Forest Resources of Liberia

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Preface

The Liberian Forest Survey was one of the projects of the United States Economic Mission to Liberia. This Mission, initiated by the Foreign Economic Administration in 1944 and continued after 1946 by the Department of State, had the following broad objectives:

To make reconnaissance surveys of Liberia's resources.

To make recommendations for the development of those resources, and

To give technical aid and advice in the operation of projects to increase Liberia's production of agricultural and other commodities for internal use and to develop surpluses of such raw materials as rubber, cacao, timber, palm oil and fibers, iron ore, industrial diamonds, and cola nuts.

The information here presented on Liberia's forests should serve as a guide for planning the development and utilization of this valuable resource.

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By KARL R. MAYER *

Introduction

Previous studies

Liberian forest resources are the least surveyed and most poorly described in West Africa. Before the exploratory work of Firestone in connection with the establishment of rubber plantations, examinations of Liberian forests were confined to localized scouting for exploitation possibilities. Such examinations, most of them by Europeans, were confined to coastal areas and resulted in intermittent, light cuttings on the lower reaches of the Cavalla, Grand Cess, Sinoe, Sangwin, Cess, St. John, St. Paul, Loffa, and Morro Rivers during the period from 1850 to 1930. The total area thus operated probably did not exceed 50,000 acres.

Failure of the original tropical evergreen rain forests to reach to the coast, except in a few areas, discouraged early forest exploration for commercial purposes. During the nineteenth century, camwood *(Baphia spp.)* was an important Liberian export, and most early forest activity was directed toward locating and removing this dyewood.

Botanical studies were made by several scientists in the nineteenth century and early in the twentieth, but the results have not been generally available. Limited studies of coastal flora were made by T. Vogel in 1841, P. Schoenlein in 1855, Naumann in 1874, and O. F. Cook in 1895-96. Other early collections were made by D. Sim in the Greenville area (1901), H. Reynolds on the lower St. Paul River (1905), and Sir Harry Johnston in several coastal areas (1907). Beginning in 1903, Alexander Whyte made forest investigations for the Liberian Development Chartered Co. in localized areas near Kakata, in the lower Sinoe River basin, and on the Kru Coast eastward from Greenville. M. Dinklage made botanical collections over much of the Liberian littoral from 1898 until his death in Monrovia in 1935. Unfortunately, his collected material and writings are not available today.

The early explorers devoted most of their efforts to forms lower than trees, largely because of the difficulties encountered in studying tree flora under tropical conditions. Employees of the Liberian

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Rubber Corp., successor to the Liberian Development Chartered Co., apparently confined their activities (1900-10) to the extraction of wild rubber.

An eight-man Harvard African Expedition visited Liberia in 1926-27 and traveled through parts of the interior. A medical survey being the primary objective, Liberian flora was but lightly treated in the expedition report. [1] David H. Linder's botanical report of Liberia, chapter 23 in the first volume of this publication, is of narrative or travelog type and contains no species lists, keys, or similar data concerning forest trees. Collections and observations were limited to the drainages of the St. Paul, Du, and Farmington Rivers, from the coast to the vicinity of Belleyella and Bellefanai. Of 1,601 flora specimens collected, only 182, or about 11 percent, were from trees, all but a few of which were of species having no commercial value.

As part of the early activities of the Firestone Plantations Co., general explorations were made in a number of coastal and near-coastal forest areas. Nothing of scientific value in the way of published reports resulted from these forest studies, probably because of failure to collect material and determine the identity of trees.

Part of the Firestone Harbel area was covered by a scientific study of forest flora in 1928-29. The report upon this study is the only readily procurable publication dealing with the timber trees of a Liberian forest area. [2] Confined to a small part of the plantation on the Dukwia (Dubwe or Du) River, which supports secondary forests, this study failed to include many species of large timber trees found deeper in the interior but not occurring in such proximity to the coast. The abbreviated and unkeyed descriptions of individual tree species in the Yale report are of minor value for dendrological purposes, but the macroscopic wood descriptions and timber-testing results are excellent, representing for some of the species the only data of this sort published to date.

Since 1920, George W. Harley and Mrs. Harley of Ganta Mission have made botanical studies in the Ganta area. Mr. Harley, who also operated a small sawmill at the mission, included a number of timber trees in these investigations. Local woods were sawn and utilized for various purposes after their working qualities and potential uses had been determined. In late 1943 and early 1944, Joseph C. Bequaert made some limited collections of flora for the Arnold Arboretum. In recent years, some brief generalized reports on Liberian forests have been made by members of the United States Economic Mission, but no comprehensive study of over-all forest resources has been attempted.

