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MANAGEMENT OF
BOTTOMLAND HARDWOODS

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FOREWORD

This bulletin describes principles and procedures involved in the management of a group of our most important forest types--bottomland hardwoods. It fills, in part, the major remaining gap in American forest management literature.

The presentation is based on years of experience in these forest types by the author, fortified by some research. Generally, however, there have not been many applicable technical studies. Fairly recently, research has been undertaken on a modest scale, but final results are still to be obtained.

It was decided to issue this report in spite of the limitations of the research background. In so doing, there is no particular fear that the presentation is hasty or faulty in any major respect. Of necessity, however, it is incomplete, and gaps remain which can be filled only as technical data and experience accumulate.

Application and understanding of the discussion will be greatly facilitated by some general forestry knowledge, because explanation and description of standard forestry terminology and methodology have not been included. Even with a general forestry background, considerable on-the-ground familiarity with the peculiar conditions of the bottomlands will be necessary to apply the recommendations.

Southern bottomland hardwood types have their greatest concentration in the Mississippi River Delta. In the aggregate, however, there is more bottomland forest acreage outside the Delta than in it, because these types occur on every major stream and many minor ones from Virginia to Texas. Essentially, the types with which this publication is concerned are those on alluvial floodplains with their intermittent fringes of colluvial soils. The only exception is the inclusion of the cypress-swamp blackgum type in the non-alluvial swamps of the Coastal Plains. The widespread southern hardwood stands in the "branch head" coves and along creeks or runs which have no alluvial floodplain are excluded. The hardwoods of the hammock and the pond sites of the southeastern Coastal Plains are also excluded.

The discussion is confined to management of bottomland forests for timber production. The place of multiple or alternative land use is beyond the scope of the paper.

Although southern bottomland hardwoods are the main subject, much of the discussion is applicable to management and utilization of hardwood forests generally. Foresters contemplating embarking on hardwood management anywhere will obtain useful concepts and recommendations from this publication.

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MANAGEMENT OF BOTTOMLAND HARDWOODS

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The principles involved in the management of bottomland hardwoods are neither unique nor peculiar. Their application follows a pattern common to placing any forest land under management: namely, the first step is to learn what there is to work with, and the second is to plan a course of action. As to the actual details of management, the bottomland hardwoods do have many unique features. The discussion of these features is the main object of this publication.

Management of most forest land--and bottomland hardwoods are no exception--usually begins with some very extensive practices. To apply these practices, only elementary information is essential. Later, as management progresses, more detailed information must be obtained. Since the most likely course of development is from the extensive to the intensive, this discussion proceeds in the same way.

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PRELIMINARY SURVEY

A simple survey of the forest and a preliminary study of logging conditions, markets, and fire and other hazards should be the starting point to management. This is mainly a get-acquainted job. It should be sufficiently detailed, however, to furnish the land manager with all the facts and information essential to a sound beginning.

Each convenient management unit or block should be inspected and classified as to timber type and class of stand. Information on timber quality, extent of damage, and other special features should be obtained by stand classes. The only estimates of volume needed at this stage are those required to classify the stands.

The conventional timber cruise, growth estimates, and management plan are not needed at this stage. These logically come later, after the first managed cut has been made. If for some special reason the cruise, growth estimates, and management plan are wanted in the beginning, there is no reason why they should not be made. The main point, however, is that these details are not essential to getting the forest under management.

With the data from the preliminary survey, the forester can lay out his forest in operating management units or compartments, select those most in need of cutting, and plan the operations to follow. The information that must be gathered in the preliminary survey is outlined in the following sections.

SITE

In bottomlands, site is important because it largely determines the combinations of species or forest types that are present. The site in turn is determined by the physiography or elevation and soil characteristics. It is not necessary to map or classify site in the preliminary survey. However, site as used herein so strongly influences type that the forester should have a clear understanding of it at the outset of his reconnaissance. The broad characteristics of bottomland sites are described, therefore, as background for type recognition.

The two major sites are first bottoms and terraces. The terraces comprise the second and older or higher bottoms. Within each of these broad groups are four secondary sites--ridges, flats, sloughs, and swamps. A fifth secondary site, peculiar to the first bottoms, is the new land or front along present or recent drainage channels.

The main differences between first bottoms and the terraces are in elevation and soil characteristics. Since the first bottoms have been formed by the present drainage system, they are of comparatively recent origin. They are subject to flooding at any over-bank stage unless protected by levees, and many areas receive backwater. The soils range from pure waxy clay to pure coarse sand, but clays and very fine sandy loams predominate. Generally the soils contain little or no silt.

Terraces were formed by earlier drainage systems. They are not subject to direct flooding except at superflood stages. The normal processes of erosion have created a definite relief in many places, and the original alluvial features--ridges, flats, sloughs, and swamps--are less evident than in first bottoms but no less important. Most terrace soils are basically silt, with varying mixtures of sand and clay. The colluvial fans and aprons, common at the foot of the rise where the bottoms and uplands merge, can be considered as parts of the terraces.

In both first bottoms and terraces, the ridges are usually the highest land, commonly varying from 2 to 15 feet in elevation above the adjoining flats. They are the banks or "fronts" of former stream courses. The flats, which are just what the name implies, constitute the general terrain between ridges. The sloughs are shallow depressions in which water collects but normally disappears during the first half of the growing season. They are either old, filled-in, or undeveloped drainage courses. Swamps are distinct depressions in which water stands throughout most or all of the growing season except in periods of drought. The new lands or fronts--including bars, islands, and towheads--have largely been deposited within the last 150 or 200 years. They are usually very fine sand and clay and are areas of unconsolidated, immature soils. There are flats, ridges, and sloughs within these fronts.

Since forest type varies with these distinct physical features, it is imperative that the forest manager know and recognize them. Throughout the detailed discussion of forest type to follow, these site distinctions will be made.

THE IMPORTANT TYPES

There are eight important forest types in the bottomlands and several significant variations of these major ones. The types are made up of various combinations of about 55 commercial species. Table 1 lists the most important bottomland forest types and describes some of their general characteristics. To prepare a sketch map showing these important types requires that the forester give the property a reasonably complete though extensive inspection. Since these types generally follow the sites or the lay of the land, judicious cut-and-try checking against air photos can save much work in determining type boundaries.

Table 1.--Southern bottomland forest types and their major characteristics

The types recognized here do not correspond to the standard types of the Society of American Foresters, because the standard types are more refined than is necessary or desirable for management purposes. (See Appendix for manner in which the Society of American Foresters types are combined in this report.) The most important or key species in each type are marked with an asterisk.

Type	Characteristic species	Occurrence by site	General features	Common variations in type
Sweetgum-water oaks	*Sweetgum *Water oak *Nuttall oak *Willow oak *Soft elm *Hackberry *Green ash Overcup oak Sweet pecan Bitter pecan Cedar elm Cottonwood Diamondleaf oak Laurel oak Red maple Honey locust Persimmon	General in first bottoms except deep sloughs, swamps, fronts, and poorest flat sites. Also on terrace flats.	Most widely distributed type. Second in quality, though nothing excels the best of this type. Produces high-value factory lumber and veneer logs.	(a) Predominantly sweetgum: on well-drained first bottom ridges and pervious silty clays on terrace flats. (b) Predominantly water oaks: on heavier soils on first bottom ridges and better drained flats; on poorly drained flats on terraces. Nuttall oak dominates on well-drained first bottom flats. Willow oak prevails on first bottom ridges and poorly drained terrace flats, i.e., pin oak flats; near the Coast laurel oak takes over. (c) Cedar elm-water oaks: on poorly drained, impervious soils on low or indistinct first bottom ridges. Of minor importance on impervious terrace soils.
White oaks-red oaks-other hardwoods	*Cow oak *White oak *Delta post oak *Cherrybark oak *Shumard oak *Southern red oak *White ash *Hickory *Black gum *Winged elm Sweetgum Overcup oak Willow oak Water oak Laurel oak Post oak Soft elm Magnolia Yellow-poplar Loblolly pine Spruce pine Beech	Best fine, sandy loam soils on first bottom ridges and all ridges on the terraces. Type extends on first bottom ridges to a few peculiar well-drained soils other than sandy loam.	Highest value type, with best species and highest quality products. Second only to sweetgum-water oaks type in area. Produces high-quality tight cooperage, factory lumber, veneer logs.	(a) Predominantly white oaks: on the most matured terrace soils. (b) Pine-hardwood: in very limited situations; most common with loblolly on terraces, but also with spruce on ridges in first bottoms of small streams of the Coastal Plains east of the Mississippi River.
Hackberry-elm-ash	*Hackberry *Soft elm *Green ash *Bitter pecan *Willow oak Cedar elm Overcup oak Sweet pecan Water oak Nuttall oak Winged elm White ash Cherrybark oak Blackgum Persimmon Red maple Boxelder	Low ridges, flats, and sloughs in first bottoms and terrace flats and sloughs. Occasionally on new land or fronts. Rarely on badly maltreated terrace ridges.	Temporary type following heavy cutting and fire or succeeding cottonwood. Widely distributed in stands from a few to several hundred acres in size. Produces mainly slack cooperage stock, lower grade factory lumber logs, and box factory logs.	(a) Pure ash: occasional small stands of pure ash may occur almost anywhere within the type but most notably on moist flats or in shallow sloughs. (b) Pure hackberry: occurs rarely on new land or front sites.
Overcup oak-bitter pecan	*Overcup oak *Bitter pecan Willow oak Nuttall oak Soft elm Cedar elm Green ash Hackberry Water locust Persimmon Red maple	Low, poorly drained flats, usually with tight clay soils; sloughs; lowest backwater basins. On low ridges with heavy soils, residual after heavy cutting in sweetgum-water oaks type.	Varies in quality from poor to medium. Widely distributed with most extensive areas in backwater basins of principal rivers.	None.
Cottonwood	*Cottonwood *Sweet pecan *Sycamore *Hackberry Willow Green ash Soft elm Silver maple Boxelder	Front land ridges and well-drained flats; rarely on abandoned fields on well-drained ridges in the first bottoms.	Pioneer type, characteristic of the fronts of all major streams. Phenomenal growth, excellent quality, and fair values for commercial veneer, standard lumber, and pulp make it one of the most valuable types.	None.

Table 1.—(Continued)

Type	Characteristic species	Occurrence by site	General features	Common variations in type
Willow	*Willow Cottonwood Green ash Persimmon Water locust Soft elm Cypress Red maple Hackberry	Front land sloughs and low flats; occasionally shallow swamps and deep sloughs throughout first bottoms.	Pioneer type on front land. Very rapid growth, excellent quality, and moderate value for factory lumber logs and pulpwood make it valuable. Usual poor quality and form make it of little value away from fronts. With cottonwood, is characteristic of fronts of most major streams but commercially important only in lower Mississippi valley.	None.
Riverfront hardwoods	*Sycamore *Sweet pecan *Green ash *Soft elm *Hackberry Silver maple Cottonwood Willow Water oak Nuttall oak Sweetgum Boxelder River birch	All front lands except deep sloughs and swamps.	Transition between cottonwood or willow and the sweetgum-water oaks type. Widely distributed but restricted in extent. Very rapid growth, moderately valuable products for factory lumber, veneer logs, and slack cooperage stock.	None.
Cypress-tupelo gum (Cypress-swamp blackgum)	*Cypress *Tupelo gum *Swamp blackgum Willow Black cottonwood Red maple Soft elm Water locust Persimmon Overcup oak Bitter pecan Sweetgum Nuttall oak Diamondleaf oak Sweet bay	Cypress-tupelo gum in very low, poorly drained flats, deep sloughs, and swamps in first bottoms and terraces. Cypress-swamp blackgum in swamp of the Coastal Plains and river estuaries.	Widely distributed in small areas. Extensive areas on lower reaches and estuaries of major streams. Potentially highest value products but growth is slow and reproduction uncertain and difficult to secure.	(a) Pure cypress: occurs scattered throughout the type. (b) Pure tupelo gum (or swamp blackgum): largely follows clear-cutting of cypress.

Recognition of the sweetgum-water oaks, white oaks-red oaks-other hardwoods, and the riverfront hardwoods types proves complicated. There is so much variation in these types that the forest looks quite different from location to location within the same type. Frequently in type classification it will be necessary to defer recording the type boundary on a map or in notes until enough area has been covered so that the aggregate tree associations can be viewed in retrospect. By this procedure, the observations needed for the classification will accumulate in the forester's mind and he can make his judgment accordingly. Judgment of type will most frequently be based on occurrence of key species and the characteristic of the site rather than on any clearly definable feature such as volume or number of a certain kind or kinds of trees, although the final tally for any extensive area of a given type will always be characteristic as to species composition. For the other bottomland types, the characteristics and lines of demarcation are quite distinct, and little trouble will be experienced in mapping type boundaries as they are encountered. Delineation of boundaries for the hackberry-elm-ash type should be excepted. The exact boundary of this type will often be rather indeterminate.

It will be unnecessary to map or recognize types of less than 20 acres except in a few special situations which might influence logging or management.

STAND CLASSES

In order to start management, it is necessary to know which areas are operable and which are not. Ordinarily, this means segregating the saw-timber stands from the others and classifying the stands as to volume and structure. When each compartment is inspected, the stands of timber should be classified. The following classes, which an experienced forester can usually recognize without making an intensive inventory of the number and volume of trees present, are useful for economic and silvicultural planning. Where the classification is not readily apparent, plot tally of stand and volume should be made as a guide to judgment.

Stand Classes for Bottomland Hardwoods

I. Heavy saw-timber stands: 8,000 bd. ft. and more per acre in trees larger than 11 inches in d.b.h.
   a. 50 percent or more of the volume in trees 23 inches in d.b.h. or larger
   b. Less than 50 percent of volume in trees 23 inches in d.b.h. or larger

II. Medium saw-timber stands: 3,500 to 8,000 bd.ft. per acre
   a. 50 percent or more of the volume in trees 23 inches in d.b.h. or larger
      1. With adequate supporting stand of saplings and poles
      2. Without adequate supporting stand of saplings and poles
   b. Less than 50 percent of volume in trees 23 inches d.b.h. or larger. Supporting stand will be present.

III. Light saw-timber stands: 1,500 to 3,500 bd. ft. per acre
   a. 50 percent or more of the volume in trees 23 inches d.b.h. and larger
      1. With adequate supporting stand of saplings and poles
      2. Without adequate supporting stand of saplings and poles
   b. Less than 50 percent of volume in trees 23 inches d.b.h. or larger. Supporting stand will be present.

IV. Heavy pole stands: At least 175 growing stock trees per acre, 5 to 11 inches d.b.h. Natural pruning has started and stand will need thinning before it reaches small saw-timber size.

V. Light pole stands: From 45 to 175 growing stock trees per acre, 5 to 11 inches d.b.h. Stocking inadequate. Not pruning properly.
   a. With a supporting stand of saplings and seedlings which will assure satisfactory stocking
   b. Without a supporting stand of saplings and seedlings; needs reproduction.

VI. Sapling and seedling stands: At least 250 established saplings or seedlings per acre of desirable species and good form.

