wood wears smoothly with use, is light in weight, and bends well when steamed. Where strength and elasticity are essential, the wood from young, fast-grown ash should be chosen. Wood technologists Brown, Panshin and Forsaith make this comment of Oregon ash: (9, p.107)

"... works well (above average in most machining characteristics), better than average in nail-and screw-holding ability, intermediate in gluing, shrinks moderately but holds shape well (even under the action of water), can be kiln-dried rapidly and satisfactorily, ..."

Uses

Ross says "Ash is the sportsman's wood." (58, p.63) It can make the type of projects that boys like to use. Bats, skis, bows, packframes—all sorts of outdoor sporting equipment is well made when made of ash.

Early settlers and miners made use of this stout wood material for wagon parts, tool handles, and implements. Today ash is gaining widespread favor in contemporary furniture design.
GOLDEN CHINQUAPIN (Castanopsis chrysophylla)

The authority, Elliot, speaking of the potential value of this rather scarce tree, says the wood of the Chinquapin is: "... pale reddish-brown, somewhat brittle, fine grained, suitable for agricultural implements and furniture, of considerable economic importance since the large trees occur in regions poor in hardwoods generally". (16, p.390)

Common Names in Use

Giant chinquapin, Western chinquapin, Golden-leafed chestnut, Bur oak, Chestnut, Giant evergreen chinkapin.

Distinguishing Characteristics

The evergreen leaf is long, slim, and leathery. The underside is a golden-yellow, from which the tree derives its name, while the top-side is a deep yellowish-green. The tree can be further identified by a spiny burr containing an edible nut.

Elliot gives this description of its flowers: "When in full bloom, the Golden chinquapin is a very beautiful tree, its compact crown a mass of creamy-white bloom against a background of dense, glossy foliage". (16, p.390)

In northwestern California and southwestern Oregon, this tree reaches a considerable size. There it will have a straight trunk from eighty to one hundred feet high and a diameter from three to four feet. In other regions it may attain only shrub-like proportions.
Jepson, in THE TREES OF CALIFORNIA, describes the bark as:
"... brown or dull gray on the surface, reddish inside, very fiberous, 1 to 3 inches thick ..." (30, p.108)

Distribution

In the Pacific Coast region from the Columbia River southward to southern California, the Golden chinaquapin is found in elevations from sea level to 10,000 feet. At the higher elevations it appears only as a shrub.

Characteristics of the Wood

The writer became interested in developing this local hardwood in his industrial arts program in northern California; it was found that when cut into small pieces for turning stock it dried easily, shrank little, and produced a minimum of checking and warping. Some pieces were turned and carved while "soaking" wet with good results. The wet wood had a distinct, acid smell similar to vinegar and it stained the cutting tools.

Chinquapin wood is medium-heavy, hard and strong, with a pleasing figure. It is close-grained and even in texture. This is a good example of a ring-porous wood; like some of the oaks, the springwood pores are plainly visible. When quartersawn it shows no noticeable rays.

Uses

The larger trees produce good saw logs. From this, the lumber is utilized, to some extent, for a variety of hardwood products in Oregon and northern California. From some small hardwood operators it is
possible for schools in this area to buy "green" chinquapin lumber. It can be used readily for school project lumber wherever oak, which it resembles, would be appropriate.
BLACK COTTONWOOD (Populus trichocarpa)

The tall and stately Black cottonwood tree of western stream beds provides welcome shade and attractiveness to watered desert areas as well as the moist lowlands of the coastal zones.

Under favorable conditions such as Oregon's Willamette Valley provides, this member of the willow family produces large saw logs that yield broad widths of clear, soft lumber. It is of considerable commercial value in this area.

Common Names in Use

Balm, Balsam, Cottonwood, Black balsam poplar

Distinguishing Characteristics

This often massive tree can be identified at a distance by its deep green, pear-shaped leaves that show their silver-white undersides as they are blown by the summer winds. (16, p.310) In the fall their leaves turn to a bright yellow. The large trees have a thick, deeply ridged bark that is pale grey in color. The Forest Service authority, Sudsworth, gives this size description:

"Black cottonwood, the largest of our poplars, under the best conditions for growth, is from 80 to 125 feet high and from 3 to 4 feet in diameter." (66, p.247)

Characteristics of the Wood

Few student-made projects can be made from this soft, weak hardwood. It may be used where clear pine is satisfactory. The whitish sapwood and the gray or brownish heartwood colors merge, consequently
there is no line of demarcation. It is "... straight-grained and semi-ringed to diffuse-porous". (15, p.96)

Cottonwood shrinks considerably, has a tendency to warp in seasoning, and is below average in stability. It produces chipped and fuzzy grain while being worked, and is not too desirable for beginners as it requires careful use of very sharp hand and power tools. It resists splitting, takes paint well, and is easy to glue; but is low in nail-holding and screw-holding ability.

Uses

Commercially the wood has a good market for excelsior, high grade paper pulp, core stock for plywood veneer, hidden furniture members, boxes, and containers.
BLACK COTTONWOOD
*Populus trichocarpa*

MILES
PACIFIC DOGWOOD (Cornus nuttalli)

Pacific dogwood is the shade-loving, flowering tree of our western woodlands. Its show of large petal-like scales, bloom in the spring and sometimes again in the fall. The flowers easily identify it to the most casual observer.