[1] *The African Republic of Liberia and the Belgian Congo*, 2 v., Harvard University Press, 1930.

[2] Cooper, G. Proctor 3d, and Record, Samuel J. *The Evergreen Forests of Liberia*. Yale University: School of Forestry Bul. No. 31, New Haven, 1931.

Purpose of present study

In brief, the study reported in this bulletin had two major objectives:

1. To determine the approximate area, volume, composition, quality, distribution, and operability of Liberian forests.
2. To recommend a program for the protection, development, and rational utilization of the forest resources.

Most of this bulletin is confined to the procedures and results obtained in connection with the first of these objectives. Most of the interior forests had never been examined, and there was no basis for a sound analysis of the forest resources as a whole. The primary consideration, therefore, was to assemble enough reasonably accurate knowledge of the forests to permit evaluation of their potential economic importance and provide a basis for a forestry program.

Every effort was made to draw upon reliable scientific aids to expedite such a broad reconnaissance. Great limitations were imposed by lack of trained assistants, and by inadequate equipment, travel problems, and difficult working conditions in the field. But it is believed that enough data and factual information have been obtained, at a preliminary level, to clarify the Liberian forest situation and generally satisfy the purposes of the assignment.

Methods employed in present study

It was necessary to limit field work to a reconnaissance that one man could make without assistance and with very little equipment. To get a representative sampling of forest conditions throughout the country, it was necessary to travel quickly and lightly. Problems of extensive foot travel in forest areas during the rainy season restricted accomplishment, but field work was done in all but 3 months of the year, i.e., from August through October.

Seven major field trips were made from March 1947 through February 1949. The first, in March and April 1947, was to forest areas in the Gold and Ivory Coasts to observe conditions, forestry practices, forest operations, and species exploited, as a background for Liberian field work. The other six trips were made within Liberia and in French territory immediately adjacent. Exact routes of travel were mapped and mileage logs were kept for all field trips.

Aerial photographs covering practically all of Liberia were taken by the United States Army Air Force during late 1945 and early 1946, in what was known as the Casey Jones Project. The photos were of great value in planning and carrying out field work and became the basis for much of the forest location, area, and volume data presented herein. The writer had taken a course in phototopography and worked as a photogrammetrist during

World War II, and was in a position to utilize the available photographs.

A total of 57 sorties and 6,950 prints were involved, but no usable index maps had been prepared. To serve his purposes and those of other staff technicians, the writer first assembled an uncontrolled mosaic of the Western Province with the 9″ x 9″ prints. All photos were then indexed on the best map available, and rough photomaps of major forest areas were later prepared at photo scale, 1:40,000. By stereoscopic examination of stereopairs (two overlapping photos), the limits and general character of high-forest areas were determined. In subsequent Western Province field work, many stereopairs covering parts of the route of travel were carried, the concerned locations were visited, and the actual forest conditions were checked against photo characteristics. A basis for interpretation of the photographs in terms of forest conditions was thus established, permitting a rough classification of all forest areas having photo coverage. Eventually, this classification practice was applied to about 95 percent of the country's high forests.

Definite limitations in the use of aerial photography must be recognized, particularly in tropical rain-forest areas. The closed canopy of all high forests prohibits accurate determination of tree heights and makes difficult the preparation of contour maps by use of a stereocomparagraph. Little can be determined as to forest composition, although several individual species can be spotted with a stereoscope at any season, and a few additional species at certain seasons, at the time of foliation, for example. With careful application of ground checks against photo detail, some basis for forest density or volume determinations is possible, but such determinations are very rough and in no way eliminate the necessity for ground work in assembling forest reconnaissance data.

Hydrography is readily determined from the photos, except in the case of small streams. Although forest trails are rarely visible, roads and trails in other than high-forest areas are usually prominent. All occupied areas show up clearly. Since trees of great size are almost never found within the limits of villages, very accurate hut counts may be made. The segregation of dense high forest with closed canopy from broken-canopy forest and low bush is not difficult, and this use of the photography was probably its most important one, aside from its general geographic use.