VII. Non-stocked stands: Less than 250 established saplings or seedlings per acre of desirable species and good form.
   a. Capable of reproducing naturally
   b. Requires planting
   c. Incapable of growing trees

Obviously timber stands do not always fall clearly and decisively into these classes. Lines of demarcation at best will be approximations based on the judgment of the forester after he has passed through the stand and observed the average predominant characteristics which define stand class. Within classes there will customarily be great variation, acre by acre. The general objective, though, should be to delineate stands of broad similarity of condition throughout, particularly as to operability and silvicultural characteristics, and then classify on the basis of average or over-all character. There is no need to labor to place minor stands and secondary subdivisions into the various classes unless distinctions are apparent and areas are of manageable shape and distribution. As a basis for judgment in stand classification and as a guide in estimating the portion of the stand which should be cut, the forester should establish occasional sample plots, recording numbers of trees and their volume and silvicultural status or condition. The main difficulty in stand classification will be in cataloging medium and light saw-timber stands.

Aerial photographs will be helpful in identifying the sapling and seedling, pole, and non-stocking stands. Field work can then be concentrated in the less easily defined classes.

Stands of heavy and medium saw timber should be mapped or recognized to a minimum size of 10 acres. For all other classes, nothing less than 20 acres need be recognized. These minimums may have to be modified locally as the situation demands.

TIMBER UTILITY, QUALITY, AND CONDITION

Generalized estimates of timber utility, quality, and silvicultural condition by stand classes are essential to determine which stands can be operated for available markets. At this stage, these estimates need only to be reasonable approximations permitting judgment with fair accuracy as to whether or not a stand is operable or when it will become operable, and roughly how much timber is available to harvest in the first cut. The saw-timber trees should be classified as overburden or desirable growing stock (these terms are defined on page 16). This classification will separate the stand into the component that should be removed and the component that should be left for growth. The overburden estimates should be broken down by the proportions in factory lumber logs and in other classes of sawlogs, and approximate numbers of cull trees. If there is special interest in a given product, such as face veneer, it can be listed separately. The average grade or general quality of the factory lumber logs and their range in quality should be estimated and recorded. Criteria to consider in recognizing class and grade of material are discussed on pages 26 ff. Observations

and records should be made also on the numbers and silvicultural condition of trees below saw-timber size. This, together with the estimates as to numbers of saw-timber-size cull trees per acre, will provide a check on the stand classification and the need of stand improvement cutting.

LOGGING CONDITIONS, MARKETS, PROTECTION

While information is being collected regarding the forest, other pertinent information helpful in placing a property under management should be gathered.

Logging Conditions

For the stands regarded as operable, a clear picture of logging conditions should be obtained during the preliminary survey. At what season can the stand be worked? This will be determined both by the drainage and soil conditions in the stand itself and by the prevailing condition influencing access to the area. How frequently do floods occur; when and how long do they last? What kind of logging equipment will be needed? Is it available now? If not, will the need for it justify its acquisition? What major transportation systems are available--highways, railroads, rivers? Can they fulfill the need? What, if any, stands will be logged by the landowner, and where should logging be contracted? If contracting appears desirable, will the opportunities interest experienced operators? What is the kind and quality of the labor supply? The fact that most information of this nature will be accumulated incidentally to other work does not belie its importance.

Markets

Somewhat related to logging conditions is the need for information on available markets. This information also may be obtained incidentally to other work, but without it planned management is impossible. What markets or uses are in prospect? How do they fit in with the nature of the timber supply? Should new or additional markets and uses be developed? If so, how and when can this be done? A later section on utilization in relation to management points out special considerations which must be taken into account in appraising bottomland hardwood marketing opportunities.

Protection

Another feature with which the preliminary survey should be concerned is the elements that must be considered in a fire protection system. This is particularly important because even rudimentary management will require a protection system. What is the fire history of the various major parts of the property? How often can fire be expected? Where are the areas of highest and lowest hazard? How will natural barriers and other physiographic features determine the protection system? What is the attitude of neighbors toward fire? Is manpower available for both presuppression and suppression work? What are the policies, plans, and operating procedures of the State fire protection organization? What special installations and equipment are needed in the fire protection system? These are typical of some of the questions that must be answered as a prerequisite to getting the area under effective fire protection.

Other protection deserves attention also. Is there any evidence of trespass and theft? Do certain areas appear to be more subject to trespass than others? Is there grazing damage to reproduction? If so, what can be done about it? Are there instances of insect attacks? Are past fire damage and rot particularly prevalent in any areas? Matters such as these will not only dictate management practices but will guide the priorities in their application.

GENERAL

Although classification of stand condition will allow operable areas to be delimited, priorities will depend on notes as to need for special or immediate attention. Are there areas of overmature timber that seem to be rapidly deteriorating? Are any areas threatened by bank-cutting by streams or rivers? Such information will come naturally and easily if the observer is on the alert.

By way of summary: When the preliminary survey is finished the forester has, first of all, an invaluable mental picture of the property. He has a general acquaintance. In addition and as background for future work, he has a map of type and stand class. Supplementing this, he has general information on the utility and quality of the stands and a rough estimate of the volume in trees to cut and leave and in culls. This information defines the operability of stands and indicates feasible silvicultural treatment. Notes and knowledge on non-operable stands and conditions are available as a guide to needed silvicultural treatment. Information has been accumulated on logging conditions and possibilities, markets, the fire situation, and other general features. He is now ready to take the next step in placing the property under management.

ESSENTIALS OF EARLY MANAGEMENT

After the preliminary survey is finished, it is time for action--actual management begins. Usually it starts with two phases of the job--installation of a protection system, and division of the property into management compartments followed by managed cutting. In these earliest phases, the intensity of management generally will be far from ideal. The protection system, however, if properly organized at the outset, will be as good as it ever need be.

PROTECTION

The first step in management is to place the property under protection. Cutting may be in progress as the protection plans shape up, but at no time should action lag in getting full protection as soon as possible. The following discussion outlines the main points in devising and installing a protection system.

Fire

Fire in bottomland forests is a very real problem, and all too often insufficient attention is given it. Fire in the bottomlands does not rage through the tree crowns, and bad fire seasons do not occur every year. Nevertheless, every 5 to 8 years a serious fire season occurs, when ground and surface fires cause very great damage.

Fire in the bottomlands usually moves rapidly along the surface, consuming the abundant shrub and weed growth and killing all tree reproduction under about 10 years of age. It also scorches the highly sensitive bark of the larger trees, causing wounds that later develop into catfaces and points of entry for rot, stain, and insects. Under extreme conditions, large saw-timber trees may be killed. A fire once every 10 years over a given area eliminates any possibility of the practice of forestry. For this reason, it is reemphasized without qualification that an effective fire protection system is a prerequisite to management.

Development and installation of this system are not strikingly different from forest fire protection elsewhere, but a few features deserve special mention.

Fire season.--With the rare exception of a dry early spring, fall is the fire season. The dangerous years are those in which the usual summer drought extends into autumn and early winter. The later the drought continues, the more fallen leaves and frost-killed vegetation are added to the fuel.

Public attitudes.--There is no compelling urge on the part of the local people to burn the woods in the bottomlands. The fires that do start are accidental. Most of them are caused by careless trespassers and by the escape of fires set for clearing fields, ditch banks, and rights-of-way. This situation is both favorable and unfavorable. It is favorable because fire does not occur often; it is unfavorable because people are unfamiliar with the destructiveness of fire and make little effort to prevent or suppress it. Awakening or increasing fire-consciousness, therefore, is important as part of the fire protection scheme.

Firebreaks, roads, and trails.--Firebreaks plowed annually late in the growing season are highly desirable. They should be at least 8 feet wide. Since their spacing depends entirely on such features as roads, sloughs, swamps, and drainage systems, it must be determined independently for each tract of timber. A very useful tool for preparing firebreaks is the Mathis four-disc plow, but any implement heavy enough to insure a clean swath is satisfactory. Continued maintenance of the firebreaks is essential during seasons of high hazard because leaves accumulate on the plowed strip.

As access may be difficult in the bottomlands, it is likely that the existing network of roads and trails on unmanaged forest land will have to be supplemented. Fire trails are not used except in fire seasons, so they need to be built only to dry weather standards.

Detection.--Air patrol during periods of high hazard is the solution to the detection problem on large properties. Methods for establishing effective air detection can be adapted to almost any large property. Fire towers are unusable because the tall timber on flat terrain obscures the view. Some ground patrol may be needed to supplement air patrol, particularly in detecting small fires in years when the fire season starts before all leaves have fallen. It should also be organized to hold trespass low during the fire season, thereby reducing the danger of fire occurrence. For small areas, detection of necessity will depend on ground patrol. Of course, where the State assumes detection responsibilities, this need will automatically be met for all properties.

Suppression.--Suppression of fires in the bottomlands generally follows standard technics except that building a fire line is unusually difficult. The vegetation is heavy and the soil is packed and hard and filled with tenacious roots. In the worst seasons, the difficulty of fire line construction puts the heaviest equipment in the South to a severe test.

Other Protection

Concentrated grazing by cattle causes severe damage to bottomland hardwood reproduction. Except for occasional very light grazing, cattle should be excluded from all areas where reproduction is needed. Hog grazing presents no serious problem.

Boundaries should be plainly marked and posted to prevent trespass and theft. Occasional inspection should be made to see whether any trespass has occurred. Friendly relations with neighbors help in reducing theft and in keeping an eye on developments.

DIVISION INTO MANAGEMENT COMPARTMENTS

Before cutting is started, a property should be divided into compartments to facilitate management and administration. Customarily, compartment boundaries will coincide with natural features such as streams, swamps, roads, and fields. Public land survey lines can also be used as compartment boundaries. It is advantageous to have compartments coincide with types as far as practicable, but stand conditions which will change under management need not be considered.

The size of compartments will vary with the size of the total property. Types, volumes, rate of cutting, frequency of cutting, and physiographic features are the kind of factors which must be considered in designing and establishing management units. Properties smaller than a few hundred acres may not require any subdivision at all.

Since compartments are the units of management, they should be very carefully selected for permanence and with the definite purpose of establishing an adequate but simple system of permanent records. All compartment boundaries should be plainly marked on the ground and on a map.

THE FIRST MANAGED CUT

The first managed cut will be somewhat of a hit-and-miss affair. It cannot be anything else, because the forester has to work with stands that have been subjected to all manner of unmanaged treatment through the years. Nonetheless, and in spite of many exceptions, there is a systematic approach which can be followed and which will yield results.

The basis for this systematic approach is the preliminary survey, which roughly classifies type and stand conditions and thus gives the forester the essential information that he needs to get

managed cutting started. Basically, he will use a common management prescription for all situations, but the details will vary with type and stand condition; and other features also will have some influence.

The discussion which immediately follows outlines first the general management prescription for the first cut and then specific prescriptions for each type and stand condition, or, where possible, for groups of types and conditions. In making the first managed cut, these recommendations should be the guide. As management intensifies, cutting methods and stand treatment can be refined as needed.

General Prescription for First Managed Cut

With only minor exceptions, the forester will find that through the years fire, unmanaged cutting, and other destructive influences have created a forest with a high proportion of low-grade and cull trees and undesirable species. In general, therefore, the first management prescription is to remove such components, plus the mature and damaged trees, in order to promote rehabilitation of desirable growing stock. During this process, the maximum possible returns in financial and silvicultural benefits will be essential. The test of the forester's skill, therefore, will be how fast he brings about full production of the land, at the same time compromising with the economic position and policy of the landowner.

In practically all bottomland forests, the effect of the general prescription will be an improvement cut supplemented with harvest of the overmature remnants of the earlier stands. Occasionally an element of thinning may be involved. The desirable growing stock should be left out of consideration until the undesirable elements of the stand are disposed of. The faster a property can be cut over in this way, the sooner it will be rehabilitated.

The actual rate at which the cut can be made will be determined by the desirability or need of supporting a specific plant or market from the area, or by the capacity of facilities or markets.

The necessary compromise of silviculture and economics--regulation of the cut--is not too difficult to make in extensive management. From the preliminary survey, an approximation of the operable areas and a very rough estimate of the volume of the components of the stand will have been secured. If sustained yield is feasible, the cut can be prorated over the years expected to elapse before the property can be cut over a second time. Otherwise, the material can be removed at the best speed circumstances permit, with cutting beginning in the decadent stands with the heaviest volumes. A plan to cover the property systematically should be made.

In general, the period allotted to removal of the undesirable components should not be more than 10 years. Although a gap in the

cutting cycle will often result, it will usually be false economics and poor silviculture to plan for any materially longer period.

If the volume of undesirable components is too great to be disposed of within a reasonable period, it is wise to postpone cutting some of the better unwanted trees until the second cutting cycle. In short, the worst should be salvaged first; this advice applies to stands as well as individual trees.

Where there is not enough material to meet the necessities of operation, plant capacity must be modified--or requirements met by purchase or trade. If these measures are not feasible, it may be justifiable to cut some of the desirable growing stock, but such cutting should be restricted as much as possible and should be concentrated on trees approaching the margin of maturity and quality. Such marginal growing stock may at times also be used to sweeten the cut in stands otherwise inoperable; but the forester should first assure himself that the silvicultural advantages of cutting in the stand more than offset the loss arising from the premature liquidation of desirable growing stock.

It must be emphasized that cutting of the desirable growing stock is always the very last expedient to be considered. If such cutting is done, it must be held to an absolute minimum. It will usually be better to suspend cutting entirely rather than to cut materially into desirable growing stock before rehabilitation is well along. For the purposes of sustained yield, such cutting is merely an insidious form of silvicultural suicide.

All this means that in the early stages of management the only material available for cutting is the accumulation of undesirable growing stock. Calculations of growth are therefore not pertinent to the early cuts. By their nature, the undesirable trees will provide little or no net growth, while the increment on the desirable trees must be retained for stand rehabilitation.

Unmanaged stands generally have a large component of trees useless for anything but firewood--that is, trees which are unsound, low-grade, malformed, and of weed species. The growing capacity of the average stand at present is reduced about 20 percent by these trees--one acre in every five is unproductive because unmerchantable trees preempt the space. Usually the only way to handle the problem is to girdle or poison such trees as rapidly as opportunity permits. Occasionally a good den tree should be left for wildlife propagation even though it is unmerchantable.

Marking for the First Cut

Marking a stand for the first improvement-harvest cut is a matter of selecting trees which should be cut from the standpoint of silviculture and which will pay their way. These trees should be selected for cutting on an individual basis, and no cutting should ever be done unless the stand is first marked. Each tree marked should be tallied by diameter class and merchantable height and classified according to the products for which it will be utilized. If the timber is to be sold on a log-scale basis or delivered to the owner's plant, there is no particular need for tallying trees as they are marked, except for the record.

In thinking of the stand in terms of its cutting needs, the forester will find it convenient to divide the trees into two classes--desirable growing stock and overburden.

Desirable growing stock includes all trees which, in the judgment of the forester, should be left for one cutting cycle or more. It includes trees that seem likely to grow to merchantable size and quality, as well as those now in this class.

Everything else is overburden--that is, trees unlikely to make a net contribution to the value of the stand over the estimated period before another cutting. Overburden trees range from rotten culls to highly merchantable trees that are ripe for harvest. Overburden trees may be overmature or decadent, or they may be taking up too much growing space. They may be suppressing or being suppressed by better trees. They may show severe damage from fire, wind, logging, rot, or insects, or may be of poor form, quality, or species.