It derives its name from the days when its wood was used for skewers or "dags", and in time "dagwood" became "dogwood" in common speech. (16, p.489)

Men have prized Dogwood through the years for machine bearings and for weaving shuttles because of its hardness and its ability to become smoother with wear.

Common Names in Use

Western dogwood, Dogwood, California dogwood, Flowering dogwood.

Distinguishing Characteristics

This is a slender tree of from twenty to fifty feet in height with its diameter ranging from six to twenty inches. Its thin, smooth bark is a dull brown or reddish in color; older trees have a bark that is broken into thin scales. (22, p.525)

The deciduous leaves are deeply veined and covered with minute hairs. The foliage assumes brilliant reds and oranges in the fall and is very showy. Adding color and helping to better identify this hardwood, the tree develops clusters of bright red fruit.
Distribution

Assuming maximum proportions in the Puget Sound area, it ranges southward to southern California.

It cares little for sunshine and is often found growing in dense shade. The Dogwood is found in climatic conditions similar to those favorable for the Douglas fir. (22, p.525)

Characteristics of the Wood

The sapwood is very wide and in color is a light, reddish-brown, while the small amount of heartwood, if present, is a dark brown. The wood is diffuse porous and fine-grained, being very dense and heavy. It becomes smooth with wear and is high in shock resistance. It is not prized for its attractiveness for it shows little figure and is lusterless when finished.

Dogwood is hard to cut and only the sharpest of tools will form it. It turns and machines nicely. This close grain wood takes glue poorly, but is high in ability to hold nails and screws.

Shrinking greatly, it is hard to season properly without cracking and end checking.

Uses

The shop instructor will find this wood valuable in his classroom use for the making of mallet heads of all descriptions because of its weight, resistance to wear, and its resistance to becoming "chewed up" by hammering. It could have many applications in the making of handles, guides, and sliding surfaces where resistance is needed and smoothness is essential.
The Dogwood of the eastern states (Cornus florida), of which the Pacific variety is similar, has a high commercial value as it is used extensively for golf clubs, shuttles, bobbin heads and small pulleys.
**EUCALYPTUS (Eucalyptus globulus)**

The Eucalyptus, an Australian import, thrives well in California, growing over much of the state in areas where the winters are moderate. Tall and graceful, this fast growing tree was planted here primarily for shade and ornamental use; large stands were also started to help hold moisture in tree-less water-shed-hills of the Coast Range.

In its native Australia, where the woodworking industry is trained and equipped to utilize this and others of the species, the wood and its by-products are of considerable economic importance.

In California in the past, large groves of Eucalyptus were planted by stock promotional companies. Shares of stock and acreage were sold to gullible easterners and others who knew little of the contrary properties of this wood. Their idea was, supposedly, to plant these hardwoods and to harvest them as a crop to be used in the making of fine furniture. This furniture would be produced in company mills and factories in a growing area devoid of hardwoods. The writer, Jack London, was among the many who "fell" for this scheme. (65, p.234)

Driving north of Woodland, California, on highway 99-W, one passes through numerous remaining stands of these trees. County maps indicate these areas as being owned by "such-and-such" hardwood companies.

**Common Names in Use**

Common Eucalyptus, Blue gum, Gum tree.
Distinguishing Characteristics

This tall, straight tree grows to over 150 feet in height, often reaching four feet in diameter. The species is characterized by its leathery, sickle-shaped leaves that produce a pungent camphor-like odor. The deciduous bark is a greyish-brown or white color and is constantly peeling. The hairy, cream-colored flower develops into a greyish-green nut.

Characteristics of the Wood

The wood is lemon-brown in color, usually straight-grained, but often the grain is interlocked which makes the logs hard to split. The wood is stiff, heavy, and strong. It lacks any outstanding figure and is rather difficult to work with tools. Screws and nails hold well in it, but it does have a tendency to split during nailing. The Eucalyptus has excellent bending qualities when steamed, and in its native Australia it has been used where this property is required. (8, p.171)

In California the practice of ring-barking the tree a season before felling it has been tried. This was done to reduce the sap content, thereby eliminating excessive shrinkage.

Uses

In Australia it has been used for wheelwright work because of its strength and good bending properties. There it is used in boat building and for making a variety of tool handles. (8, p.171)
It would seem worthwhile for the teacher who lives in areas where many of these trees are now being removed, to experiment with Eucalyptus wood in his shop program.
BLACK LOCUST (Robina pseudoacacia L.)

A native of the Alleghany Mountains, the Black locust was introduced by the early settlers to the western states. They brought it here for the beauty of the growing tree, and for the many uses to which its hard, tough wood could be put.

Common Names in Use
Locust, Yellow locust, Acacia and False Acacia, Post locust, Peaflower locust, Black locust.

Distinguishing Characteristics

This member of the pea family can be identified during the spring by its masses of white, fragrant, pea-like flowers. The leaves are pinnately compound, the leaflets being oval in shape. Like other pea-family members, seed pods are formed, which are three to four inches long.

The tree attains a height of seventy to eighty feet with a trunk of three to four feet in diameter. The gray, greenish-brown bark is very ridged. In winter when the tree is bare of leaves, the bark appears black. Long thorns are attached to the bark and twigs, which make it easier to identify.