Travel routes on all field trips were selected in advance on the basis of studies of the photo coverage. So far as possible, travel was planned to minimize mileage in nonforest areas and to concentrate on the major high-forest areas. Travel was aimed at a sampling of all forest types and conditions in all sections of the country. For all trips except the two in Western Province, photomaps on tracing cloth, at photo scale, were prepared in advance and carried in the field. This involved the assembling of mosaics for the entire Eastern Province and for the forested sections of the Central Province. Time devoted to phototopographic and photomapping work was great, but without the data provided by the photography, the present report would have had little foundation as to forest areas and

volumes. Use has been made of the photomaps and related photo data in other phases of the United States Economic Mission program, and the preparation of a reliable Liberian base map by mission engineers was greatly facilitated by the availability of such maps and data.

All field travel was logged in as much detail as was practicable. Field notes were transcribed each night and summarized at the end of each trip. All travel other than by air, water, or vehicle was afoot. There was no hammock travel. Travel time was carefully recorded, with time notations for such items as change in forest cover, change in average forest volume classes, entering and leaving all nonforest land classes, road and trail junctions, stream crossings, all inhabited places, major topographic features, and breaks in travel. At frequent intervals, as required by trail conditions, paced 1- or 2-minute checks of travel speed were made in miles per hour to the nearest tenth of a mile. On the average, such travel rate checks were made at 10- to 15-minute intervals, as estimating of travel rate under tropical forest trail conditions is extremely difficult, even after long experience.

For each notebook time entry, direction of travel and rate of travel in miles per hour to the concerned point or feature were noted. In transcribing field notes, distance between successive points was computed to the nearest tenth of a mile and summarized for each day's travel. All foot travel was done with a pocket compass in hand, and average direction of travel observed and recorded to the nearest of 16 compass points, e.g. NNE., WSW. Hut counts were made in every inhabited place visited, including only structures actually occupied as living quarters. These counts facilitated spotting of inhabited places on the aerial photos or photomaps, the latter having been prepared to include notations of numbers of structures visible in each village, half-town, or farm area. The hut counts were also of value in later preparation of Liberian base maps.

Forest areas were classified throughout the 2 years of field work as low bush, broken bush, and high forest. Low bush included all areas recently farmed, having no true canopy. Here, whatever merchantable trees occurred were scattered. Typically, low bush is a dense, tangled growth from 10 feet or less up to about 50 feet in height of dominant stems, of relatively uniform though very mixed composition, and with complete ground cover. Off the trails, one usually cannot penetrate it without cutting a path.

Broken bush included all areas in which the dominant, codominant, and intermediate stems (combined, these trees make up the high-level canopy) did not form an unbroken canopy and in which the gross volume per acre in merchantable trees of all species was 5,000 board feet or less.

High forest included all areas in which the dominant, codominant, and intermediate trees formed an unbroken closed canopy and the gross volume per acre in merchantable trees of all species exceeded 5,000 board feet. High forest was further classified into volume classes of 5,000 board feet each: 6,000 to 10,000 board feet per acre, 11,000 to 15,000 board feet per acre, etc. These volume

classes were estimated ocularly throughout travel in high-forest areas, and changes in average volume class noted for later determination of travel mileage by volume classes. A minimum of 20 chains, or ¼ mile, of extent along a travel route was used to justify recording a volume class, and the same requirement was applied to all land classification.

Few departures from the combined canopy and volume requirements for high-forest and broken-bush classification were noted, but in such cases the canopy was considered determining. Rough 1-acre plots (33 feet on each side of the trail for 10 chains) were tree-counted, and an average volume per tree was applied to check merchantable volume estimates. This crude sampling permitted rough determinations of average acre volumes and subsequent extension of such volumes to weighted volume estimates for large areas, based upon acreages derived from photo data.

As field work progressed, an arbitrary breakdown of high forest was made. That which had a gross volume per acre in merchantable trees of all species of more than 15,000 board feet was considered primary high forest, and the rest, secondary high forest. Measured sample plots were taken at intervals to check ocular estimates and to obtain stand-table data. These sample plots were either 1-acre circular plots or rectangular plots averaging 1 acre (1 chain by 10 chains). All plot radii or limits were taped, all tree diameters were measured either with a diameter tape or a cruising stick, and merchantable heights were measured with an Abney level. Individual tree species were not reported on sample plots because of the excessive time required for accurate identifications, but predominating species and species groups were noted when known.