In dealing with overburden, it is helpful to distinguish the cull component into two classes, sound and rotten. A sound cull is a tree so malformed or limby that if it is of saw-timber size it does not contain one 12-foot log of tie-and-timber class or better; or, if it is below saw-timber size, it cannot be expected to produce one such log through further growth. Rotten culls are any trees, originally growing stock, in which rot has destroyed at least 50 percent of the stem volume that would otherwise be usable. Rotten culls are wholly useless, but sound culls may have some slight utility.

The criteria that distinguish overburden are broadly those which determine selection for cutting under the conventional selection systems of silviculture, with special emphasis on present and potential merchantability. Species, utility, and quality are important as they bear on the economic desirability of the individual trees; and species, vigor, extent of injury, and competitive position in the stand must be considered as they affect silvicultural desirability.

Species.--Hardwoods are much more variable than softwoods in silvics and utility. In marking, the forester must always balance these two aspects against each other, remembering that growth capacity, form, tolerance, reproductive ability, quality, absence of defects, or adaptation to site may justify leaving a tree of a species of lower utility in preference to one of high species utility. A cow oak, for example, should not always be kept, nor should all bitter pecans be cut.

Utility and quality.--Whether or not a tree, or a log within a tree, is adapted to a given use depends on its soundness, species, and the nature of its defects. Thus large high-grade white oak logs are useful for tight cooperage, but very rough, sound white oaks are suitable only for cross ties or fence posts. No sweetgum, however large and clear, can ever be used for tight cooperage, though it is very desirable for face veneer and slack cooperage.

For each use or utility, there are factors of quality which are expressed by grade. The principles upon which hardwood utility and quality are based are not particularly difficult to grasp, but the use classes and log grades must be understood before a good selling job can be done. Especially in the run-down stands with which the forester will be dealing, neglect or ignorance of the principles of utility and quality will invariably cause difficulty and embarrassment. The principles of utilization are discussed in a later chapter, and the appendix lists the uses and characteristics of the various species. Information on recognition and interpretation of defects is also available.2/ Study of these references, coupled with observation and experience, should enable the forester to do a reasonably good job of evaluating utility and quality.

Vigor.--The vigor of a tree is a measure of its general health and its ability to respond to release. It is an indication of capacity to grow. Trees with insufficient vigor to live until the next cutting cycle should be cut, as should those which are growing in diameter at an unacceptable rate at the time of marking and which have no prospects of responding to release. Whether growth rate is acceptable will be determined primarily from the size of the tree and its quality.

Vigor can be recognized in the general appearance of the tree. Among the best indicators are bark characteristics: the color, luster, thickness, smoothness, texture, amount of fissuring, shape of ridges, and degree of scaliness or plating. The shape of the

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2/ Lockard, C. R., Putnam, J. A., and Carpenter, R. D. Log defects in southern hardwoods. U. S. Dept. Agr. Agr. Handbook 4, 37 pp., illus. 1950. For sale by the Superintendent of Documents, Washington 25, D. C., 25 cents.

crown; the color, luster, and density of foliage; the crown-stem ratio; presence of dead or dying branches in the upper crown; and relative proportion of fine, growing shoots compared to short, gnarly, or club-like branches are further indications of vigor.3/

Occurrence and extent of injury.--In many bottomland stands, most of the trees removed in the first managed cut will be injured trees. Injury or insect infestation not sufficiently serious to threaten to kill a tree or prevent it from increasing in value during the next cutting cycle is not in itself reason for cutting. However, the damaged tree should always be marked when there is a choice between competing trees which are otherwise similar.

Identification and evaluation of injury require on-the-ground observations. Of all the injuries, those resulting from past fires are by far the most prevalent. They are also more serious than all others combined. However, not all fire scars indicate that the value of the tree has seriously decreased or will decrease during the next cutting cycle. Mere presence of recent or incipient fire injury is not enough in itself to require marking.

Competitive position in the stand.--Competition among desirable trees is not ordinarily critical at the time of the first managed cut. Occasionally, however, the reason for marking a tree will be to improve the competitive position of a more desirable individual. For example, if a vigorous ash pole is being overtopped by an otherwise desirable soft elm of commercial size, the elm should be cut. Use of this criterion for marking requires judgment for which no specific instructions can now be given. Skill will come with experience. Rarely will thinning in the ordinary sense be a reason for marking much timber in the first managed cut in the bottomlands.

Applying General Prescription to Stand Classes

The foregoing general criteria for guiding the marking in the first managed cut apply to all stand classes. The details of their application and the effects vary by stand classes and the management needs of each class. The variations are reflected in the silvicultural results of the cutting and in the amount and kind of products. The variations which will be experienced in the various stand classes are summarized in table 2 (pages 20-21).

3/ For a method of determining whether growth rate is acceptable and for further information on the recognition of vigor classes, see: Guttenberg, Sam, and Putnam, John A. Financial maturity of bottomland red oaks and sweetgum. South. For. Exp. Sta. Occas. Paper 117, illus. 1951.

It should be recognized that the utilization opportunities will determine the manner in which the cuts visualized in table 2 are applied to the various stand classes. Generally, for the better stocked, more highly valued stands, there will be no difficulty; but the poorer in quality the stand becomes, the more difficult it will be from the standpoint of economics to follow through with the recommended silviculture. Table 2 assumes full utilization for all classes of material.

All kinds of usable material may be present in any class of stands, but for brevity's sake only those kinds which determine the feasibility of cut are specifically mentioned in the table.

Type Influences Treatment

For the sweetgum-water oaks, white oaks-red oaks-other hardwoods, and riverfront hardwoods types, the three most widespread and most variable types in tree size and species composition, table 2 applies without qualification. The main variations from the table occur in the group of types which is restricted in tree size distribution and species composition and also in the group which is restricted in species composition only.

Treatment of types tending toward single species and single age or size class

This group, which comprises about 25 percent of the bottomland forest area, includes the following types or variations. All except the cypress-tupelo are temporary types.

1. Cottonwood
2. Willow
3. Cypress-tupelo
4. Sweetgum-water oaks, predominantly sweetgum variation
5. White oaks-red oaks-other hardwoods, white oaks variation
6. Hackberry-elm-ash
   a. Pure ash variation
   b. Pure hackberry variation
7. Riverfront hardwoods
   a. Pure sycamore variation
   b. Pure silver maple variation

Table 2.--Stand classes: their characteristics and nature of the first commercial improvement cut

Stand class	Nature of stand and products	Cutting objectives	Cutting priority	Silvicultural results of the cut
I. Heavy saw timber (8,000 bd. ft. and more per acre)				
a. 50 percent or more of the volume in trees 23 inches d.b.h. and larger	Largest and best trees usually overmature. Products mostly factory and veneer logs.	Harvest of mature timber, salvage of overmature and damaged trees.	Highest; large values at risk, highly operable.	Sparse residual stand, often good in thrifty groups.
b. Less than 50 percent of the volume in trees 23 inches d.b.h. or larger	Skilled cutting especially desirable, as this class has best possibility of early formal management. Factory logs predominate, but great variety in size and utility of products within and between stands.	Normally stand improvement and release; occasionally salvage; secondarily harvest.	Medium; high if damaged.	Good residual stand except where much timber is overmature and damaged.
II. Medium saw timber (3,500-8,000 bd. ft. per acre)				
a. 50 percent or more of the volume in trees 23 inches d.b.h. and larger				
1. Adequate supporting stand	Large trees--mostly residual old growth; overstory often seriously obstructing promising second growth. Factory logs of many sizes but mostly of medium to poor quality.	Harvest, salvage, stand improvement, release.	High; strong salvage considerations and early possibility of developing sustained yield. Highly operable.	Fair to good residual stand, scattered or in groups.
2. Same as above, but inadequate supporting stand	Saw-timber overstory usually in very poor condition from same causes that damaged or eliminated understory. Products largely factory logs of good size but medium to poor quality; also considerable tie-and-timber logs. Species composition often poor.	Harvest, salvage, stand improvement.	High; next after class I-a because of urgency of salvage and desirability of promoting reproduction.	Sparse residual stand in need of regeneration.
b. Less than 50 percent of the volume in trees 23 inches d.b.h. and larger. Supporting stand will be present.1/	If undamaged, fair chance of sustained yield after first cut. Factory logs medium to poor in size and quality and often only a small majority of total. Tie-and-timber log volume large, sometimes good deal of bolt stock and pulpwood.	Stand improvement, release, occasionally salvage.	Low; small values at stake. Further development will greatly increase operability. Medium priority if damaged.	Good residual stand unless original stand had heavy early damage or sparse understory.
III. Light saw timber (1,500-3,500 bd. ft. per acre)				
a. 50 percent or more of the volume in trees 23 inches d.b.h. or larger				
1. Adequate supporting stand	Cut will usually be near minimum operable volume. Products will range widely in size and quality, but saw timber predominates, running half factory logs, half tie-and-timber logs. Very desirable to integrate saw timber with other uses.	Harvest, salvage, stand improvement, release.	Low; small value involved, and hard to market the products. Medium priority if of maximum volume and seriously damaged.	Good to sparse residual stand, depending on damage and development of supporting stand.
2. Same as above, but without supporting stand	Stands mainly residual old growth following heavy cutting and repeated burning or grazing. Products chiefly sawlogs, about half factory and half tie-and-timber.	Harvest and salvage; stand improvement incidental.	Lowest or next to lowest; values small and reproduction usually comes in with protection. Medium priority in rare instances when salvage at stake.	Sparse residual stand needing reproduction.
b. Less than 50 percent of volume in trees 23 inches d.b.h. or larger. Supporting stand will be present.	Only the best such stands are operable. Sawlogs; often runs strongly to tie-and-timber logs, but all products usually occur in substantial amounts. Integrated operation generally imperative.	Stand improvement, release, harvest, salvage.	Lowest of any saw-timber stand, as products hard to market, low values at stake, and saplings and poles usually develop satisfactorily for time being if left alone. Need for salvage or existence of markets raises priority.	Good residual stand.
IV. Heavy pole stand (more than 175 trees per acre 5 to 11 inches d.b.h.	Stands are mainly even-aged. Excellent chance of early formal management if not seriously damaged. Products almost entirely pulpwood and chemical wood, rarely piling or low-grade local-use sawlogs.	Thinning and stand improvement; occasional salvage.	High if not badly damaged; then low because of low present values.	Excellent young residual stand with great possibilities.

1/ Rarely a medium stand of saw timber with less than 50 percent of volume in trees 23 inches d.b.h. or larger may be encountered without a supporting stand of small trees. If it occurs, treat as "medium saw timber (large) without supporting stand" if the stand volume is in the upper range of its class; treat as "light saw timber without supporting stand" if stand volume is in lower range of its class.

Table 2.--(Continued)

Stand class	Nature of stand and products	Cutting objectives	Cutting priority	Silvicultural results of the cut
V. Light pole stand (less than 175 trees per acre 5-11 inches d.b.h.)				
a. With supporting stand of saplings	One of commonest conditions. Products mainly low-grade cordwood and posts, occasionally traces of low-grade, local-use sawlogs.	Mainly stand improvement and release; occasional salvage.	Medium.	Sparse residual stand but established reproduction has good future.
b. Without supporting stand of saplings	Same as above.	Stand improvement, occasional salvage.	Lowest of any condition. Generally little can be done except to get regeneration.	Very sparse residual stand. Reproduction badly needed.
VI. Saplings and seedlings (at least 250 trees per acre)	Low-grade cordwood, traces of saw timber, largely low-grade, local-use logs. Total too light for commercial operation.	Release and stand improvement.	Very low. With protection will usually develop satisfactorily for time being.	Reproduction promising.
VII. Non-stocked (all potentially productive conditions)	No produce, except perhaps a little low-grade local-use material.	Elimination of undesirable seed source and clearing as site preparation.	Generally cutting is not essential.	Elimination of undesirable seed source.

The cottonwood, willow, and cypress-tupelo types, and the pure ash variation of the hackberry-elm-ash type should be handled on an even-aged basis. The others may be handled either as even-aged or all-aged stands, depending on management objectives. In uneven-aged management, it will not be possible to maintain pure stands, as more tolerant species will invade. Skillful management, though, can maintain predominance of the desired species. Generally, the stands in these types are pretty well stocked with trees of fair to good quality. Because of these silvical characteristics, stand treatment will tend toward thinnings as a basic approach, rather than the salvage or improvement cutting that dominates the approach in the major types, which usually have larger proportions of damaged and malformed trees.

In the rather rare instances where heavily stocked overmature cottonwood stands are encountered, the best approach is to clear-cut, with the expectation of natural regeneration by other riverfront hardwoods. In younger cottonwood stands, it is well to anticipate the ultimate replacement of the type by more tolerant species. Intermediate cuts should be planned to maintain optimum growth of the residual cottonwood and at the same time encourage establishment of the succeeding stand. By the time the final cut of cottonwood is made, an adequate understory of acceptable species should be ready to take over the site.

Special attention must be paid to the immediate management of willow stands. Willow grows very rapidly and does not assert dominance. This means that in normally well-stocked stands thinnings must start just as soon as they are economically feasible and must be continued at intervals of about 5 years. Thinnings should be from below. In unmanaged willow stands, as much as half of the volume may be lost from competition in 5 to 8 years.

For the white oaks variation, special handling is desirable if the type is to be maintained. Treatment will emphasize stand improvement or cleaning directed at eliminating undesirable species like hickory, red oak, and winged elm. Because of the gap in seed years and the fact that the oak mast is especially palatable to animals, cutting should be gaged insofar as practicable to coincide with heavy seed years, which occur, on the average, every 6 to 8 years.

If young stands of sycamore and silver maple are to be developed satisfactorily, cleanings are usually needed to remove invading box elder and inferior individuals of hackberry, soft elm, and sweet pecan.

As a general circumstance, except for cypress-tupelo, special pre-harvest measures such as weeding and site preparation will be necessary to regenerate all these types and variations, and planting

will ordinarily be needed for the cottonwood type. However, the mixed types which normally succeed these types are usually fully satisfactory for management objectives.

Treatment of types limited as to species composition but variable as to tree size or age

These types and variations are characterized by a lack of variety in species composition. They are usually all-aged by groups and they occupy about 35 percent of the bottomland area. Generally, the species distinguishing the type or variation make up at least two-thirds of the volume. In many instances, all of these except the water oaks variation have been derived from better quality types by repeated excessive cutting plus fire. The stands are usually light and occupy the poorer sites or abused favorable sites.

Cutting in these types or variations should accent harvest or salvage aimed at stand improvement. Wherever the local site permits, the objective should be to convert to more productive types; otherwise, the forester should endeavor to improve the quality of existing types. Almost without exception, drastic stand improvement measures are essential to direct the silvicultural trend properly.

This group includes:

1. Overcup oak-bitter pecan

2. Hackberry-elm-ash

3. Sweetgum-water oaks
   a. Water oaks variation
   b. Cedar elm-water oaks variation

The sites occupied by these types and variations are the most susceptible in the bottomlands to the invasion of buckvine. As well-established buckvine is the one form of ground cover with which tree seedlings cannot compete, it must not be allowed to start ahead of the trees. To avoid preemption of the sites susceptible to buckvine invasion, openings created by cutting must be seeded promptly. This can only be attained by maintaining a desirable and adequate seed source. Fire protection is absolutely essential, for fire encourages the spread of buckvine by killing other vegetation and promoting the sprouting of buckvine. Where buckvine is already densely established, stand improvement is futile. Such areas will require development of special treatments to eradicate the buckvine.