Characteristics of the Wood

Gibson, writing in AMERICAN FOREST TREES states this of the strength of Black locust: (22, p.536)

Locust wood is remarkable for strength, hardness and durability. It is about one pound per cubic foot lighter than white oak, but is thirty-four per cent stiffer and forty-five per cent stronger. Its strength
exceeds that of shagbark hickory, and it is doubtful whether a stronger wood exists in the United States.

The wood of the Black locust is frequently confused with that of the Osage-orange, but can be readily distinguished because of the lighter shade of yellow or orange-brown. Also, when the yellow shavings of the Osage-orange are placed in tepid water the coloring matter is easily dissolved while this is not true with the Locust. The sapwood is narrow and a yellowish color, while the heartwood varies through colors of yellow, dark yellow, greenish or golden-brown. The Locust is a ring-porous wood and the rays are visible. (9, p.580)

The properties of the Locust are: exceedingly strong in bending, extremely stiff, very high in shock resistance, very hard and heavy. It machines well, but is difficult to work with hand tools. Locust holds screws and nails well and is moderately low in shrinkage. It takes a fine finish.

Uses

In the days of the horse and sail, this wood found extensive use in wagon and carriage parts, while in ship building it was used for the treenails that held the ship's members pinned together. It is highly rot resistant and thus is used extensively where durability is required.

The wood can be used for projects that really interest boys for it makes fine bow staves and boat parts. It can be used to advantage in rural areas for stout handles and implement parts.
WESTERN JUNIPER (Juniperus occidentalis)

The Western juniper is not one of the hardwoods, but because of the attractiveness of its wood in turnery and for other small school projects it is included in this list of suggested woods.

Common Names in Use

Juniper, Sierra juniper, Cedar, Western cedar, Western juniper

Distinguishing Characteristics

This conifer has a short, bushy shape, with the limbs often extending to the ground. The leaves are scale-like needles, and its blue-black "berries" are covered by a whitish bloom. These are not berries, but cones. The trunk is grooved and ridged, dividing into large roots. The bark is cinnamon-brown in color. The Juniper can be identified further by crushing its needles which emit a whitish resin and produce an aromatic, pungent odor.

Distribution

The Western juniper's range is the arid, "tree-less" areas of east central Washington southward through southern California. It dots the sagebrush hills and high valleys of our western states. Favoring the rocky soils of high elevations, it is distributed in altitudes from 2,000 to 10,000 feet.

Characteristics of the Wood

The wood is somewhat similar in appearance to the popular Eastern red cedar, though usually more of a warm light brown than red and is finer grained. It is aromatic, soft, brittle and it
splits easily. The sapwood is thin and creamy-white while the heartwood ranges from yellow-brown to a purplish-red and is enhanced by many solid knots. It has a beautiful grain, is easily worked with sharp tools, has a good luster, and takes a fine finish.

Uses

It is used commercially on a limited scale for fence posts and small novelties. It also holds some possibilities for pencil stock. In the school shop it produces beautiful turnings and projects, such as small boxes and chests.
PACIFIC MADRONE (Arbutus manziesii)

The smooth, naked, orange-barked Pacific madrone is a familiar sight to westerners, for it ranges in the hills and valleys from the Puget Sound country to southern California.

The Spanish translation for Madrona is "strawberry tree". Undoubtedly the early Spanish explorers and settlers gave it this name because of the color of its bark.

This is another of the western hardwoods that are being knocked down or passed over by the lumberman that seems to hold a real potential value for the currently expanding west coast furniture industry. There is a growing demand for custom-built cabinet work which could make possible the utilization of this heretofore little used species.

Common Names in Use

Madrone, Madrona, Madrono, Madrove, Laurel, Manzanita.

Distinguishing Characteristics

This tree can be easily identified by the smooth peeling, reddish-brown bark of the main bole and by the naked greenish and orange limbs and twigs. When small it is sometimes confused by the uninitiated with the shrub, manzanita.

The Madrone can grow to very sizable dimensions. For example, near Roseburg, Oregon, there is a tree measuring nine feet in diameter and over 100 feet in height. The leaves are evergreen, simple, three to five inches long; shiny dark-green on the upper side and silvery-
white below. The tiny bell-shaped flowers grow in large white clusters and develop into handsome orange-red berries in the fall.

Distribution

Madrone thrives best in the coastal fog belt regions from Canada to lower California, it is also found mixed with the conifers, oaks, and maples of the inland foothills. The tree is tolerant of shade and is usually found growing among other species.

Characteristics of the Wood

Madrone produces a heavy, hard wood when dry, yet when "green" it is soft and it cuts easily. The sapwood is cream-colored, frequently having a pinkish cast. The heartwood is an attractive light reddish-brown. (9, p.602)

During the seasoning, whether it be air or kiln dried, this wood has a tendency to cup and shrink considerably; consequently the "green" lumber must be cut thicker than most hardwoods to make the required finished dimensions. (69, p.7) This is a diffuse-porous wood, fine grained with the rays not visible. The wood has some tendency to be cross-grained. In tests reported by Davis of the Forest Products Laboratory at Madison, Wisconsin, the madrone proved to rank among the top American hardwoods in its all-round machining properties. (13, p.28)

Uses

Commercially, the burl of the Madrone has considerable value for veneer stock, most of which is being sold to European buyers. Because of its hardness and resistance to shock and wear, it is
being substituted for dogwood in the making of rollers and shuttles.