In all field work, a merchantable tree was considered one having a diameter of at least 2 feet outside bark, at breast height (4½ feet above average ground level), or at a point 1 foot above the butt swell, and containing one or more merchantable 16-foot logs. On sample plots, trees were tallied by 2-inch diameter classes and number of whole logs. Many Liberian timber trees are prop-rooted or have basal flares, flanges, or swellings, which prohibit stem diameter measurements at breast height. For large trees with such basal features, it is necessary to climb above ground to measure stem diameter above the influence of such abnormalities. No fixed top merchantability limit was used, each tree being estimated on sample plots to point of forking or heavy branching. Excessively crooked or otherwise defective trees were considered unmerchantable, and dead trees were excluded.

All tree and stand volumes were based upon the International ¼-inch log rule for the average all-species form class involved. No defect data being available to determine percentage of cull, all gross volume summaries have been reduced by 10 percent to allow for defect and wastage. Ocular estimates were made of the average-acre volumes in stems between 1 and 2 feet in diameter outside bark at the points described above, to provide some basis for estimates of unmerchantable volumes in broken-bush and high-forest areas. Such estimates were reduced to percentages of merchantable volume as field work progressed, and the unmerchantable stand

volume was found to vary inversely and fairly proportionately with merchantable volume.

No reproduction studies were made, nor was any attempt made to classify and record forest-cover types, subtypes, or associations of species. Site factors were noted in a very general way, but no site classifications were attempted.

All streams encountered in travel were recorded as small streams if under 10 feet in average channel width, medium streams if 10 to 50 feet in width, and large streams if over 50 feet in width. The width of all large streams at point of crossing was estimated and recorded, along with notes on banks, current speed, rapids, type of channel, and so forth. Usually such crossings of large streams in high-forest areas could be located on the photographs by means of channel features or large stream-bank trees. The direction of flow of all streams was recorded for point of crossing.

Directions and distances to prominent hills or other landmarks from points on the travel route were noted. Duration of rains during daylight hours was noted to the nearest hour, along with other very general weather observations. Place names were listed on the basis of the best local information available. The photomaps were posted at intervals to add travel route data, enter correct hut-count figures, and determine average factors for converting airline distances to ground-route distances. A copy of an average day's field notes, with explanation of abbreviations and symbols used, is shown in appendix IV.

Dendrological work was a major problem from the outset. It was felt that identifications of timber-tree species on the ground was essential to the success of the project, but the difficulties to be overcome were great. Before the fall of 1947, no adequate flora handbooks were available, and recourse was made to groping rather blindly through unkeyed and unillustrated publications that provided some coverage of Liberian tree species.

Collections of botanical specimens were made in the course of all field work, but not until the fall of 1947 was collecting done with a view to preservation and use for permanent herbarium purposes. Lack of proper equipment and facilities, both field and office, hampered this work, and there were many field problems in connection with procuring, handling, and transporting specimen material. The writer had had no previous experience with the flora, which is very complex, and no specialized taxonomical training. Time devoted to field identifications could not be allowed to interfere excessively with general reconnaissance, yet without a working knowledge of tree species, the value of reconnaissance work would be greatly reduced. The solution of simply collecting and sending the collections outside the country for identification was felt to be undesirable, as the only sure method of learning tree species is to identify them on the ground. Furthermore, the time lag between observation and collection of material and eventual determination of identity would prohibit application of the knowledge gained at the time and place and in the way that it should be applied. Little progress could be made in other phases of the assignment without more knowledge of the Liberian timber trees.

It was for the reasons cited that a dendrological project was begun when adequate flora handbooks were finally procured. This work was extremely tedious and time-consuming, but it is believed that it will prove a most valuable contribution to future forestry work in Liberia, and it has made possible a much more comprehensive report upon Liberia's forests than would otherwise have been the case. Most of the collections of leaves, flowers, fruits, and seeds of timber trees were made on the last four field trips. Most material was collected on side trips from stop-over points or during breaks in daily travel, but a considerable amount was collected during travel.

Trees are the last segment of any tropical flora to be well-known, owing to the difficulty of collecting botanical specimens. In the absence of felling operations, in connection with land clearing or commercial timber operations, there are no easy means of getting good specimens. Cutting down individual trees was too time-consuming for other than small trees. Climbing was much used, but again large, long-boled trees were not susceptible, unless well-hung with vines and lianas. Dislodging with thrown objects served for relatively small trees, but most collections from large trees were obtained by shooting, either with rifle or shotgun. Much material, of course, was available on the ground, but uncertainty as to origin usually rendered it unusable. Eight-power binoculars were carried at all times and proved of great value in dendrological work.