Heavy stand improvement is usually needed in these types or variations. Achievement of such improvement by stages is recommended, both because it avoids opening the stand excessively at any one time

and because it usually fits in best with the landowner's desires. In order to improve species composition, cull trees of the better quality species should often be left for seed. Priority in treatment should be given to areas where results are likely to be pronounced and immediate.

Handling Unmerchantable Components

In each and every stand class there are some overburden trees that cannot be marketed. The amount and percentage of this material is determined by the kind, utility, and quality of the stand in relation to the markets available or anticipated. The younger and poorer the class of stand and the poorer the markets, the greater the difficulty; but even in the best quality saw-timber stands the problem is present. To place the stand in the best condition for future growth and development, money or effort must be expended to kill unmarketable trees, even though they are large enough to have commercial value if a local market existed. The handling of this unmerchantable portion of the overburden then becomes a job distinct from the commercial operation.

In young stands and in low-quality stands, the job is bigger in proportion to the total management job than in the older and better stands. No greater skill is required in these stands, but the higher percentage of non-saw-timber overburden increases the difficulty.

It is fully recognized that a silvicultural investment (a current cost not currently offset by sales) rarely appeals to a landowner. The question of how large an investment is justified must be worked out on the ground independently for each situation, bearing in mind that in any case future benefits must exceed costs to justify the investment.

Removing the unmerchantable overburden

It is usually best to mark the unmerchantable trees that are to be eliminated after the commercial operation is completed. The marking will be influenced and limited by the investment per acre which the landowner is prepared to make. It may remove all the unmerchantable overburden, or it may be a light treatment which liquidates only those trees that are most harmful to the stand and which covers only the areas most in need of improvement. Some degree of selective treatment, relating prospective benefit to cost, will attain the greatest return on the investment. At the present stage of bottomland forestry, more often than not, the treatment will be partial rather than complete.

Unmerchantable overburden trees can be removed by felling, but deadening on the stump, by girdling or poisoning, is cheaper. Effective girdling requires complete severance of the cambium (often with a deep notch into the sapwood), and when trees are under 10 to 12 inches in diameter, profuse sprouting may follow. Poisons have the advantage of greatly reducing sprouting. Use of "Ammate" (ammonium sulfamate) crystals applied in notches at the base of the tree, or Ammate solution in frills at breast height is very effective in the uplands.4/ This treatment has not been adequately studied in the bottomlands and it deserves further check. Sodium arsenite is a very effective poison to bottomland hardwoods when applied as a solution in frills.5/ However, because it is highly toxic to man and animals it is hazardous to use. New information is constantly becoming available on the use of chemicals, and the forester should acquaint himself on the status of knowledge immediately before undertaking any poisoning work. On the whole, it now seems that application of one of the poisons in a frill will ultimately prove to be the most economical method and probably will be sufficiently effective.

Cautions to observe

In applying stand improvement measures, care should be taken not to open the crown canopy to the point where buckvine takes over the site or undue epicormic branching occurs. The latter phenomenon may not be very important, but the dangers should not be overlooked.6/ Additional research is needed on this problem before specific instructions can be given.

Obviously, it is important that all markets be explored before any trees are deadened. In view of the complex nature of hardwood utilization and markets, this undertaking challenges the ingenuity, imagination, and energy of any forester. A thorough familiarity with utilization in relation to management is required. This subject is discussed in the section to follow.

4/ Peevy, Fred A. How to control southern upland hardwoods with Ammate. U. S. Dept. Agr. M-5296, 7 pp., illus. 1949.

5/ Maisenhelder, Louis C. Poisoning of bottomland hardwoods. Miss. Agr. Expt. Sta. Cir. 139, 7 pp., illus. 1948.

6/ Jemison, George M., and Schumacher, F. X. Epicormic branching in old-growth Appalachian hardwoods. Jour. Forestry 46: 252-255. April 1948.

Wahlenberg, W. G. Epicormic branching of young yellow-poplar. Jour. Forestry 48:417-419. Sept. 1950.

INFLUENCE OF UTILIZATION ON MANAGEMENT

The fundamentals of utilizing and marketing hardwoods conform to very definite patterns and customs which are unique in themselves and quite different from the pattern for softwoods. This point is emphasized at the start because the factors associated with softwood utilization are those that have usually guided the forestry profession in the relation between utilization and management. The differences between hardwood and softwood utilization exist in all hardwood types, but the greatest contrasts are found in the bottomlands.

PECULIARITIES OF HARDWOOD UTILIZATION

Bottomland forests are characterized by a great variety of species and by great variation in quality and form of trees and logs within species. Since the species have markedly different inherent utility, and since the variations in quality and form further influence utility, it is apparent that a great many uses are possible for the products of a forest.

Ten or twelve species, ranging from sweetgum to almost worthless rock elm, may be found on a single acre. One sound sweetgum may produce high-quality veneer logs, while another nearby will yield at best only low-grade crating lumber. Often whole trees, because of small size, crookedness, or defect, will cut out only bolt, post, and cordwood material. Portions of sawlog trees will have similar limited utility. Within each use-class of material, there are gradations in quality which can be segregated into groups of like adaptability or grades. Understanding of the utility classes, and the grades within them, and recognition of what these requirements and specifications mean in applied forest management are essential skills for the bottomland forester.

Utility Classes

Despite their heterogeneity, the uses of bottomland hardwoods fall into five broad classes of logs and round products. These utility classes can be consistently recognized in standing timber. Ranged in order from the lowest to the highest in value, they are:

1. Fuel wood
2. Pulp and chemical wood
3. Posts, props, and piling

4. Bolts, including some 8-foot logs
   a. Common stock, suitable only for boxing, crating, blocking, and the like
   b. Quality stock, suitable for small dimension, veneer, cooperage stock, and specialties

5. Sawlogs
   a. Local-use logs
   b. Tie-and-timber logs (logs for any standard structural lumber)
   c. Factory lumber logs (covers all industrial uses requiring broadly similar round timber: e.g., slack cooperage stock, and package and commercial veneer)
   d. Face veneer and tight cooperage logs

The huge variations in utility bring about corresponding variations--much greater than are ever seen by pine forest managers--in the demand for and value of the products from a bottomland forest. Logs for face veneer may sell for several hundred dollars per thousand board feet, while local-use logs may not justify the expense of manufacture.

For the higher uses, the requirements and specifications are very exacting. Frequently they are based on appearance, as with furniture and face veneer. For other products, such as handles, great strength and other technical qualities may be the determining characteristics.

Grades

Formal grades have been developed only for factory lumber logs, and even here they have been in use for such a short time that they are not widely applied. For all classes of material, however, very important grading processes based on local experience and judgment do take place.

Fuel wood.--Although it is stretching a point to describe them, experience and custom recognize informal fuel wood classes or grades which influence the sale price and acceptability of the wood. The heavier species such as oaks and hickories make the best firewood, whereas light species such as hackberry, cottonwood, and willow are less desirable. Size, straightness, soundness, and ease of splitting are also recognized as affecting value.

Pulpwood and chemical wood.--Though actual value is known to vary greatly, there are no grades for pulp or chemical wood except "acceptable" and "unacceptable." Specifications as to species, size, form, and soundness make this division. There is great diversity in local specifications.

Posts, props, and piling.--The main volume of use here is for posts. Local post specifications vary greatly. For props and piling, commercial specifications are established and well observed.7/

Bolts, including some 8-foot logs.--Although local custom and trade recognize and follow specifications for bolts, no standard grades have been established.

Sawlogs.--There are no standard grades except for factory lumber logs, but veneer log specifications having the practical effect of grades are commonly applied independently by the various buyers.

The standard grades for factory lumber logs were developed by the U. S. Forest Products Laboratory.8/ They are based on the proportion and arrangement of clear (defect-free) space on the log surface. The grades are designed to permit sorting logs into groups based on their grade yield of lumber (by National Hardwood Lumber Association grades). The proportion of clear cuttings which can be obtained in remanufacture is the basis for grading the lumber and in turn the real basis for grading the logs.

This principle contrasts strikingly with grading softwoods. The difference lies in that hardwood lumber is commonly destined for remanufacture into articles of beauty or technical utility, while a piece of softwood lumber is regarded primarily as a final product or structural unit. This difference means that defects, including knots, for the two kinds of lumber are regarded and handled very differently. Any imperfection or blemish in hardwoods limits a clear cutting and is therefore a defect.9/ This is true regardless of the size or soundness of the defect, and distribution of defects is more important than their number, size, or character. In softwood lumber, the seriousness of the imperfection depends on its size and character--that is, whether it will weaken the piece. Number and distribution of defects are much less important.

7/ Standard specifications for round timber piles. Designation D 25-37, American Society for Testing Materials, 260 S. Broad Street, Philadelphia 2, Pennsylvania.

8/ Hardwood log grades for standard lumber: proposals and results. U. S. Forest Products Laboratory No. D1737, illus. 1949.

9/ See pages 3 to 5 in "Log defects in southern hardwoods," cited in footnote 2, page 17.

The local grades or customs and practices in regard to veneer and stave logs all depend on the same basic principle as the grades for factory lumber logs, namely, the proportion of clear cuttings that can be obtained from the log.

Standard classes and grades for local-use and tie-and-timber logs have never been developed. When they are prepared they will be based primarily on the principles followed in grading softwoods, rather than those used in grading hardwoods. Defects in logs of these two classes are recognized and regarded essentially as they are in softwoods.

CORRELATING MANAGEMENT AND UTILIZATION

The foregoing fundamentals of hardwood utilization have a decisive effect upon the intensity of management which can be practiced. For material that meets the requirements of the higher uses, no particular marketing or utilization problem exists. In operable stands containing factory lumber logs and better products, the management prescriptions outlined earlier can be followed with comparative ease.

Difficulties increase as the proportion of the lower utility classes in the stands increases and the volume of the higher classes decreases. Market limitations may first exclude the smaller sizes and less desirable species of factory logs but are not ordinarily serious for this class of logs. By and large, the limitations become more serious in tie-and-timber logs, and are extremely serious for all local-use logs and non-sawlog material. The exact utility and quality level at which the problem becomes acute varies greatly from place to place and time to time and may be expected to decline generally, but even when lower class products can be sold at some profit, it will always be easier and more remunerative to sell the higher utility classes.

The Need for Integrated Utilization

It is estimated that not over a third of the present bottomland forest area is operable for factory lumber logs, even under cutting practices which disregard the need for conserving the growing stock. If cutting is restricted to the overburden, as it should be under management, perhaps only about 25 percent of the area can readily be given a commercially profitable cutting for factory lumber logs. Or, in reverse, three-fourths of the area, of which a large proportion has some saw timber, will not support a cutting (solely for this product) that is both silviculturally sound and commercially profitable.

To a limited extent, stands without an operable factory lumber log component are being worked economically for other saw-timber products such as cross ties. Such operations, if properly directed, can be very favorable to silviculture. In the main, however, over much of the bottomland area, good silviculture depends largely upon removal of classes of material that cannot be manufactured at a profit under available markets.

As operable sawlog stands offer an immediate opportunity for applied silviculture, most commercial management can and will begin in such areas. It is in the marginal stands, however, that the forester's skill in utilization will determine to a great degree whether bottomland hardwood management is practical. The only alternative to utilization is an outlay for stand improvement work, but the greater the need for such work, the less attractive it seems as an investment, even though it may be perfectly sound on a long-term basis.

Some system of integrated marketing seems the soundest approach to hardwood silviculture. No single class of utilization will result in maximum volume utilization and maximum value return at the same time. Sale of the entire usable content of the stand for a single use would be possible only if all the material went into the lowest use class involved, but this procedure would sacrifice values in the higher classes of material. On the other hand, selling the stand for the highest class of material present in substantial proportion leaves unutilized much of the total volume in lower class wood. By putting each class of material to its highest use, integrated marketing would make it possible to manage stands profitably which otherwise would be uneconomical to operate. It would also put the maximum area under the forester's direction and care. In working out management plans and techniques, therefore, the forester should take every opportunity to develop an integrated market which, insofar as possible, will carry over to an integrated operation in the woods.

In general, the development of such a market will hinge on two things. First, it will depend on the existence, within a given territory, of industries which compete with each other for wood, but whose total raw-material requirements include all utility classes of timber insofar as possible. The second requirement for an integrated market is the development of a class of log and timber jobbers to act as middlemen catering to this diverse industry.

Current Utilization Practices

Several features of customary utilization practices relative to the use of hardwood timber should be recognized in planning for management. These are discussed briefly by classes of materials.

Fuel wood

This is one of the two or three principal uses of round timber. Although substantial amounts are sold in most towns and small cities adjacent to bottomland stands, it is handled almost entirely by unorganized, individual, part-time enterprise. Most of it is cut on farms and plantations, with little or no regard for possible higher uses of the trees or of the silvicultural consequences. Near well-settled agricultural communities, the actual and potential effects on the forest are tremendous for better or for worse. Methods of production, distribution, and use are archaic and the ultimate in inefficiency. Improvement might help make this use a most constructive silvicultural tool.

Pulp and chemical wood

A small volume of a few species is used for pulpwood, but such use is erratic and spotty as to time and location. A common practice is to clear-cut promising young stands of lumber and veneer species. With the probable expansion of the dissolving pulp industry using southern hardwoods, there is hope that proper pulpwood utilization may become of real practical benefit in expanding bottomland hardwood utilization and in turn favorably affecting management. Utilization of chemical wood is similar but much less extensive, and its future appears dim.

Posts, mine props, and piling

Most of the firm, tough species that produce reasonably well-formed stems are used on occasion for piling. However, this use is generally on such a small scale, and so local and sporadic, as to be of little significance. Whether it could be developed is questionable. Mine prop use depends more upon proximity to the mines than upon forest type or species, and very little bottomland forest is well situated in this respect.

Posts are the important item under this heading. Both durable and non-durable species are used widely--so much, in fact, that the supply of durable species for post making is about exhausted in most stands accessible to agricultural communities. Most non-durable species can be given preservative treatment by simple methods adapted to domestic and local production.

Post production and use presently is on about the same slipshod, wasteful basis as fuel wood production and closely related to it. The possibilities of organizing it to the great benefit of silviculture are very substantial.

Bolt stock

A common or merely sound grade of bolts, generally 10 inches in diameter and larger and 4 feet (or sometimes even less) up to 8 feet in length, has limited use for boxing and crating, low-class slack cooperage, and cross ties. Most bolts, though, are cut from logs of standard length. The industries which buy bolts are rather localized, tending to individual specialization, including such odd items as tie plugs and paper plugs. The largest and most generalized use is for fruit and vegetable crating, with the amount, kind, and quality of crates closely tied to the agriculture of the local area. Low-quality wood suffices for such stock, but cutters take whatever suitable timber they can find.

Quality bolt stock is used for a great variety of items from lollipop handles to high-grade veneer. Sizes, specifications, and species vary with the product. Bolts are made down to 10 or 12 inches in diameter, if of excellent quality, and down to 30 inches in length; first-class ash, hickory, and persimmon may go down to 8 inches in diameter. The material is frequently taken out of the woods in log lengths.

Veneers, small dimension, implement and athletic goods, handles, both slack and tight cooperage, and textile equipment are important items produced from quality bolts. Most of the timber used is cut into standard logs, but some high-quality material that will not yield standard logs because of small size, or sweep, or inherent short length is harvested and used as bolts. These uses are widely but thinly spread, and log procurement is coming to be integrated with the lumber operation to some extent. The markets are rather specialized and spotty.