(9, p. 603)

Little use has been made of this wood for furniture, but with modern methods of kiln drying, machining, and gluing; it has real potentialities.
MANZANITA (Artostaphylos)

There are some thirty species of the genus *artostaphylos* growing in California alone—from the ocean dunes to the high Sierran ridges. It is usually in shrub form, but in some areas it reaches tree size. The Manzanita is discussed here for it is a wood that can be brought easily into the school by boys, and after careful drying can be worked into interesting small projects.

**Common Names in Use**

The following are common names for a few of the species: Green manzanita, Woolley manzanita, White-leaved manzanita, Parry's or Common manzanita.

**Distinguishing Characteristics**

Usually shrub-like it makes up much of the chaparral or brushy regions of our western hillsides, in some instances forming impene-trable thickets, and in other places growing singly as shrubs or low trees.

The manzanita is easily recognizable after seeing its gracefully crooked stems, its mahogany colored bark, and its usually grayish-green foliage. The Woolly manzanita is identified by its leaves which are sage green above and often covered with white hairs underneath. The dark red bark sloughs-off the limbs revealing a smooth inner bark of a pale greenish color with a red tinge. Manzanita in Spanish means "little apple" and the small green colored fruit with red cheeks do resemble tiny apples. (9, p.508)
Distribution

The manzanitas are spread extensively at all elevations of the Pacific coast and are found widely distributed in Washington, Oregon, and California except in the lower central valleys.

Characteristics of the Wood

Like the madrone, manzanita when freshly cut is relatively soft and then dries very hard. The wood is usually reddish-brown in color, although burls from a species called the "tree heath" used in place of imported briar root for pipe making, are pinkish-white. The red colored burl is considered commercially worthless for this purpose. (21, p.4)

This dense wood with its beautiful, natural coloring is fine textured and produces a high polish with sharp tools. Manzanita wood is highly refractory and will insist on splitting, checking, and warping unless the most careful seasoning procedures are carried out.

C. L. Hill, writing in a publication of the Forest and Range Experiment Station at the University of California, suggests this method of preparing manzanita, to be followed by end coating and then the salt brine seasoning method: (27, p.2)

Drying troubles are likely to be worse with wood in a log or round form than when the material is sawed up into smaller pieces. It is best, therefore, to saw round logs or bolts, as quickly as possible after they are cut, into suitable blanks or the rough forms of most convenient dimensions for working up into the final product desired.
Uses

Manzanita has a definite use where small pieces of beautifully colored woods are desired; i.e., desk lamps, small bowls and dishes, pipes, and attractive carvings. Other examples of good project uses for this wood are: small rollers, bearings, machine stops or mallet heads, all of which can be readily turned from this local hardwood.
BIGLEAF MAPLE (Acer macrophyllum)

Bigleaf maple is the only commercially important maple of the West. It is being cut extensively for furniture and flooring. This wood can be purchased through most hardwood lumber dealers under the trade name of Western maple.

The Bigleaf maple is familiar to most of us in Oregon, Washington, and California as it is the common large maple tree that shades and beautifies our streets and yards.

**Common Names in Use**

Broad-leaf maple, Oregon maple, California maple, White maple, Water maple, Bigleaf maple.

**Distinguishing Characteristics**

The two features that will help to distinguish this maple from other maples growing in this area, is the size of the mature tree and the immense leaf from which this species derives its name. In favorable conditions where the soil is moist and loamy, the tree has reached heights of seventy-five feet with a spread of branches about the same distance. Trees up to five feet in diameter breast high have been measured. (9, p.466)

The deciduous leaves which are pinnately lobed, usually have five "fingers" and measure up to fifteen inches long. The seeds which are joined in pairs of wings are hairy and hang in dense clusters.

**Distribution**

This maple, growing throughout California and north to Canada,
is a magnificent tree in western Oregon and Washington. It inhabits the banks or bottoms of constant streams, moist valley flats, or springy mountain sides. (30, p.201)

**Characteristics of the Wood**

The qualities of this wood are very similar to the eastern Hard maple although it is not quite as dense and heavy. The sapwood is a reddish-white sometimes with a grayish cast. (9, p.585) The heartwood is a pinkish-brown. The grain is generally straight, but occasionally wavy. It is moderate in weight, hardness, and strength. It machines well and takes a good polish. This Maple takes stain and paint well, but like its eastern kin, is difficult to glue.

The pores are small and diffused, not easily seen with a hand lens. The rays are visible and when quarter-sawn this maple produces an attractive pronounced ray fleck.

Bigleaf maple shrinks moderately during its curing stages, but under modern kiln drying procedures, as observed at the Chromy Planing Mill at Scio, it presents no major seasoning difficulties.