All specimens were transported on the day of collection in large rubberized canvas bags. Upon reaching the stop-over place, work was immediately begun to identify and preserve the specimens. Leaves and flowers were placed in plant presses, utilizing slatted wooden frames, heavy blotting paper, folded newspaper, and heavy cardboard or manufactured corrugated metal spreaders, and the whole was bound with rope. Since there was little opportunity to use sunlight, practically all drying was done over wood fires in native huts. Completely waterproof covers or containers for the presses were never available, and considerable damage and loss resulted from rains and accidental submergings during stream crossings. As identifications considered final were made, collection numbers were assigned and all pertinent data recorded. All identifications were made from two sources. [3]

Duplicate leaf specimens were preserved whenever available, along with unidentified specimens. Fruit specimens were preserved if subject to dry storage, as facilities were not available for preservation in liquids. An unfortunately large proportion of forest tree fruits are fleshy, bulky, or otherwise not susceptible to dry storage or easy handling in the field. All fruit and seed specimens were placed in individual envelopes or other containers and protected with naphthalene flakes. Flowers were handled as were

[3] Hutchinson, J. and Dalziel, J. M. *Flora of West Tropical Africa,* 4 v., Royal Botanic Gardens, Kew, England, 1927, 1928, 1931, 1936.
Aubréville, A. *La Flore Forestière de la Côte. d'Ivoire,* 3 v., LaRose Editeurs, Paris, 1936.

leaves, but very few were usable after drying. Wood and bark samples were collected in small numbers, as the problems of obtaining and transporting adequate wood samples were never solved. Many wood samples which could not be taken with the party due to shortage of labor, were eventually lost; and few left at points enroute for later transportation to Monrovia ever reached their destination. Collection of wood samples is best handled under field conditions in Liberia as a separate project or in conjunction with felling operations.

A total of 235 Liberian tree species were identified by the writer by methods outlined herein. Leaf specimens of most of these species were mounted on 12″ x 16″ manila envelopes, no other mount material being available, and cellophane tape was used in mounting. A typed card giving pertinent collection data was stapled to each mount. All mounted leaf specimens, along with flower, fruit, and seed specimens, when available, were photographed and 8″ x 10″ enlarged prints made. The quality of the prints is not as good as is desirable but is the best that could be had locally from the mounts, which offer too little tone contrast for good photographic work. All photographs were taken indoors under flood lamps and without proper facilities for fixing loose specimens in good position and getting true vertical exposures.

Other methods employed in office procedures for field data are covered in other sections of this report. All field procedures in this survey were crude, and many office procedures were similarly less precise than those followed in such work in most countries. These weaknesses were inherent in the project and, under the working conditions encountered, were largely beyond remedy. The knowledge that infinitely more must be done in the field before a complete analysis of the forest situation could be made was not allowed to prejudice the present study insofar as objectives were concerned.

A single principle was followed: to learn as much about Liberia's forests as one man could learn in a few years with the facilities at hand and under the conditions encountered. Many desirable investigations could not be considered, many more had to be conducted in the most expeditious rather than the most effective way, and only a few were of a type that an individual technician can properly handle. It was necessary periodically to revise downward the standards which could be met under the limitations imposed. Despite many shortcomings, it is believed that the results obtained are essentially sound, when considered in their proper perspective, and are also conservative. Every effort was made to select and employ methods so as to obtain quantitative and qualitative results that were not above the average but preferably somewhat below.

All place and natural feature names used in this report follow the spelling of the 1949 United States Economic Mission preliminary base map of Liberia (1: 500,000) if shown thereon; otherwise they follow the spelling of the Firestone map of Liberia as of August 1943. Places not shown on either map are spelled as suggested by local pronunciation.

TABLE 1.—*Summary of major Liberian forest reconnaissance trips made by K. R. Mayer*