Sawlogs

Local use.--The lowest class of sawlog, the so-called local-use log, actually has two broad classes of use. The first is the strictly local, domestic, farm use. The other is production of low-class, local material such as foundry crating and car blocking, sawed mine timber, and ungraded building material for local retail sale. Although users cut whatever and as good timber as they can get, the bulk of their needs requires only that logs produce items that are essentially sound. Considerable waste is permitted in reworking for final use. The minimum specifications for this class of logs admit material which is economically submarginal for either factory lumber or standard structural items.

Local uses are well established and traditional, but only within agricultural communities or near industrial and mining centers. The use has been largely disorganized, inefficient, and in such small volume that the impact on timber supply is very localized. Considering

the present trend in cost and utility of softwood lumber, however, it should be possible to expand and organize this type of production. If cutting is properly done, great silvicultural benefit could be realized by harvesting trees that are too poor for factory lumber logs or tie-and-timber logs.

Tie and timber.--Tie-and-timber logs are the lowest class of logs suitable for standard products handled in organized commerce. In addition to heavy structural timbers and ties, this use includes some commercially graded construction boards and smaller timbers. Production of this light material is in the pioneering stage and is still small in volume and inherently confined to the soft-textured woods. Development of future markets for this light structural stock offers a novel opportunity for any branch of the hardwood lumber industry, especially where the haul to consuming centers is short.

Production of heavy oak and gum timbers and ties is a long-established, distinct branch of the hardwood industry. Increased output of hardwood timbers and improved integration with the lumber industry is practicable and would aid in solving the problem of harmonizing utilization and management.

Factory lumber.--As has been stated, this class offers no particular utilization problem.

Face veneer, tight cooperage, and specialty.--These very high-class special-use logs represent broadly an extension and intensification of the same principles and considerations applicable to factory lumber logs. The demand generally exceeds the supply, especially since lumber and even lower use classes encroach upon the supply to a great extent. Profitable sale of such material is seldom any problem except as economic handling and concentration of scattered small lots of it are involved. Rarely are present-day stands exploited for these uses alone (except tight cooperage), for stands containing more than a few scattered trees of suitable size and quality are few and far between. Integration of face veneer and specialty log production with factory lumber log cutting is fairly good.

REGENERATION

NATURAL REPRODUCTION

In most of the bottomland forests, natural reproduction is normally adequate and dependable in amount, quality, and species. To foresters whose experience has been mainly with pine, however, or in the northern part of the country, it will probably seem that reproduction is too sparse throughout the forest, and that nearly all open areas are a hopeless snarl or jungle of weeds, vines, and brush.

Conditions for Securing Natural Reproduction

Except for a limited number of species such as hackberry, mulberry, and the elms and hickories, which are mostly of secondary importance or even undesirable, the important bottomland hardwood species are intolerant of shade. Hence advance reproduction is rare, and even depleted stands will have young stock only in openings large enough to allow direct sunlight to reach the ground for most of the day.

A few species, especially the water oaks, will germinate in very dense patches in temporary shallow pools of water beneath a complete canopy, but the seedlings invariably die within 3 years unless they are released. Others, like the ashes and the other oaks, germinate sparsely and develop for some years as scattered individuals in partial light in small openings. But without release they dwindle away before reaching pole size. Release of such advance reproduction is often one of the chief benefits of removal of the overburden.

Water, standing or moving, prevents establishment of reproduction whenever it submerges seedlings during their active growing season. While dormant, the species native to sites subject to flooding are very little affected, even when completely under water. If they are submerged in advance of the growing season, some will stay dormant longer than usual and will begin growth after the water goes down. It appears that cypress at least will endure in this manner far into the growing season. After the buds open, no species but willow can stand having its foliage submerged for more than a few days.

The frequency, depth, and duration of flooding chiefly determine the restocking of lowland areas. Regeneration will probably fail if floods regularly occur during the growing seasons at shorter intervals than are required for seedlings to grow above the average depth of inundation. In some places, floods will prevent establishment of

some species but recede in time to favor species which leaf out late. This, probably more than any other factor, accounts for the location and development of the cypress-tupelo and overcup oak-bitter pecan types.

Shallow water every year can be as detrimental as deep water less frequently, and may be more selective as to species, probably accounting for the cypress-swamp blackgum type. In swamps where water usually stands throughout the growing season, regeneration will be delayed until a rare year or succession of years occurs when conditions are favorable for establishment. The backwater basins, being the most frequently flooded areas after the swamps, are nevertheless among the driest in fall and are especially subject to widespread fires. A burn results in a reversion to buckvine rather than tree reproduction, because buckvine has superior sprouting capacity and tolerance to flooding.

Any cattle grazing is more or less incompatible with hardwood regeneration, and, in the smaller bottoms especially, cattle have been a major influence in preventing hardwood regeneration. Very light grazing, comparable to a normal stocking of deer, might not be serious, but the best practical advice is not to allow grazing except in very special controlled situations.

Hogs probably are of more benefit than harm to regeneration, except where conservation of oak mast is urgent. There is a possibility, still untested, of using cattle or goats to eradicate buckvine and other ground cover detrimental to regeneration.

On the great bulk of the forest, the soil itself has little bearing on reproduction. Where coarse, loose sand lies at the surface or under a thin veneer of fine material, however, trees will fail because the summer water table is normally too deep to deliver moisture through the sand. Such sites are limited in area. They are important probably only in the Mississippi Delta, principally between the levees.

The very fine-textured clay soils of the lowest backwater flats and occasional hardpan basins of the terraces generally have sparser stands than more porous sites and remain bare longer except for the typical thickets of poor willow ("pin") oak on the latter sites. Because of the texture of the soil, the fertility and moisture on these sites are unfavorable for reproduction except of willow oak on the terraces.

Similar soils with better elevation or subsurface conditions accumulate enough organic matter to crumble nicely when exposed to air, absorb and release moisture freely, and provide enough nitrogen for most plants. When these soils are cleared and cultivated, or overrun by repeated hot fires and exposed to the sun, the humus disappears and the sites become dry and puddled to rock-like hardness, incapable of

growing anything but weeds like goldenrod, at least for many years. Locally these are known as "buckshot" soils, and they have little immediate promise for forest regeneration. This is a very particular and relatively limited condition.

The most serious cause of inadequate reproduction is fire. A fire on any given area every 10 years will prevent its restocking to good trees. Prescribed burning has no place in bottomland regeneration.

Regeneration in Specific Types

The foregoing remarks apply broadly to all bottomland types, but a few types and variations of types have peculiarities that require brief description.

Cottonwood and willow

Cottonwood and willow demand absolutely bare, moist, mineral soil for germination and for at least the first few weeks of growth. Even light, low, ground cover competition, especially sod, greatly hampers growth. At no time will these species tolerate any overhead shade, even from weeds. They will, however, endure long flooding and silt deposition, though only willow survives complete inundation during the growing season. Cottonwood and willow stands are normally extremely dense and development is very rapid, averaging 5 feet of height growth per year for 10 to 15 years. Cottonwood asserts dominance promptly, allowing the better trees to get ahead, but willow stagnates early.

Site clearing and ground scarification would be necessary to make either species succeed itself, and even then success would further depend on appropriate flood stages or an unusually rainy summer. Usually it is preferable to allow mixed riverfront hardwoods to come in as the natural succession to cottonwood and willow. Generally the only work needed to secure a good stand of mixed hardwoods following cottonwood and willow will be eradication of box elder, large vines, and sound cull hackberries, elms, and pecans as they develop under the cottonwood.

Cypress-tupelo

This type will regenerate only in swamps where all competition is eliminated and ground cover is limited to annual herbs.

Regeneration is seriously hampered by three factors. The first of these is fire. When the swamps dry out, the rank vegetation burns furiously, and the species themselves are unusually

vulnerable to fire damage. The second obstacle is the tendency of cut-over swamps to fill up with planer tree, buttonbush, and similar shrubs.

The last obstacle is water. No seeds can germinate under water. Cypress submerged while still dormant will remain dormant far into the normal growing season. When the high water customarily lasts far into the summer, early growth will be extremely slow. After the tree has grown above normal high water, however, it will develop rapidly if fire and competition are eliminated. A copious seed supply is essential to offset the hazards of submergence. A few days' submergence while the tree is in leaf is fatal.

Tupelo and blackgum are a trifle less demanding than cypress. As soon as high water goes down, they leaf out and rapidly run up an unbranched shoot, which gets above high water stages within two or three growing seasons. In shallow swamps, regeneration of these two species is fairly sure and prompt, barring fire and competition. In deep swamps, however, even with protection, site clearance, and ample seed, regeneration depends on water stages so low that they may occur many years apart. The shallow but relatively permanent coastal swamps pose an essentially similar problem for which there seems to be no solution but time and an ever-ready seed supply or else artificial control of water stages.

Like cottonwood and willow, this type is typically even-aged by species, and distribution of stands of any given age class within the swamp is often governed or arranged by water depth or contour. These conditions result in distinct two- or even three-storied effects by groups.

Overcup oak-bitter pecan

This type takes over backwater flats and sloughs commonly flooded for a few weeks after the general growing season begins. Because its principal species, including persimmon and green ash, remain dormant and leaf out a month or so later than most species, they endure submergence better. It is lack of competition rather than affinity for these sites that brings them in. Given the chance, they do better on sites with superior drainage and soil texture.

The effects of floods and the manner in which seed collects on low spots as water recedes make reproduction spotty and periodic at best. Except on the very lowest sites, where buckvine does not normally occur, there is great risk of developing a hopeless mat of buckvine through delayed regeneration coupled with fire. Successful regeneration depends on complete fire protection and improvement cutting to the greatest extent consonant with saving an adequate source of seed.

Sweetgum variation and white oaks variation

These variations (of the sweetgum-water oaks and the white oaks-red oaks-other hardwoods types respectively) were common in the virgin forest, but seem unlikely to reproduce naturally even in the rare situations where they still remain. Regeneration would require almost complete opening of the stand, prolific local seedfall, and absolute control of fire and grazing. Generally the most satisfactory course may be to let the main type reproduce in its own fashion and then develop high proportions of these species by favoring them in the course of harvest cutting and stand improvement.

Early Development of Reproduction

Given a seed source and freedom from fire, most openings in the hardwood forest will regenerate. The sunlight that is necessary for seedling growth, however, also induces a jungle of weeds, vines, briars, and brush so thick that individual desirable trees, though numerous, must be searched for amongst the welter.

Such brush-patch beginnings are typical of most bottomland species and forest types. Unless the seedlings are thick enough to form a complete cover in themselves, they apparently must use the jungle as a nurse crop. The need seems to be for enough low cover to prevent baking or puddling of the soil, or the formation of sod.

Close examination of the average brush patch will reveal seedlings and small saplings in numbers between a few hundred and two or three thousand per acre. Many of these young trees will be seemingly overwhelmed by ground cover, as many as two-thirds may be of undesirable species, and half may be crooked, forked, bushy, or suppressed.

Nevertheless, within a few years after the area appears the most hopeless, a very promising stand of saplings emerges and the jungle melts away under its shade. Such sapling stands generally contain between 400 and 1,200 well-established trees per acre, the majority dominants and codominants of desirable species and form. At this stage, moreover, the better species and the best-formed trees tend strongly to grow the most vigorously and to assert dominance, and hence to suppress many of the undesirables.

This is not to say, however, that if fire is kept out optimum growing stock is assured. If left to nature, the resulting pole stand will often fall considerably short of realistic possibilities; much productivity will be wasted on inferior stems. Nearly always a release and cleaning will be highly desirable at the small pole stage, when products may be merchantable or useful for cordwood, posts, or mine props.

PLANTING

The dependability of natural regeneration makes planting largely unnecessary. This is fortunate, for it would be difficult and costly in the bottomlands. To date very little is known about planting any tree but cottonwood. Except for this species, which can and should be planted on adaptable sites, no field-scale planting can be recommended at the present time.

STABILIZED MANAGEMENT

For the first managed cut, no detailed plan for regulating the amount of cut on the property as a whole, or on individual compartments, is essential. Before a second cut is made, however, a management plan should be prepared. It may not be very intensive or rigid, but it should systematically cover the property with a budgeted cut. From the preliminary survey and the experience of the first cut, the establishment of compartments should be made final. From an inventory of these compartments and from other data, the possible yields, consistent with growth estimates and long-period management plans, can be estimated. All supporting data and instructions for cutting and other operations should be incorporated into the management plan.

As few bottomland forest tracts are ready for more than the first managed cut, the technics and problems of stabilized management have only secondary significance at this stage. Hence the subject is treated very briefly. But as all forest managers will ultimately have to make a management plan, they should not overlook it in their early planning. The following discussion describes some of the considerations involved in taking the inventory, determining growth, yield, and ideal stocking and stand structure, and calculating the cutting budget.

MANAGEMENT INVENTORY

Each compartment or logging unit should be inventoried before any major part of a growing season has elapsed after the first managed cut. A dependable and efficient system of records for inventory, cutting, and logging data should be developed. Reinventory of each compartment at the time of the next cut will show the net increment between the two cuts. If carefully planned, such an estimate of growth is at least as convenient and economical as any other.

Inventory Information Needed

A statistically sound sampling system should be used in making the inventory of the cut-over stand. It will be satisfactory if the accuracy of the total saw-timber estimate by compartments is within 5 or 10 percent.

All trees which contain at least one tie-and-timber log should be classed as saw timber and so tallied. Trees with only local-use logs should be tallied as sound culls. The local-use logs in tie-and-timber or better trees should be included in the estimate for these

trees. For trees that are classed as saw timber, the grade of the logs to be expected from them should be obtained from a separate study of grade. The percentage of the various grades found in the separate study can be applied to the total sawlog volume estimate.

The proportion of the total saw-timber stumpage which will be salable will vary with time, place, and component grades. The distribution of inventory by species, grade, and diameter must be known if merchantability, utility, or value comparisons are to be made at different times or places. It is advisable also to maintain the original criteria separating undesirable and desirable growing stock (cut and leave) as a check upon the progress of the stand under management.

The inventory data should include:

1. Saw-timber-size trees by diameter, species, log length, and grade: segregated into desirable growing stock and overburden, with overburden divided into undesirable growing stock and culls.

2. Trees under saw-timber size but larger than 5 inches d.b.h., by species and diameter: segregated into desirable growing stock and overburden.

3. In situations described later, growth data from increment borings.

4. Notes on presence or absence of reproduction; problem areas to be located on the maps. No data are needed unless a separate tally of overburden to be removed in site preparation is desirable.

The data should be collected and compiled by types and stand classes. During the inventory, the rough type and stand classification map prepared in the preliminary survey should be checked and corrected in line with the effects of the cutting.

A network of permanent sample plots to be remeasured regularly can be used in lieu of standard repeated forest surveys as a means of keeping track of stand changes and growth. Such a system has real merit and should be given consideration in applying advanced forest practices. A system of permanent sample plots has not been used to any great extent, so there is little experience on which to base detailed recommendations. Enough is known, though, to be sure that skilled hands can make the system work.

Some Inventory Methods

Both the field and office work of obtaining and keeping the inventory are complicated, but realistic management needs the information. There are several ways to accumulate the data. A few popular technics are outlined here.

Plots, located either at random or in line, are preferred to strip sampling, both for efficiency in recording data and to facilitate checking the cruising and the computations.