**Uses**

Next to alder, this is the most widely used western hardwood. It is currently being used for good furniture and flooring. For, although it is softer than the eastern Hard maple, it is very comparable in other respects. Bigleaf maple burls and figured logs are commanding a good price mostly for export to European veneer plants. The figured veneer consists of burl, blister, curly, and quilted patterns. The quilted grain unique to this species is very valuable
for expensive furniture facing. The supply of these trees is being rapidly depleted, and according to P. J. Landry of the Kelso Veneer Company of Kelso, Washington, quilted maple will become a commercial rarity within a short time. (9, p.587)

In the school shop this western maple, whether it be purchased as finished lumber or cut locally and processed by the classes, will provide an excellent wood with which the boys can work. It will make attractive maple cabinets and furniture and will be more easily worked by the learner than the harder eastern maple.
OREGON MYRTLE OR CALIFORNIA LAUREL
(Umbillularia californica)

The name of this beautiful tree, whether it be Oregon myrtle or California laurel, seems to be interchangeable, some reliable references use one while equal authorities use the other. The hardwood lumber trade uses the term Oregon myrtle while the Forest Service calls it California laurel. The map of its distribution is interesting to those who feel that it is unique only to southern Oregon and a small part of northern California.

Common Names in Use
- California myrtle, Oregon myrtle, California laurel, California bay tree, Bay, Pepperwood, Cajeput.

Distinguishing Characteristics

This is an evergreen, broadleaf tree, belonging to the laurel family. Under favorable conditions it attains a height of sixty to one hundred feet. To even the untrained it can be identified easily merely by crushing its dark, long, leathery leaves, for they give off a strong, pungent, camphor-like odor. The aromatic smell is very noticeable when passing underneath these trees. The fruit which matures in the fall is yellowish and olive-like. (22, p.530)

The size and shape of the tree depends on the region where it grows. In many places it is short and very rounded; in other locations it may grow tall and spindly, not at all suitable for cutting boards. Near the California-Oregon border it reaches its maximum
proportions and will obtain diameters of three feet. (16, p.420)

Distribution

Oregon myrtle ranges from southwestern Oregon through the Coast Range to southern California, and through the Sierra foothill canyons. It grows best in the shade and protection of gulches near moist stream beds. It thrives from sea level to elevations of 4,000 feet. (16, p.420) The trees most prized for their lumber are found in southern Oregon.

Characteristics of the Wood

This is the most expensive lumber produced on the west coast, and the burl of this tree brings the highest price of all our American woods.

The sapwood is thick and ranges from white to light brown. The heartwood generally appears as a light golden brown to a silvery greyish-brown often with streaks of dark brown to black. (9, p.564) Besides its coloring the wood is especially favored for its interesting figured grain that produces many pleasing effects. It has an especially good luster. When dry the wood is heavy and hard. It works nicely with tools and takes glue well.

The freshly cut logs are often placed in water for storage and being heavier than the water they sink. This is believed to aid in developing the coveted dark streaks.

A disadvantage of bringing myrtlewood into the lumber room is that the sapwood is susceptible to attack by powder-post beetles, as was described in the chapter on seasoning and storage.
Uses

The lumber is prized for cabinets, interior paneling, and flooring. Fine myrtle turnings are sold by better department stores and gift shops, such as, Cumps of San Francisco. On the coast routes of northern California and southern Oregon, a sizeable "tourist" myrtlewood industry thrives. Many of the products of these "tourist" industries are inferior in design and workmanship.

It is used some for expensive gunstocks, but is considered by interviewed experts as inferior to the Black walnut, as it is less stable for precision match shooting.

In the school woodshop it is a favorite, for the boys are fascinated by the beauty of the wood as their projects near the finishing stages.
CALIFORNIA - LAUREL
Umbellularia californica

MILES

0
100
200
CANYON LIVE OAK (*Quercus chrysolepis*)

Maul oak is another accepted common name for the Canyon live oak, and gives an indication of the toughness of this wood. It is easy to visualize the part oaken implements made of this timber played in the development of the West.

The older botanists, such as Hough and Jepson, whose classic first-hand observations often were made by packing deep into the undeveloped western forests; describe how wood from this rugged oak was fashioned into implements by the Indians and later by the settlers.

Common Names in Use


Distinguishing Characteristics

Usually smaller than the Oregon white oak or the Valley oak of California, this rugged evergreen is found, under ideal conditions, to reach a trunk diameter up to five feet and heights of sixty feet. Often the bole is leaning and crooked, making it undesirable for profitable logging. The small, shiny, dark-green leaves are evergreen, and this tree is unique in that it can have two types of leaf forms.

Ross says: (58, p.55)

One leaf looks very much like holly. The other leaf has a smooth edge or it may have several points along the edge that look slightly misplaced. The younger the tree, the more holly-like leaves it will have.

The fruit, which matures at the end of the second year, is an acorn with a turban-like cup. (30, p.165)
Distribution

It grows in elevations of 1,000 to 9,000 feet ranging from southwestern Oregon to lower California. (66, p.297) Occurring on canyon sides and bottoms, it achieves best growth in the richer humus soils of the canyon floors.

Characteristics of the Wood

The sapwood is whitish while the heartwood, according to Sudsworth is: (66, p.295)

... of a light brown color, variable in grain from fine to coarse, very heavy, stiff and exceedingly tough and strong. Its strength is well known to mountain freight teamsters, who prize wagon tongues and whiffle-trees made from it very highly.

The present day woodworker is interested in its ease of working and its attractive appearance when it is quarter-sawn to display the light-catching wood rays. It seasons well and is almost as heavy dry as when freshly cut.