Date and Province	Duration	Distance by mode of travel									
		Party					Personal				
		Afoot	Air	Water	Vehicle	Total	Afoot	Air	Water	Vehicle	Total
	Days	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*
1947:											
April 16–May 4: Western	19	205			39	244	289			39	328
May 21–June 13: Western	24	267			19	286	333			20	353
Nov. 7–Dec. 23: Eastern	47	245		335		580	435		338		773
1948:											
Apr. 22–June 15:											
Eastern	79	664		105		769	793	450	137	232	1,612
Central	6	59			202	261	35			226	261
Total	85	723		105	202	1,030	828	450	137	458	1,873
Nov. 16–Dec. 3: Central	17	165			499	664	165			499	664
1949:											
Jan. 19–Feb. 11:											
Western	15	145			41	186	180			41	221
Central	9	66			583	649	85			599	684
Total	24	211			624	835	265			640	905
Total by Provinces:											
Western	58	617			99	716	802			100	902
Central	32	290			1,284	1,574	285			1,324	1,609
Eastern	126	909		440		1,349	1,228	450	475	232	2,385
Grand total	216	1,816		440	1,383	3,639	2,315	450	475	1,656	4,896

Field trips

Table 1 summarizes forest reconnaissance travel within Liberia during the 2-year assignment. Observations of forest conditions and related matters were made on many additional short trips, incidental to purposes other than forest reconnaissance. On all major forest reconnaissance trips, personal travel was recorded apart from that of the party, the latter being inactive during stopovers. Depending upon length of trip, source of labor, and other factors, the number of Liberians in the party ranged from 15 to 30 men, averaging about 25. All party equipment and supplies were head-loaded during travel in the interior. Vehicular travel was largely confined to beginning and completing trips from points along the few Liberian motor roads. Water travel consisted of coastal trips between Monrovia and beginning or ending points of foot travel, or travel along lower river stretches, the former by small motor vessel or surfboat, the latter by canoe. Air travel between Eastern Province points was under very poor visibility conditions and hence contributed little to survey purposes.