The preview of the area which was obtained in the preliminary survey should be the basis for planning the intensity of sampling for all phases of the work. A 10 percent sample of the stand used to be conventional, but generally some lesser sample will suffice. The precision needed depends on the area, density, value, and variation of the stand. In most cases, the sampling prescription is calculated in terms of number of plots. Given an estimate of the variation within a stand and a standard of precision desired, the requisite number of plots can be derived by common statistical procedures. Good results, especially from a minimum of sampling, depend on freedom from bias in all measurements, consistent classification, and accurate computation.

For cruising purposes, circular 1/5- or 1/4-acre plots are appropriate for saw-timber trees larger than 17 inches d.b.h. For small saw timber in trees 11 to 17 inches d.b.h., a concentric plot of 1/10 or 1/20 acre is adequate; the exact plot size depends on the density, variation, and value of this group of trees. The non-saw-timber stand, including culls of all sizes, can generally be sampled adequately on a 1/10- or 1/20-acre plot. Large saw-timber trees should be classified as to species group, desirable growing stock or overburden, d.b.h., and merchantable length. The classification should be by 2-inch diameter classes and to the nearest 8 feet of merchantable length. Small sawlog and other trees should be classified in 2-inch d.b.h. classes as to species group, desirable growing stock, or overburden.

In addition, an estimate of log class and grade should be obtained by taking subsamples in an unbiased manner. The technic must be developed at the time of the survey. The average volume per tree for small saw-timber and non-saw-timber trees should be obtained by sampling. This information, applied to the tree count, will estimate the volume for these groups. Growth data from increment borings should be obtained from the same trees sampled for log class and grade for large saw timber and those sampled for volume in the smaller classes.

Sound cull and undesirable growing stock trees 7 to 11 inches in d.b.h. should be subsampled for short logs and bolts where these are salable.

Tallying of species and later computations can be greatly simplified by treating the species in logical groups. Data on sample trees for estimating grade of saw-timber-size trees and volume of under-saw-timber-size trees, and for making growth determinations, should be kept separate by individual species. These data can be used to approximate the detailed species distribution if it is desired, even though species groups are used elsewhere.

The following groups combine species which have form-class, silvical, or utilization characteristics in common. Added to some groups are rather rare species which occur too infrequently to justify separate tally. Some groups are made up of species of dissimilar characteristics. A tally recorded by type, though, will show which species are actually involved, because the dissimilar ones do not grow together. The grouping is merely suggestive and should be freely adjusted as local circumstances dictate. In application, these groups will automatically be condensed because of the limited range in site (and accordingly in species) within a given area.

A.
1. Sweetgum
2. Cottonwood
3. Willow
4. Sycamore
5. Blackgum
6. Magnolia
7. Yellow-poplar

B.
1. Cherrybark oak
2. Southern red oak
3. Northern red oak
4. Black oak
5. Water oak
6. Willow oak
7. Nuttall oak
8. Shumard oak
9. Laurel oak
10. Diamondleaf oak
11. Pin oak

C.
1. Cow oak
2. Delta post oak
3. White oak
4. Bur oak

D.
1. Overcup oak
2. Post oak

E.
1. White ash
2. Green ash

F.
1. American elm
2. Hackberry
3. Sugarberry

G.
1. Bald cypress
2. Pond cypress
3. Red maple
4. Silver maple
5. Box elder
6. Water tupelo
7. Swamp tupelo
8. Water locust
9. Sweet bay
10. Swamp cottonwood

H.
1. Cedar elm
2. Winged elm
3. Water hickory (bitter pecan)
4. Sweet pecan
5. Hickory
6. Honeylocust
7. River birch
8. Beech

I.
1. Persimmon
2. Sassafras
3. Red mulberry
4. Black walnut
5. Holly

J.
1. Loblolly pine
2. Spruce pine

K. Weed species: tally all weed species merely as sound culls.

Computations

For the customary compilation of area, volume, and stand tables, any standard technique used in assembling forest inventory will yield satisfactory results.

One method of breaking the total saw-timber estimate down by log grade is that used in the South by the U. S. Forest Survey. Each 16-foot section (or terminal 8-foot section) in standing sample trees is graded in the field according to the grade of the best 12-foot section it contains. Cull deductions may be indicated log by log in percent. The net volume of each section is then computed by means of Mesavage and Girard's table of percentages of total tree volume represented by logs in consecutive positions in the stem.10/

Securing volumes for non-saw-timber trees requires subsampling enough tapers and lengths to enable construction of local diameter-class tree volume tables by groups of species. Alternatively, it may be convenient to accept the bias of ready-made volume tables such as the Mesavage form-class cubic-foot tables. If the latter tables are used, they may tend to give low estimates for all except such species as cottonwood, willow, sweetgum, tupelo, and yellow-poplar in dense stands.11/

Topwood Estimates

Because of lack of available markets, there is no substantial need in the bottomlands for measurement of topwood, but since it makes up about 40 percent of the total cubic volume of saw-timber trees, it is often desirable to have some estimate of it. The cheapest method is to sample, during a timber-cutting operation, the ratio of cubic cordwood volume in tops to log-scale volume. The ratio varies with species, tree size, and form, but usually averages from 1 to 1-1/2 gross cords of topwood per thousand board feet (Doyle) in stems. The ratio is greatest in timber of small diameter and with short boles.

10/ Mesavage, Clement, and Girard, J. W. Tables for estimating board-foot volume of timber. U. S. Dept. of Agr., 94 pp., 1946. For sale by the Superintendent of Documents, Washington, D. C., 20 cents per copy.

11/ Mesavage, Clement. Tables for estimating cubic-foot volume of timber. Southern Forest Expt. Sta. Occasional Paper 111, 71 pp. 1947.

GROWTH DETERMINATIONS

Data on growth and increment can be obtained by comparing data from successive inventories. Until a second inventory has been finished, however, a crude estimate of growth may be made by stand table projection.12/ The increment borings previously suggested will be used for this purpose. The great weakness of such a method is ignorance of mortality and acceleration or deceleration of growth. If growth percents from comparable stands are available, they can be used to give an approximation of growth, thus providing another approach to this problem.

There is a question as to how to handle growth estimates for areas which still support excessive volumes of overburden after the first managed cut has been made. Obviously, the second cut in such stands should be on essentially the same basis as that generally prescribed for the first managed cut. Nevertheless, in the interest of calculating the cutting budget under stabilized management, such stands must be considered. The allowable cut should therefore be calculated from the increment on the growing stock, and to this increment should be added any operable held-over overburden. The held-over overburden should not be included in any calculations of growth--it is merely surplus to be disposed of as quickly as possible and with minimum influence on management plans for desirable growing stock.

A detailed, hypothetical estimate of stand development and growth may occasionally be needed in analyzing the forestry possibilities of a tract. The data from increment borings obtained in the inventory should be used. Growth should be computed for the desirable growing stock separately, in which case neither mortality nor cull need be a serious consideration. Growth of overburden can either be disregarded or it can be projected according to pertinent increment borings, adjusted as to cull and anticipated mortality. The increment data should be adjusted for expected acceleration if cutting is anticipated or deceleration if competition is slowing down growth and cutting is not anticipated. Deceleration can be estimated by projecting the trend indicated by borings made in the particular stand. The degree of acceleration can be estimated from increment borings in trees that have been released in similar stands.

12/ Wahlenberg, W. G. Methods of forecasting timber growth in irregular stands. U. S. Dept. Agr. Tech. Bul. 796, 56 pp., illus. 1941.

STOCKING AND STAND STRUCTURE

The volume in practically all stands after the first improvement cut will be far below the optimum. To allow a margin for safety and build up growing stock, therefore, succeeding cuts should be kept as far below growth estimates as the circumstances of the owner and operating requirements permit. From a strictly silvicultural standpoint, a second cut should be made only when stocking increases enough so that thinning and salvage are required. As the stands approach the structure and density of those outlined in table 3, larger proportions of the increment can safely be cut, until the point is reached where the cut should remove all increment accumulated during the cutting cycle. Periodic cuts at 10 years apart are a good round figure to aim at, but the interval will reasonably vary from 7 or 8 to 15 years. The silvicultural ideal may have to be compromised with business requirements and operating conditions that may dictate adjusting the cutting to either side of the desirable time.

Areas with non-merchantable stands will have to be carried without conventional treatment until an operable stand develops. As soon as one does develop, it can be worked as recommended previously for the first managed cut.

Stand development should be directed towards production of large, high-class, high-grade trees. When the ideal is approximated, the stand will contain as many as possible of the larger sizes and as few trees of the smaller sizes as is consistent with the need for maintaining a balanced growing stock in terms of size; that is, enough, but only enough, of the smaller sizes to furnish a reserve from which to recruit replacements for the larger sizes as they are harvested. Cutting of healthy and vigorous trees should be so timed as to avoid any needless sacrifice of high-yielding investment value by premature conversion to current income, or any sacrifice of earnings by deferring cutting too long. Such timing requires close financial calculations. In fully developed, intensively managed stands, trees 28 to 32 inches d.b.h. will be the usual mature sizes on reasonably good sites, with larger trees occurring commonly. Some 36-inch or larger trees may be grown for special products like face veneer.

Theoretically, the possible cut in the ideal stand as presented in table 3 simply serves to set the stand back to exactly the shape in which it began the cycle. If the surplus trees of the smallest sizes are not cut, most of them will die before doing any harm. Surplus trees above 6 inches should be cut if best results are desired.

Table 3.--Optimum stocking per acre, uneven-aged bottomland hardwoods on good site 1/

D.b.h. (inches)	After cutting; beginning of new cycle		Midway of cycle or average stand		End of cycle; ready for cutting		Cut	
	Trees	Volume	Trees	Volume	Trees	Volume	Trees	Volume
	No.	Cords 2/	No.	Cords 2/	No.	Cords 2/	No.	Cords 2/
2	26.0	(3/)	36.0	(3/)	36.0	(3/)	...	(3/)
4	17.2	0.2	20.0	0.3	30.0	0.4	12.75	0.2
6	10.5	.4	13.0	.5	15.8	.6	5.28	.2
8	8.2	.6	9.7	.7	12.2	.9	4.05	.3
10	7.0	.8	7.6	1.0	9.0	1.2	2.02	.4
12	7.0	1.3	6.8	1.2	7.1	1.3	.10	(3/)
Total	75.9	3.3	93.1	3.7	110.1	4.4	24.20	1.1
		Bd. ft. Doyle		Bd. ft. Doyle		Bd. ft. Doyle		Bd. ft. Doyle
14	6.5	338	6.2	322	6.0	312	...	...
16	5.3	503	5.6	532	5.7	541	0.40	38
18	4.3	632	5.3	779	5.6	823	1.30	191
20	3.2	688	4.3	925	5.3	1,139	2.10	451
22	2.3	678	3.2	944	4.3	1,268	2.00	590
24	1.6	524	2.3	897	3.2	1,248	1.60	724
26	1.1	561	1.6	816	2.3	1,170	1.20	609
28	.8	524	1.1	721	1.6	1,048	.80	524
30	.45	369	.80	656	1.1	902	.65	533
32	.27	272	.45	452	.8	804	.53	532
34	.11	139	.27	329	.45	547	.34	408
36	.04	57	.11	165	.27	392	.23	335
38	.02	28	.04	64	.11	191	.10	163
40	...	...	.02	34	.04	76	.04	76
42	...	...	...	...	.02	37	.02	37
Total	25.99	5,313	31.29	7,636	36.79	10,498	11.31	5,211
All trees	101.89	...	124.39	...	146.89	...	35.51	...
Pct. of full stocking	58.0		72.6		93.0		35.0	

1/ A cutting cycle of not less than 10 years is assumed.
2/ 128 cubic feet, gross, with 75 cubic feet assumed as the net content of wood from 4-inch trees and 80 cubic feet assumed from 6- to 12-inch trees. Topwood in saw-timber trees disregarded.
3/ Negligible.

If management is skillful and intensive for several cutting cycles, those types inherently amenable to selection management, as most bottomland types are, should gradually assume their proper structure and build up to and stabilize at approximately their optimum stocking.

The rate at which management achieves this goal will necessarily vary with a multitude of factors such as existing stand class, type and site, markets, rate of cutting, and stand improvement work. The species distribution in the ideal stand will vary with site but should be manipulated to develop the best integration of stumpage values and growth rates. Choice of individual trees to cut under intensive management will be based on criteria used in the first managed cut.

CUTTING BUDGETS

As a basis for estimating the cutting budget for the first cutting cycle after the initial managed cut, comparison of the original inventory data with that of the reinventory, supplemented where necessary with growth estimates obtained by stand projection, will show the volume of timber with which the manager will have to work during the cutting cycle. For the second cutting cycle and those to follow, increment as well as volume will be obtained by the repeated inventories and the cutting budget determined in relation to it as appears most wise under the circumstances.

What portion of the growth or increment should be reserved from cutting at any one time in the interest of building up growing stock must be left to the dictates of policy harmonized with good forestry practice. There are no technical data to indicate the maximum portion of the growth which could be cut in understocked stands from the standpoint of sound forest management. Ideally, of course, all increment in desirable growing stock should accumulate until the stand reaches full and optimum stocking. Economically, this may not be wise or even possible. The only guide will be firm judgment, operating on the general premise that until the optimum is reached as much volume should be added to growing stock during each cutting cycle as economic and silvicultural realism permits.

FORESTRY POTENTIALS IN THE BOTTOMLANDS

The potentialities of the southern bottomland types are tremendous. These types now occupy about 30 million acres, and despite inroads by agriculture and other factors a minimum of 25 million acres of this land will remain permanently in forest. Under management much of this land will grow 500 board feet (Doyle) of excellent hardwoods per acre per year. In addition, two-thirds of a cord per acre per year can be produced from topwood and small trees which should be removed for cultural reasons. In short, the bottomlands are a large and productive region.

Thus far, very little of the bottomland area has been placed under management. Growing stock is depleted, and depletion is continuing. In one sense, this means that the forestry opportunities are unlimited because the field is wide open. In another sense, the forestry future is harsh because profitable operations following sound silvicultural principles are difficult where depletion is far advanced.

There is ample evidence and example, however, to indicate that aggressive interest and action in forestry can be well rewarded within a period of time acceptable to most private enterprise. The time has come, therefore, to get off dead-center on bottomland forestry and make it a reality. It is bound to spread as it gains a foothold, because it is too good to pass by.

Although the factory lumber from bottomlands has long been in high demand, there remains a large volume of lower grade material for which markets are limited or lacking. Unquestionably, there will be some expansion of markets brought about by human ingenuity and scarcity. Everything possible should be done to encourage expanded markets, for the main key to intensive bottomland forestry is the development of utilization opportunities for low-grade material.

In no broad area in the United States does the forester have the opportunity and at the same time the challenge that exists in the bottomlands. Now is the time to take hold of these opportunities and to accept the challenge which they offer.

APPENDIX

FOREST TYPES RECOGNIZED IN THIS BULLETIN WITH CORRESPONDING TYPES RECOGNIZED BY THE SOCIETY OF AMERICAN FORESTERS[1]

Types of the text	S.A.F. types covered by types of the text	Remarks
Sweetgum-water oaks	82. Redgum	
	83. Redgum-Nuttall oak-willow oak	
	84. Willow oak	
	86. Oak-elm-ash	When water oaks predominate with green ash.
	87. Southern cypress-hardwoods	When cypress is secondary and sweetgum-water oaks are predominating hardwoods.
White oaks-red oaks-other hardwoods	80. Hickory-swamp chestnut oak-white oak	
	81. Redgum-swamp red oak	
	86. Oak-elm-ash	When red oaks or white oaks predominate with white ash.
	70. Loblolly pine-southern red oak	Very limited and very small areas in the bottomlands.
	71. Loblolly pine-white oak	Same as above.