Uses

Wood of the Canyon live oak is applicable in the school woodworking program for boat knees and stem pieces, for oak furniture, and in situations that call for tough, strong hardwood with an attractive appearance.
CANYON LIVE OAK
Quercus chrysolepis
OREGON WHITE OAK (Quercus garryana)

The Oregon white oak is a major hardwood of the Pacific Coast and the only western oak of any commercial importance. Next to the Valley oak of California Quercus lobata, which is worthless except for its shade and beauty, the Oregon white oak is the largest of the western oaks.

Common Names in Use

Garry oak, White oak, Pacific post oak, Oregon oak, Oregon white oak.

Distinguishing Characteristics

A large oak when growing in moist, alluvial bottoms and valleys, it can be distinguished by its deciduous, smooth edged, deeply cut, lobed leaves. The fruit of this oak is a plump acorn, about one inch long, held in a shallow hairy cup. The crown of foliage is round topped and broad, often irregular. In the best sites it grows to three feet in diameter and sixty feet high.

Distribution

Oregon white oak ranges from Vancouver Island southward into the coast ranges of northern and central California. Peterson says: "... generally at elevations from sea level to three to four thousand feet. It occurs mixed with Kellogg oak and Douglas fir, and also with madrona, ponderosa pine and ash." (52, p.10)

Characteristics of the Wood

The heartwood is yellowish-brown while the sapwood is nearly
white. It bends well and can be employed where curved wood members are required. (52, p.11) The wood is ring-porous and fine grained. The wood rays are shown to good advantage when the lengths are quartersawn. It has the same quality, appearance, and properties as the eastern White oak. Older growth is brash and flinty, the second growth is bendable, resilient, and more easily worked.

Its limiting factors appear to be in its brashness, tendency to check while seasoning, and the relative small amounts of clear lumber that is obtainable from the log. (52, p.11)

Uses

This White oak makes an excellent water tight material because of the tyloses that close off the pores, thus preventing the passage of liquids, (see tyloses page 16). For school use it makes fine boat parts because of this characteristic plus its strength and good working properties. Also for the same reasons it can be utilized by the students in the making of trailer bodies, wheelbarrows, toboggans, and outdoor furniture. Of course, its use is not restricted to projects that must be water resistant, for like its eastern relative the White oak (Quercus alba), it makes one of the very best American furniture woods.

Gibson, (22, p.236) writing in 1913, describes how wood from young Oregon white oaks was split in long, thin ribbons to be used in basket weaving. This might be a suggestion for our present day industrial arts program since the popularity of woven chair seats and basketry is reoccurring in modern home furnishing.
OREGON WHITE OAK
Quercus garryana
CALIFORNIA SYCAMORE (Platanus racemosa)

The California sycamore, whose attractive wood is very similar to the sycamore of the eastern United States (Platanus occidentalis), is found growing along the warm stream beds of California's interior valleys and canyon bottoms.

Common Names in Use

Western sycamore, Buttonwood, Buttonball, California sycamore.

Distinguishing Characteristics

The large leaves, resembling in shape that of the maple, are a light yellow-green and covered with fuzz on the underside. In the fall before the leaves drop, they turn a beautiful bronze color. The bark at the base is brown and furrowed; while the rest of the smooth trunk and branches are a characteristic ashy white with greenish-gray areas, giving them a mottled appearance. The balls which contain the seeds are hung from branchlets in strings. This species grows from forty to eighty feet high, but just as often is found growing low, twisted and sprawling. It has a massive crown of wide spreading limbs supported on a trunk that is from one to five feet in diameter. (30, p.181)

Distribution

The California sycamore ranges from the lower Sacramento River, through the interior valleys and coastal ranges to Lower California. It is never found in the fog belts. (66, p.335) It requires moisture, thus, lives along gravelly creek beds where it is found mixed with
cottonwood, willow and California walnut.

**Characteristics of the Wood**

Because the wood is similar to that of the *Platanus occidentalis*, the properties described by Brown, Panshin and Forsaith for the eastern species will apply. (9, pp.570,571) The sapwood ranges from whitish to light brown, while the heartwood is in shades of light brown to dark or reddish-brown. The growth rings are distinct while the pores are barely visible. The rays are wide; and when the log is quartersawn, exposing the radial surface, it shows a beautiful pattern of reddish-brown or silvery fleck.

The wood is difficult to split as the grain is irregular and interlocked. It machines satisfactorily at high cutting speeds and is hard, strong, and heavy. Sycamore wood shrinks considerably, is inclined to warp in drying, but dry quartersawn stock stays in place well and keeps its form well when bent after steaming. (9, p.570)

**Uses**

This tree has a potential value for cabinet work because of the beautiful figure of the quartersawn lumber and its hardness which is so desirable in the surface of good furniture.
TAN OAK (Lithocarpus densiflora)

The bark of the Tan oak is high in the tannin used for tanning leather. In the past this tree has been felled, stripped for its bark and then the log left to rot. It is a fine hardwood, and it is hoped that with improved hardwood logging practices, and further seasoning data followed by dry-kilns in the area in which the tree thrives it will be profitable to produce Tan oak lumber.

Actually Tan oak is not a true oak but a link between the chestnuts and the oaks.

Common Names in Use

Tanbark oak, Squaw oak, Chestnut oak.