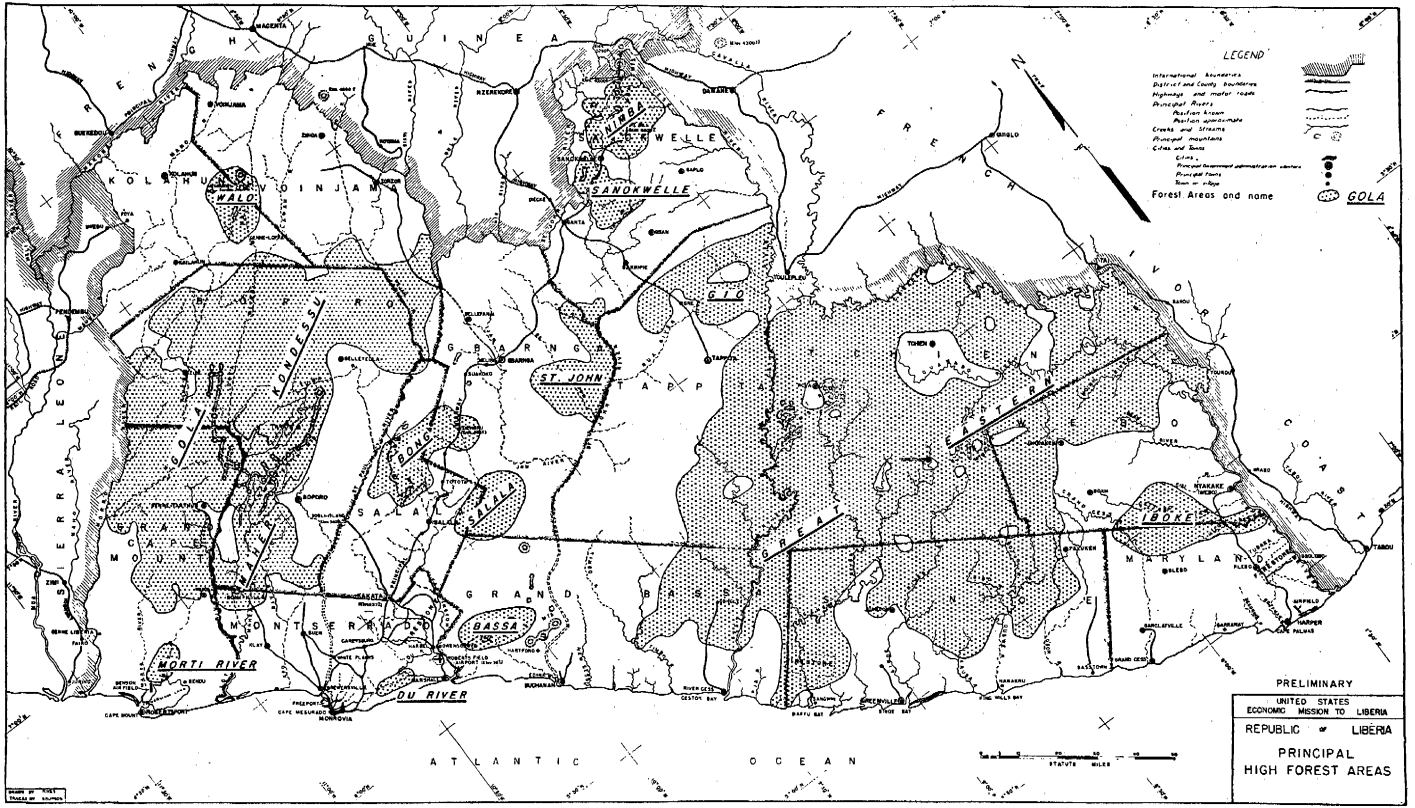
Physical Aspects of Liberia

Geography and topography

Liberia occupies part of the tip of the great West African bulge, lying closer to South America than any other part of Africa. Beginning at the Cape Palmas turning of the Gulf of Guinea coast, at a point nearer the Equator than any other Guinea coast area west of the Niger delta, Liberia's coastline extends about 370 miles northwestward. In general, Liberia is the most southern portion of the land which slopes to the Atlantic from the Fouta Djallon Mountains and the Massif du Tamgue, the sources of the Niger, Senegal, and Gambia Rivers. Outposts of these highlands occur in extreme northern Liberia.

Because of the relative narrowness of this southward sloping base of the northern highlands, none of Liberia's river systems are extensive. All the major rivers, the Morro, Loffa, St. Paul, St. John, Cess, and Cavalla, rise in French territory. Bounded, clockwise, by Sierra Leone, French Guinea, and the Ivory Coast, Liberia's approximate 37,200 square miles extend from about 4°30′ to 8°30′ north latitude and from about 7°30′ to 11°30′ west longitude. There are no fresh-water natural lakes and no large inland swamps within its boundaries. The coast is remarkably unindented. It is relieved only by promontories at Cape Mount, Monrovia, and Cape Palmas, and its tidal lagoons and mangrove swamps are much less extensive than those of the Gold and Ivory Coasts.

The hydrography of the country is shown on the map (p. 12) to a greater degree of accuracy than on any previous maps. Similarly, major mountain areas are better represented than hereto-



Republic of Liberia: Principal high-forest areas.

fore, it having been possible to strengthen this preliminary base map by reference to aerial photography. A narrow coastal belt of flat land, in most places devoid of high forest, is succeeded inland by a belt of gently to steeply rolling country of variable width. The latter belt is greatly dissected by narrow valleys and supports typical tropical evergreen rain forests, as well as the bulk of the country's agriculture. Farther inland, hillier country rises to poorly defined plateaus, and in places low mountains occur, but prolonged mountain ranges are not found.

Mountains in the extreme northern parts of the Western and Central Provinces rise to 4,500 feet. Secondary mountains occur in the northern half of the Eastern Province and produce the curious divergence of the lower Cess and Cavalla Rivers, which to the northward are in very close proximity. While the belts of relief described above are definite enough for mention in a gross geographic description, all but the coastal quarter or less of Liberia is of complex topography and probably presents a more disjointed mixture of topographic features than any other West African area. Only by careful topographic interpretation of aerial photography can the extent of this lack of conformity to broad topographic trends be fully appreciated.

No Liberian streams other than the Cavalla are navigable except for 3- or 4-foot drafts in the 10 to 20 miles from their mouths to their first rapids. The Cavalla River is navigable to just above Webo, some 50 miles from its mouth. The mouths of all rivers are blocked by sand bars, particularly dangerous during the dry season, and some rivers have rocky reefs. Most stream channels are braided with many rapids and small islands. Gradients are steep and most streams overflow their banks during the rainy season. Throughout the country, stream channels are remarkably sinuous. The most dominant strike of the major relief is southwest to northeast, but in many areas the topography is extremely complex. Extensive rocky outcrops are rather uncommon over the country as a whole. A conspicuous feature of the extreme northern parts of the Western and Central Provinces is the isolated, smoothly rounded balds, supporting a sparse herbaceous and grassy vegetation and often exhibiting extensive bare rocky faces. Such domes were not observed in the Eastern Province.

Erosion appeared to be of consequence, as a natural feature, only in the northernmost sections of the country, particularly in the Western Province. Localized erosion is common within the town sites in all hilly to mountainous areas.