1/ Society of American Foresters. Forest cover types of the eastern United States. Ed. 3, revised, 39 pp. 1940.

Types of the text	S.A.F. types covered by types of the text	Remarks
Hackberry-elm-ash	85. Sugarberry-elm	
	86. Oak-elm-ash	When elm and ash are predominate.
	87. Southern cypress-hardwoods	When cypress is secondary and hackberry, elm, and ash predominate.
Overcup oak-bitter pecan	89. Overcup oak-water hickory	
	87. Southern cypress-hardwoods	When cypress is secondary and overcup oak and bitter pecan predominate.
Cottonwood	61. Cottonwood	
Willow	88. Willow	
Cypress-tupelo	94. Southern cypress	
	95. Tupelo gum	
	87. Southern cypress-hardwoods	When cypress predominates over the hardwoods.
Riverfront hardwoods	59. River birch-sycamore	
	60. Silver maple-American elm	
	85. Sugarberry-elm	When sugarberry and elm are mixed on riverfront lands with other species such as sweet pecan, sycamore, and boxelder.

IMPORTANT BOTTOMLAND SPECIES

These species, for one reason or another, attain importance in the bottomlands of the South. Recognized common names and scientific names are according to "Check List of the Native and Naturalized Trees of the United States, including Alaska." U. S. Forest Service, Washington, D. C. 325 pp. Rev. ed. 1944. Comparative growth rate is average diameter increase in 10 years (for dominant and codominant trees on average or better sites) as follows: Poor—less than 2 inches; medium—2 to 3 inches; good—3 to 4 inches; and excellent—better than 4 inches. Comparative tolerance is based on a general scale in relation to all American species. When factory lumber is listed as a primary use, it automatically implies the myriad of uses into which hardwood lumber is remanufactured.

Recognized common and scientific names	Other common names	Occurrence in the bottomlands	Comparative growth rate	Comparative tolerance	Reproduction	Susceptibility to damage	Primary uses	Remarks
				WHITE OAKS				
White oak (Quercus alba and var. latiloba)	Forked-leaf white oak	Widely on well-drained soils of oldest terrace and colluvial sites.	Poor to medium	Intolerant	Adequate in openings wide enough to let direct sunlight to ground.	No special problems	Face veneer, tight cooperage, factory lumber, ties and timbers.	Broad utility and high value. Prized both for commercial and farm use; a clean, healthy tree; easy and safe to grade. Not primarily a bottomland species.
Cow oak (Q. prinus)	Swamp chestnut oak, swamp white oak, basket oak	Widely on best well-drained loamy first bottom ridges, but principally on well-drained silty clay and loamy terrace and colluvial sites.	Medium to good	Moderately intolerant	Easily obtained in openings but sparse because mast is highly palatable to animals. Sprouts efficiently.	No special problems	Essentially same as white oak, but coarser grain and wider sapwood due to rapid growth are slight handicap for face veneer and tight cooperage.	Same as white oak except that cow oak is typically a bottomland species.
Delta post oak (Q. mississippiensis)	Post oak, yellow oak	Mississippi Delta only. Well-drained silty clay and loamy terrace sites. Rarely in first bottoms.	Medium	Moderately intolerant	Easily obtained with light but seldom prolific.	No special problems	Same as cow oak.	Wood has distinct yellow-tan cast requiring separate handling as face veneer. Same as cow oak, otherwise.
Post oak (Q. stellata)	...	Widely on most matured terrace and sandy colluvial sites. Usually on poorer soils.	Poor	Moderately intolerant	Easily obtained with light. Sprouts freely.	Commonly infested with spot or flag worm and with grubs on poor sites.	Factory lumber at low value. Good tie and timber species.	Third-rate tree. Natural pruning of upper stem is slow, trees generally short. Good farm-use species. Hard to grade because of spot worm. Not primarily a bottomland species.
Overcup oak (Q. lyrata)	Swamp post oak, swamp white oak	Widely on the lower poorly drained sites of both first bottoms and terraces of the larger streams. Scattered on better sites. Prevalent in sloughs and backwater areas.	Very variable but generally medium	Moderately intolerant	Prolific but often killed by high water during growing season. Starts readily in either open or shade but soon dies in shade.	Insect damage very common. Especially liable to mineral stain and heart check.	Utility extremely variable with site and fire damage. At best equivalent to white oak. Frequently worthless for factory lumber because of stain and insects. Checking during seasoning prevents use for ties and timbers.	Poor second-rate species. Next to post oak, the poorest of the white oaks. Log grades determined mainly by insect damage and heart check.
Bur oak (Q. macrocarpa)	Mossy cup oak, burr oak	Only in north part of Mississippi Delta and western stream bottoms on wetter sites in either first bottoms or terraces.	Variable but generally medium	Moderately intolerant	Prolific in open areas but often killed by high water during growing season.	No special problems	Ties and timbers; factory lumber. Generally higher quality than overcup oak because free of insects.	Hard, strong, and durable wood; excellent farm-use species. Second-rate species commercially because of roughness.

Recognized common and scientific names	Other common names	Occurrence in the bottomlands	Comparative growth rate	Comparative tolerance	Reproduction	Susceptibility to damage	Primary uses	Remarks
				RED OAKS				
Southern red oak (Quercus falcata)	Swamp oak, red oak	Widely on older terraces and colluvial deposits. Drier sites.	Medium	Moderately intolerant	Easily obtained with light.	Readily susceptible to insects and disease when wounded or growing on poor sites.	Ties and timbers. Best trees produce factory lumber logs.	Second-rate tree because of tendency to roughness and insect and stain damage. Not primarily a bottomland species.
Cherrybark oak (Q. falcata var. pagodaefolia and leucophylla	Swamp red oak, bottomland red oak, red oak	Widely on best loamy sites in first bottoms and on most well-drained terrace and colluvial sites.	Good to excellent	Intolerant	Easily obtained with full light. Sprouts fairly efficiently.	No special problems except tendency to ant infestation when overmature or injured on poor sites.	High value. Face veneer, factory lumber, cross ties.	Best red oak. Rapid growth and high-quality wood of general utility. Safe and simple to grade.
Shumard red oak (Q. shumardii)	Striped oak	Restricted to good loamy ridge soils on terrace or colluvial sites. Rarely on first bottoms. Widely distributed but very scattered.	Good	Intolerant	Easily obtained in full light.	Same as cherrybark oak.	High value. Face veneer, factory lumber, cross ties.	Quite similar to cherrybark oak in utility but more selective as to site. A poor variety of this species (schneckii) grows in the uplands.
Black oak (Q. velutina)	Yellow butt oak	Widely scattered on oldest or most matured terrace and colluvial sites. Drier sites.	Medium	Intolerant	Fair but erratic.	Greater than average susceptibility to disease and insects on poor sites.	Ties and timbers. Factory lumber from better trees.	Poor second-rate tree, often very poor. Best trees, on best sites, equivalent to cherrybark oak. Not primarily a bottomland species.
Northern red oak (Q. borealis)	Red oak	Only in northern two-thirds of Alabama and Mississippi, excluding Delta, on well-drained terrace and colluvial sites.	Medium to good	Moderately intolerant	Fairly easy to obtain	No special problems	High value. Face veneer, factory lumber, ties and timbers.	Excellent tree. Equivalent to cherrybark oak. Not primarily a bottomland species.
				WATER OAKS				
Nuttall oak (Q. Nuttallii)	Swamp red oak, southern pin oak, pin oak, swamp black oak, striped oak	Widely in first bottoms of major streams on flats, low ridges, shallow sloughs, and margins of swamps. Less common on similar sites on terraces of major streams.	Good to excellent	Intolerant	Prolific but often killed by high water during growing season. Starts readily in either open or shade but soon dies in shade.	No special problem for healthy trees on the better sites. On terraces and in backwater areas overmature and damaged trees are subject to insects and mineral stain. Death of mature trees common in case of drought or lowered water table.	Highly acceptable for factory lumber.	Good second-rate tree. Excessive checking in seasoning inhibits use for ties and timbers. Insects and limbiness on poor sites limit higher use.
Pin oak (Q. palustris)	Northern pin oak	Northern part of Mississippi Delta. In first bottoms on wet flats with impervious soil.	Good to excellent	Intolerant	Prolific in openings.	No special problems	Local-use lumber, props, and fuel.	Almost worthless for standard lumber because of knots; excessive checking and frequent large dead knots reduce utility for ties and timbers.

Recognized common and scientific names	Other common names	Occurrence in the bottomlands	Comparative growth rate	Comparative tolerance	Reproduction	Susceptibility to damage	Primary uses	Remarks
				WATER OAKS (continued)				
Willow oak (Quercus phellos)	Pin oak, water oak, black oak, red oak	Widely on both first bottoms and terraces. At best in first bottoms on well-drained low ridges. Satisfactory on terrace flats with well-drained silty clay soils. At its worst in pure stands on hardpan terrace flats.	Generally good to excellent but varies greatly with site. Poor to medium on hardpan flats.	Intolerant	Easily obtained in full light. Sprouts fairly efficiently.	On poorer sites especially subject to insect infestation and mineral stain.	Factory lumber. Ties and timbers principally from terrace stands.	Very important species because of wide distribution, rapid growth, and relatively high utility. On hardpan terraces almost worthless for the better uses because of insect damage, mineral stain, and limbiness. Tendency to check excessively, especially in first bottom timber.
Water oak (Q. nigra)	Striped oak, pin oak, orange oak	Widely on better loamy ridges in first bottoms and on any ridge and silty clay flats in the terraces.	Good to excellent, though very variable.	Intolerant	Prolific in full light. Sprouts fairly efficiently.	Very susceptible to disease and insect attack on impervious and dry terrace soils.	Factory lumber. Ties and timbers from terrace sites. On poorer sites, insect damage, mineral stain, and adventitious knots often make it worthless for higher uses.	A very good second-rate tree on good sites. Knotty, grubby, and stained on poor sites. May check excessively in drying.
Diamondleaf oak (Q. obtusa)	Water oak, spotted oak, obtusa oak	Near Coast on flat, hummocky, wet first bottom sites.	Good to excellent	Moderately intolerant	Reproduces well in small clumps in shallow pools in direct light.	Fairly resistant to insects and disease. After fires or on poor sites, insects, stain, and disease are serious.	Factory lumber, unless too badly stained or insect-damaged.	Second-rate tree. Checks excessively.
Laurel oak (Q. laurifolia)	Water oak, spotted oak, willow oak	Near Coast in wet flats and on margins of swamps. Most common on terraces of minor streams.	Good to excellent	Moderately intolerant	Erratic but plentiful with light.	Commonly insect-infested and stained.	Rarely for factory lumber or ties and timbers.	Knots, grubs, stain, and tendency to check excessively make it about worthless for the present in most situations.
				OTHER SPECIES				
Sweetgum (Liquidambar styraciflua)	Redgum, gum	Wide occurrence on almost all sites. Best and commonest on loamy or clay ridges on first bottoms and on silt loam flats on terraces.	Good	Very intolerant	Very easy to obtain in full light. Sprouts efficiently.	Quite free of insect and disease problems. On poorer sites, tops die as trees mature. Drought or lowered water table leads to serious mortality.	Broad utility and high values. Face, commercial, and box veneer. Factory lumber. Furniture and interior trim. Cross ties, structural lumber, and pulp.	Most important single bottomland species. Usually high-quality; easy to grade given due regard to overgrown knots.
Cottonwood (Populus deltoides)	Southern cottonwood, poplar	Widely distributed but mostly on newly deposited soil along major streams.	Excellent, 6 to 8 inches in diameter in 10 years.	Very intolerant. Cottonwood and willow most intolerant bottomland species.	Reproduces abundantly and quickly but only on wet mineral soil. Sprouts well.	No serious problem unless fire occurs, then very susceptible to decay and mortality.	Factory lumber. Package and commercial veneer. Truck and wagon boxes. Pulp.	Fastest growing tree in North America. Highly prized. Clear wood; light and tough.
Swamp cottonwood (P. heterophylla)	Bigleaf cottonwood, black cottonwood	Widely scattered but only in shallow swamps.	Good to excellent	Very intolerant	Erratic and sparse.	No special problem	Box lumber and package veneer. Pulp.	Rarely associated with P. deltoides, commonly with cypress and tupelo gum in terrace or coastal swamps.

Recognized common and scientific names	Other common names	Occurrence in the bottomlands	Comparative growth rate	Comparative tolerance	Reproduction	Susceptibility to damage	Primary uses	Remarks
				OTHER SPECIES (continued)				
Black willow (Salix nigra and var. altissima)	Willow	Margins of principal rivers of Coastal Plains and Mississippi Delta. Important only on riverfront land.	Excellent	Very intolerant. Along with cottonwood most intolerant bottomland species.	Reproduces profusely but only on bare wet mineral soil. Sprouts vigorously.	No special problem	Production limited to the Mississippi River Delta. Factory lumber, commercial and package veneer, pulp. Interior trim from red heart lumber.	Very fast-growing but short-lived. Will stagnate if not thinned early. Very tolerant of submergence and silting. Outstandingly tall, clear stems.
Blackgum, black tupelo (Nyssa sylvatica)	Hill blackgum	Throughout region on colluvium and terraces with silt loam soils. Prefers well-drained sites but will stand brief spring flooding.	Poor to medium	Intolerant	Sparse	No special problem	Cross ties, factory lumber, pulp.	Rather low value due to great tendency to warp, though can be excellent when large enough for quarter-sawing. Commonly grows with white oaks and hickory.
Water tupelo (N. aquatica)	Tupelo, tupelo gum, swampgum, olive tree, bay poplar, gum	Throughout region but almost exclusively in swamps of the flood plains of alluvial streams.	Medium	Intolerant	Prolific on open, wet soil on proper site	No serious problem	Package and commercial veneer, factory lumber, cross ties, pulp.	Normally in even-aged dense stands, often with cypress but little else. Swollen butts of trees in deep swamps develop punky texture unfit for use. A substitute for sap sweetgum for most uses. Exceptionally clear and defect-free.
Swamp tupelo (N. sylvatica biflora)	Swamp blackgum, blackgum, gum	Non-alluvial coastal swamps from Virginia to Louisiana. Unimportant west of Mississippi River.	Medium	Intolerant	Prolific on open wet soil on proper site	No special problem	Same as N. aquatica but with more stress on veneer. Notable use for small dimension direct from round timber.	Same as N. aquatica. Also associates with sweet bay. Swollen butts not so serious because of shallower swamps.
Green ash (Fraxinus pennsylvanica lanceolata)	Swamp ash, ash	Widely on first bottoms except in deep swamps, but most common on flats. On terraces in flats and sloughs.	Medium	Very intolerant	Prolific in openings. Best on wet sites. Sprouts efficiently.	Very susceptible to fire damage. Cankers with dry yellow heart rot occasionally serious.	High value. Thick factory lumber, handles and athletic goods, vehicle and implement parts.	On low, wet sites commonly develops swollen butt which is brash, thereby reducing utility. Outstandingly clear; easy to grade.
White ash (F. americana)	Cane ash, ash	Widely on ridges and high, hummocky flats on terraces and on colluvium.	Medium	Very intolerant	Prolific in openings. Sprouts efficiently.	No special problems, but very sensitive to fire.	Same as green ash except somewhat preferred for handles and athletic goods.	No problem with swelled butts as in green ash. Exceptionally defect-free; simple and safe to grade.
American beech (Fagus grandifolia)	Beech	Widely in minor stream bottoms, usually on well-drained terrace ridges. Common on colluvial soils.	Poor	Very tolerant	Erratic except in very favorable circumstances.	No special problem	Low value because of "blind" or overgrown knots. Factory lumber and cross ties.	Third-rate tree because of "blind" knots and slow growth. One of most tolerant bottomland trees and tends to eliminate better species from best sites.
American elm (Ulmus americana)	Soft elm, red elm, white elm, water elm	Widely in both first bottoms and terraces except deep swamps. Especially on first bottom flats.	Medium. Good on well-drained flats in first bottoms.	Tolerant	Prolific in openings. Becomes established as an understory. Sprouts vigorously.	No special problem	Factory lumber, slack cooperage and bending stock. Commercial and package veneer.	Good second-rate tree. Tendency towards poor form. Adventitious sprouting and sapsucker attack common but otherwise exceptionally clear.