Distinguishing Characteristics

Tan oak is a smooth-trunked tree with light green leaves three to five inches long. These leaves are covered with fine hairs above with a rust colored wooliness on the underside. (16, p.394) The flowers are fluffy white and when in bloom the tree resembles the Golden chinquapin. The fruit is an edible acorn that can be identified by its bristly cup. The mature trees range in size from fifty to eighty feet high and from one to five feet in diameter.

Distribution

Tan oak grows from southwestern Oregon down California's Coast Range to the Santa Barbara area and is found sprinkled in the northern foothills of the Sierras. It thrives best near the coast, at low elevation, in rich, moist, well drained gravel and sandy soils. It is
tolerant of shade and is found mixed with redwood, fir, liveoak and madrone.

**Characteristics of the Wood**

The wide sapwood which darkens with age is a light reddish-brown when first exposed. The heartwood is a light brown tinged with red, aging to a dark reddish-brown. The wood is very heavy; this creates a handling and trucking problem in the woods. Because of its aggregate rays, fine grain and coloring, it is one of the most beautiful of west coast hardwoods.

**Uses**

The main objection to its use has been the severe warping and checking in seasoning. The Forest Products Laboratory at Madison, Wisconsin, made kiln drying test schedules with Tan oak and the results were published in 1950. They found there was still a considerable amount of surface checking and cupping with kilns running at the lowest temperatures and the highest humidities that could be maintained in a commercial dry-kiln. The report did suggest that long term air drying under weighted piles followed by kiln drying to bring the moisture content to a desired low percentage would produce satisfactory results. (69, pp.1,3,7)

The above procedures would be necessary for any satisfactory commercial venture. By following the suggestions made in the chapter covering seasoning and storage, it is possible to produce amounts of dry Tan oak lumber suitable for the school's use. Furniture and the
many other projects the student can build with this wood will be of special interest to him. It will be valuable not only because it is of a hard, attractive wood from our western forests, but it will be unique in its rarity.
THE BLACK WALNUTS

(Juglans nigra) and (Juglans hindsii Jepson)

Walnut is the most valued of our American cabinet lumbers, and has been so since long before the Civil War. Because of its edible nut, fine wood, and pleasant shade, the early settlers brought the hard-shelled seeds of their familiar eastern Black walnut (Juglans nigra) west with them. A rapid growing tree that fruits prolifically, this walnut spread; the nut was carried by animal, stream, and man so that now this Black walnut is found throughout the West.

There are two species native to this Pacific Coast area: the California black walnut (Juglans hindsii Jepson); and a sub-species, the Southern California black walnut (Juglans californica Wats.) Because of its small size and inferior wood, the latter will not be considered for project lumber. The Juglans hindsii, which was found growing along the creek beds of central California, is now used extensively as a parent plant to which the less hardy English walnut is grafted.

Common Names in Use

Black walnut, Walnut.

Distinguishing Characteristics

Gibson writes that Black walnut will vary in size: "... from a diameter of two feet and a height of fifty, to a diameter of six or more and a height of 100 or 120. Trunks which grow in the shade are tall, clear, and symmetrical; those in the open are shorter with more
taper." (22, p.345) The pinnate leaves are from one to two feet long made up of a series of slender leaflets. The fruit is the edible nut enclosed in a hard-shelled ball which is in turn covered by a green pulpy hull. The Black walnut is characterized by its rough, brownish-black bark on trunk and limbs. Although very similar in appearance, the California variety does not attain the great size of its eastern cousin.

**Distribution**

The natural growth range of the Black walnut is the eastern United States. Along the Pacific slope states of Washington, Oregon, and California, this magnificent tree is found shading our yards and highways; and often along streambeds where the nuts have been deposited and have germinated in the hospitable silt. It attains its maximum growth in well drained, rich, moist soil.

**Characteristics of the Wood**

The appearance and properties of the lumber derived from the eastern species are too widely known and appreciated by the woodworker to warrant a detailed description in this report. On the other hand, one of the most beautiful and prized grades, known by its trade term, *Claro*, obtained from the native Californian, *Juglans hindsii* Jepson, is probably little known to most woodworkers.

D. C. Criteser of Woodland, California, was interviewed and he gave a wealth of factual information on the Black walnut and a number of other hardwoods growing on the Pacific Coast. Criteser is an
experienced hardwood log and burl buyer, who also specializes in cutting and seasoning walnut for custom-built rifle stocks. He made this statement: "The best walnut in the world comes from the Sacramento Valley." He based his opinion on the demand and prices paid him by eastern and European buyers for the figured Claro. He felt that the long growing season was responsible for its particular growth. The Claro walnut that he was "working-up" was from the butt-out of the larger trees.

The California black walnut differs from the eastern species in that its wood is a rich reddish-brown in color, whereas the latter tends more to the yellow-browns. These lower lengths have a highly figured grain, much of it is the fiddle-back, so highly prized for gunstocks. Walnut is desirable because of its all-round excellent working qualities; its coloring, luster, and its attractive grain formation. It also has the highly desired and not too common property of being very stable under varying temperature and moisture conditions.

Criteser's method of seasoning the three and one-half inch slabs of walnut, which had been cut to size by chainsaw, was satisfactorily done in this manner. The slabs were soaked in a strong salt brine solution for ninety days; the brine was changed a number of times. End coating was then applied. He used "Cerenul-A", which is an end-coating manufactured by one of the major oil companies. He also suggested paraffin for sealing the pores. Then, contrary to the slow air seasoning methods recommended by other reliable sources, the slabs were dried in covered piles in the hot summer sun. After curing, this
wood was bandsawed into carefully selected blanks and was then ready to be worked by gunsmiths to form stocks which are carved and inletted for the finest barrels.

Uses

Walnut from the western trees can serve to make an unlimited variety of projects. Students of high school age are particularly interested in wood-turning, for good-looking projects can be made in a short time. Here walnut is a great favorite because it lends itself so well to shaping and finishing on the lathe. In furniture and cabinet work this wood is unsurpassed.
PACIFIC YEW (Taxus brevifolia)

The Pacific yew is neither a hardwood nor a conifer, for although it has needle-shaped leaves it does not bear cones. It was felt that this little tree should be included in this research because of the hardness of its wood and for its historic use as a bow wood.

Common Names in Use

Yew, Pacific yew, Western yew, Mountain mahogany.

Distinguishing Characteristics

The Pacific yew is a small, shade-loving tree growing under the protection of the tall firs, redwoods, maples and stream-side alders. It can readily be identified by its awl-shaped needles that resemble those of the redwood. These evergreen leaves are soft to the touch (16, p.272); dark, shiny green above and a chartreuse green coloring on the underside. Seeing the scaly, thin, reddish bark and the fluted trunk which rarely exceeds two feet in diameter, will help to identify the Yew. Elliot describes in his book TREES OF THE PACIFIC COAST, (6, p.276) a Pacific yew that he measured in Oregon and found to be four feet through and about seventy-five feet high. The tree was exceptionally large for this species, as the average tree will range from six to twelve inches in diameter and reach a height of about twenty-five feet. The seed is contained in a bright red, berry-like fruit rather than having seed cones as its conifer-like appearance would imply.
Distribution

The Pacific yew is distributed from British Columbia southward through the Coast Ranges and Sierra Nevadas of central California. Growing to its largest size in the rain-forests of western Oregon and Washington, it is often found along the alluvial benches and the flats of cool creek bottoms; in company with other undergrowth of the forest.

Characteristics of the Wood

The thin band of sapwood is a light cream color as it adjoins the bright orange or reddish-brown of the heartwood. Unlike the conifers, it has no strong characteristic taste or odor. (9, p.506) Yew wood is noted for its strength in bending and compression, and its resistance to shock; properties which are required for archery bows. It is fine-textured, very heavy, and is refractory under tools. In the final stages of working, it takes a beautiful finish. Wood of the Pacific yew is remarkably durable when exposed to conditions that cause decay. (30, p.82) To one who is unfamiliar with this wood and its working characteristics, yew has the appearance of one of the soft coniferous woods, for like the Douglas fir, the annular growth rings are very distinct; instead it is hard.

Bow-makers who were interviewed described this method for gathering yew wood. The tree is cut to length, the wood split into bolts, then often left leaning against a nearby tree for a season. This is done to eliminate a considerable amount of the weight.
Uses

Scarcity and small size limit the Pacific yew in commercial importance. (9, p.507) It is used locally for fence posts and novelties, but very little reaches the market other than for bow staves.

Historically, yew was significant to the cultures of both the English and our northwest American Indians. The wood of this species is very similar to European yew which won fame when the English long-bow was the most effective weapon man had devised until the discovery of gun powder.

Gibson describes this utilization of the pacific yew by the northwest coast natives: (22, pp.199-200)

They made bows of it, and it was superior to any other wood within their reach for that purpose. In fact, if they could have picked from all the woods of the United States they could scarcely have found its equal ....

The northwestern Indians put this remarkable wood to other uses. They made spears of it and sometimes employed them as weapons of war, but generally as implements of the chase, particularly in harpooning salmon .... The Indians whittled fishhooks of yew before they were able to buy steel hooks from traders .... A proper crook was selected where a branch joined the trunk, and serviceable fish hooks were made without any cross grain. They were strong enough to hold the largest fish that ascended the rivers .... The Indians found a further use for this wood as material for canoe paddles. It is so strong that handles can be made small and blades thin without passing the limit of safety. The manufacture of boat paddles from yew continues.

In school shops and in recreation programs, yew wood is being used primarily for bow staves. It is unexcelled for making thin canoe or kayak paddles of great strength. This little tree should not be overlooked for making lathe-turned projects and small cabinet pieces.
PACIFIC YEW
*Taxus brevifolia*

MILES

ALASKA
B.C.
ALB.
WASH.
OREG.
IDAHOO
WYO.
MONT.
NEV.
UTAH
CALIF.
ARIZ.
APPENDIX B

A SUPPLEMENTAL LIST OF NATIVE AND INTRODUCED

HARDWOODS SUGGESTED FOR SCHOOL PROJECT USE

Almond
Apple

Birch, Western paper
Buckeye, California

Cherry

Elm

Ironwood, Desert

Hazelnut
Holly

Magnolia

Mesquite

Mountain mahogany, Curlleaf

Olive
Osage orange

Pear
Persimmon
Pepper

Tamarisk
Thornapple, Western

Walnut, English
Wax myrtle, Pacific