Recognized common and scientific names	Other common names	Occurrence in the bottomlands	Comparative growth rate	Comparative tolerance	Reproduction	Susceptibility to damage	Primary uses	Remarks
				OTHER SPECIES (continued)				
Cedar elm (Ulmus crassifolia)	Rock elm, southern rock elm, hard elm	Widely in first bottoms on flats and poorly drained, low ridges. Some on terrace flats with tight soil. Restricted to major streams.	Poor	Very tolerant	Scattered. Persists beneath overstory.	No special problem	Local-use lumber. Rarely for factory lumber. Generally low utility for any use.	Third-rate tree, but possesses greater utility than is yet recognized. Extremely hard wood, so cannot be used with other elm. Severe adventitious sprouting degrades upper logs. Fluted, odd-shaped stems common.
Winged elm (U. alata)	Hard elm, rock elm, white elm	Widely on terrace ridges and colluvial sites. Occasionally on high terrace flats with tight silty soils.	Poor	Tolerant	Prolific in openings. Becomes established sparsely as an understory.	No special problem	Sparingly for factory lumber. Local-use lumber.	Too hard for slack cooperage. A relatively small tree of good form. Commonly with blackgum, post oak, and hickory.
Sugarberry, hackberry (Celtis laevigata, C. occidentalis)	Hackberry Hackberry	Widely on first bottoms except deep swamps, most common on flats. On wet flats and in shallow sloughs on terraces.	Poor to medium	Very tolerant	Prolific in openings. Becomes established as an understory.	Once tree is wounded, rot occurs and advances rapidly.	Slack cooperage mostly. A little for factory lumber.	No distinction between these two species. Sugarberry is the common species. Hackberry occurs only in north part of region. Growth rate extremely sensitive to competition. A small tree of poor form.
Hickory (Carya spp.)	Hickory	Widely on terrace ridges and colluvial sites. On high terrace flats with silty clay soils.	Poor	Very tolerant	Prolific. Sprouts efficiently. Develops as an understory.	A borer commonly attacks weakened trees and trees on poor sites. Favored by sap suckers.	Striking tool handles, athletic goods, wagon stock. Very sparingly for factory lumber.	Four true hickories are included and no distinction made. Third-rate species. Only best-quality material used.
Pecan (C. illinoensis)	Sweet pecan	On riverfront lands of Mississippi Delta and along major rivers west of the Delta to Texas.	Good	Intolerant	Scattered but dependable. Becomes established under cottonwood.	No special problem	Factory lumber, athletic goods.	Good tree. Has become established in the trade for flooring and furniture.
Water hickory (C. aquatica)	Bitter pecan	Widely only on low flats, in sloughs and margins of swamps in both first bottoms and terraces of major streams. Greatest concentrations in flats of principal backwater basins.	Poor	Intolerant	Prolific in full light	No special problem. Leafs out late, withstands flooding well.	Factory lumber. Accepted same as sweet pecan when quality permits.	Extreme tendency to ring shake makes it third-rate tree. When free of ring shake, quite acceptable.
Honeylocust (Gleditsia triacanthos)	Honeylocust	Scattered widely on all sites except sloughs and swamps.	Medium	Intolerant	Sparse and unpredictable. Common on old pastures.	No special problem	Local-use lumber, posts, occasionally factory lumber.	Tendency to ring shake and heart check in large, old trees.
Water locust (G. aquatica)	Water locust, swamp locust	Scattered widely in nearly all alluvial swamps, and sloughs and wet flats of both first bottoms and terraces.	Good	Intolerant	Erratic but occasionally prolific in openings in swamps. Sprouts vigorously.	No special problem	Rarely for either factory or local-use lumber.	Third-rate tree: poor form and small size.

Recognized common and scientific names	Other common names	Occurrence in the bottomlands	Comparative growth rate	Comparative tolerance	Reproduction	Susceptibility to damage	Primary uses	Remarks
				OTHER SPECIES (continued)				
Magnolia (Magnolia magnolia)	Magnolia	Mainly within 100 to 200 miles of Coast on oldest terraces and colluvial sites. Principally in minor stream bottoms.	Medium	Tolerant	Erratic and scattered	No special problem	Factory lumber. In strong demand as substitute for yellow-poplar.	Good second-rate tree. Appears rough but cuts out fairly clear lumber.
Sweet bay (M. virginiana var. australis)	White bay, bay	East of Mississippi River in swamps of the Coastal Plains.	Poor to medium	Intolerant	Erratic but occasionally prolific in openings	No special problem.	Package veneer, pulp, limited use for box factory lumber.	Scattered distribution and small maximum size limit its use.
Yellow-poplar (Liriodendron tulipifera)	Poplar, tulip poplar	Mainly east of Mississippi River. Only on best well-drained terrace and colluvial sites. Mainly along minor streams.	Excellent	Very intolerant	Prolific on bare soil in wide openings	No special problem. Very susceptible to fire damage. Some mineral stain.	Factory lumber, commercial and package veneer, pulp.	A clean, clear species, highly desired. Greatest general utility hardwood species. Not primarily a bottomland species.
Red maple (Acer rubrum)	Soft maple	Scattered widely in first bottoms except on ridges and in deep swamps. On wet flats in terraces.	Medium to good	Tolerant	Dependable; normally establishes a sparse understory. Sometimes forms thicket in openings.	Mineral stain very common. Spot worm prevalent.	Factory lumber	Scattered occurrence and poor form have limited its use. Valuable when of suitable size and form. Used regardless of spot worm but at depreciated value.
Silver maple (A. saccharinum)	Soft maple	On river fronts in northern portion of Mississippi Delta and along other major streams almost to Coast.	Excellent	Very intolerant	Prolific on bare mineral soil	Spot worm common.	Factory lumber: furniture, trim, flooring. Pulp.	Good second-rate tree. Short-bodied but clear, large size. Substituted for hard maple where texture is not too important.
Boxelder (A. negundo)	Ashleaf maple	Widely on river fronts of major streams.	Excellent	Intolerant	Prolific on bare mineral soil. Reproduces under cottonwood overstory.	No special problem	Very rarely used. Some lumber and crating. Pulp.	Matures when young and small. Very poor form. Practically a weed tree.
Sycamore (Platanus occidentalis)	Plane tree	Widely on fronts of major streams. On banks of minor streams.	Excellent	Intolerant	Prolific on bare mineral soil	Overmature trees subject to ant attack, which causes ingrown bark pockets.	Commercial and package veneer. Occasionally factory lumber. Butcher blocks.	Very large trees likely to be windshaken. Favored veneer species. Especially clean, clear boles.
Black walnut (Juglans nigra)	Walnut	Scattered in northern part of region on the best well-drained loamy sites.	Medium to good	Intolerant	Sparse but dependable; confined to best well-drained soils.	No special problem	Face veneer. Factory lumber for cabinets and interior trim. Gun stocks and other specialties.	Very high value. Not common in the major bottoms.
River birch (Betula nigra)	Red birch, water birch	On river fronts in northern Mississippi Delta and along other major streams, and along banks of minor streams to the Gulf.	Good	Intolerant	Prolific on bare mineral soil	No special problem	Commercial and package veneer. Rarely for lumber. Little used.	Poor second-rate tree. Prevalence of "sugar streak" inhibits use for "face" purposes.

Recognized common and scientific names	Other common names	Occurrence in the bottomlands	Comparative growth rate	Comparative tolerance	Reproduction	Susceptibility to damage	Primary uses	Remarks
				OTHER SPECIES (continued)				
Persimmon (Diospyros virginiana)	Persimmon	Scattered widely on wet flats, shallow sloughs, swamp margins on first bottoms. Similarly but less common on terraces.	Poor	Very tolerant	Sparse but dependable. Occurs in the understory. Sprouts efficiently.	No special problems	Shuttle blocks, golf club heads	Good self-pruning tree. Heartwood valueless because of excessive checking in seasoning, but little heartwood develops on favorable sites.
Red mulberry (Morus rubra)	Mulberry	Scattered widely in first bottoms except in swamps and on dry ridges. On well-drained flats on terraces.	Poor	Very tolerant	Occurs easily from seed and sprouts well. Reproduces in the understory.	Stem canker causes considerable mortality locally.	Fence posts	A small understory tree. Highly prized for fence posts.
Holly (Ilex opaca)	Holly	Very scattered on high terraces and colluvial sites. Principally in minor stream bottoms.	Poor	Very tolerant	Sparse but dependable	No special problems	Decorative foliage and fruit. Special cabinet work in trifling amounts.	Matures at small size, short stems. Wood has negligible commercial demand.
Sassafras (Sassafras officinale)	Sassafras	Scattered widely on any well-drained site. Best on well-drained first bottom ridges.	Medium	Intolerant	Sparse, erratic except for sprouting	No special problem	Boat lumber, rarely interior trim, posts.	No appreciable factor in commerce, though lumber is lightweight, durable, and straight-grained, and works and bends well.
Baldcypress (Taxodium distichum)	Cypress, yellow cypress, red cypress	Widely in swamps, deep sloughs, low, poorly drained flats.	Poor	Tolerant	Erratic, complicated by water and timing of floods. Averages poor but is occasionally excellent.	No special problem. Very old trees are prone to be "pecky."	Factory and structural lumber, boat and tank stock, piling.	Highly prized because of durability, exceptional working qualities and special utilities.
Pond cypress (T. ascendens)	Cypress, black cypress	Shallow swamps and ponds of southern Coastal Plains east of the Mississippi River.	Poor	Tolerant	Erratic. Generally poor.	No special problem but "peck" in overmature trees.	Structural lumber, cross ties.	Smaller and far less important and useful than baldcypress.
Loblolly pine (Pinus taeda)	Old field pine, Rosemary pine	On oldest, well-drained terraces and colluvial sites. Mainly along minor streams.	Good	Intolerant	Reproduction made difficult by hardwood competition, but species is maintaining itself.	No special problem	Structural lumber, pulp.	Not primarily a bottomland species.
Spruce pine (P. glabra)	Rosemary pine, white pine	East of Mississippi River on well-drained, high ridges of first bottoms and better terrace sites of minor streams.	Excellent	Moderately intolerant	Reproduction adequate in small openings on proper site.	No special problem	Structural lumber, pulp.	Rougher than loblolly pine. Occurs only in the bottoms.

Recognized common and scientific names	Other common names	Occurrence in the bottomlands	Comparative growth rate	Comparative tolerance	Reproduction	Susceptibility to damage	Primary uses	Remarks
				WEED SPECIES				
Blue beech (Carpinus caroliniana)	Ironwood	Widely on any well-drained terrace or colluvial site. Mainly on terraces of minor streams.	Poor	Very tolerant	Prolific in openings. Occurs in understory.	...	...	Bad pest where dense enough to exclude other species. Does not reach timber size.
Hophornbeam (Ostrya virginiana)	Ironwood	Same as blue beech	Poor	Very tolerant	Same as blue beech	...	...	Same as blue beech
Planer tree (Planera aquatica)	Water elm	Widely in swamps, deep sloughs, low poorly drained flats in both second bottoms and terraces.	Poor	Moderately intolerant	Occurs easily after cutting or fire.	...	...	Too short and poorly formed for timber use. Bad pest.
Roughleaf dogwood (Cornus drummondi)	Swamp dogwood	Widely on low first bottom ridges and better drained flats, but somewhat indicative of rather poor impervious or dry site.	Poor	Tolerant	Sparse but can largely preempt open areas on appropriate sites.	...	...	Too small and poorly formed for any timber use.
Swamp privet (Forestiera acuminata)	Privet	Widely on wet flats and shallow sloughs in first bottoms.	Poor	Tolerant	Prolific on proper site	...	...	Too small for timber use. Can be a serious pest.
Hawthorne (Crataegus spp.)	Haw	Widely on well-drained flats and ridges of first bottoms, well-drained flats in terraces.	Poor	Very tolerant	Scattered in understory. May make a thicket in openings.	...	...	Too small and poor form for timber use. A moderate pest.
Buttonbush (Cephalanthus occidentalis and var. pubescens)	Buttonball	Widely in deep sloughs and swamps	Poor	Moderately intolerant	Prolific in openings after heavy cutting and fire	...	...	A large bush or shrub which has ruined much swamp site.

SPECIES OCCURRING BUT UNCOMMON IN THE SOUTHERN BOTTOMLANDS

Durand oak (Quercus durandii)
Primarily an upland tree east of the Mississippi River but occurs scattered on well-drained bottoms west of the River. General appearance and characteristics suggest a hybrid between cow oak and either overcup or post oak. Utility similar to cow oak.

Swamp white oak (Q. bicolor)
A northern species that occurs very rarely on the upper fringe of the southern bottomlands.

Basswood (Tilia spp.)
Upland trees that occur rarely on best terrace and colluvial sites. White, tasteless, odorless wood, extremely light and tough.

Pumpkin ash (Fraxinus tomentosa). Scattered throughout on wet flats and in swamps. No practical difference from green ash.

Black cherry (Prunus serotina). Scattered throughout but very sparse on oldest terrace and colluvial sites. Lumber and veneer highly prized for furniture and cabinet work.

Atlantic white-cedar (Chamaecyparis thyoides). Concentrated in swamps of the eastern Gulf Coast and south Atlantic Coastal Plain. Quite similar to cypress in utility.

Florida maple (Acer floridanum) and sugar maple (Acer saccharophorum)
Scattered widely but sparsely in smaller bottoms. Not in the Mississippi Delta.

Osage-orange (bois d'arc) (Maclura pomifera)
Fairly common on small bottoms in northern parts of Louisiana and Texas and south Arkansas and Oklahoma. Very durable wood, highly prized for fence posts. Too small for common use but welcomed for specialties such as insulator pins and archer's bows.

Catalpa (Catalpa spp.)
Sparsely on terrace sites and small bottoms in central Mississippi and Alabama and southwest Georgia. No particular commercial use except fence posts.

Flowering dogwood (Cornus florida)
An upland species that rarely extends to the best and oldest terrace sites. Sought for shuttle blocks.

Southern waxmyrtle (Myrica cerifera)
A shrub of the lower Coastal Plain that frequently fringes and occasionally invades the bottomlands.