Climate

The Liberian climate has been described, to the extent that available meteorological data permit, in other reports of the United States Economic Mission to Liberia. Sufficient data to define adequately climatic conditions throughout the country will not be available for many years; hence only broad generalities are possi-

ble in discussing this most vital feature, which exerts so much influence on many Liberian matters.

Rainfall is more clearly reflected in the forest vegetation than is any other climatic feature. Disregarding a relatively small and unimportant zone of coastal swamp forests, the major zones of forest cover in the country are primarily a product of rainfall. Very roughly, the belt in proximity to the coast which receives from 125 to 200 inches or more of rain per year supports typical evergreen rain forests. Farther inland, a belt receiving from 75 to 125 inches supports deciduous forests; and northern areas with less than 75 inches have savannah-type forests intermingled with grasslands.

The rainfall and vegetative cover of adjacent areas support the belief that the Liberian climate is unique in West Africa because of its excessive localized precipitation, which does not fit into the over-all regional picture. Thus, in the Eastern Province, typical rain forests apparently extend much farther inland than at any point in West Africa except in a narrow Ivory Coast area between the Liberian border and the Sassandra River. It is believed that there is also less sunshine in the Eastern Province as a whole than elsewhere on the Guinea Coast: cloudy days are more frequent and sunlight is less intense. Liberian rainfall is concentrated in the May-to-October period, but the month of maximum rainfall appears to vary considerably, not only in various localities, but from year to year. The November-to-April dry period carries with it harmattan winds so dust-laden from their desert origin that visibility is greatly reduced.

Hot and humid, the Liberian climate is conducive to rank vegetative growth, entirely broadleaf or hardwood as concerns native forest-tree species attaining merchantable size. Daily mean temperatures probably range from 80° to 85° F., with maxima of 100° to 105° and minima of 45° to 50° at the greatest elevations. Hail has been observed in northern areas. The daylight range of temperatures is not great over most of the country, probably averaging 15° F., but changes up to 30° were noted in mountain country. High relative humidity greatly influences vegetation and also makes the Liberian forests in their natural state practically fireproof. Relief from the high humidity, which ranges from 60 to 90 percent during most of the year over most of the country, is gained in some degree at high altitudes and during the middle of the dry season. It is the excessive humidity rather than the temperature which makes arduous field work in forest areas very fatiguing for foreigners, and also makes the proper care of field equipment and the satisfactory handling of field data and records a constant and annoying problem.

Soils

A final report, *Reconnaissance Soil Survey*, recently submitted by William E. Reed, Agricultural Research Specialist, United

States Economic Mission to Liberia,[4] presents the most complete analysis of Liberian soils made to date. Reference is made to this report for details of the forest soils of the country. No soil investigations of a technical nature were made during the present study. In general, it was considered that the soils of the rain forests and those of the deciduous forests differed but little in gross characteristics. Rain-forest soils appeared to contain adequate organic matter for tree growth, though the humus was not as heavy as anticipated.

Deciduous-forest soils were more shallow, with deeper surface litter, and generally rockier. All forest soils are probably very acid, and deficiencies of some elements needed for optimum growth conditions undoubtedly occur. Forest soils appeared to decrease in quality inland, and the northern part of the Western Province was considered to have the poorest soils observed in Liberia. There can be little doubt but that the great bulk of Liberian soils are far better suited to tree crops than to any other more intensive and demanding use, particularly as for agriculture on a permanent basis. The torrential rainfall and resultant leaching out of soil nutrients are ameliorated by full protective cover, which serves also as insulation from high temperatures. Bare ground temperatures in bright sunlight of up to 130° F. were noted.

Changes in soils following removal of original forest cover, intermittent agricultural use, and reversion to forest cover must be carefully studied if future applications of silvicultural systems to Liberian forests are to be fully effective. There is a smattering of information on the silvical characteristics of a few species of West African timber trees of major importance, but for the vast majority of the species that will be of economic importance in future Liberian timber operations, nothing in regard to soil and other site-factor demands is known. Vegetative successions following forest clearings will be of great importance in all future forestry work in Liberia, and a knowledge of soil changes under various silvicultural systems will be requisite for successful forest management.

Economic Factors

Population and labor

An attempt was made to sample the population in the course of the forest reconnaissance field work. This was done by counting the inhabited huts in every occupied place visited, from the smallest half-town or farm community to the largest villages. These counts were compared to hut counts made from aerial photographs and to hut counts used for official taxing purposes. All abandoned villages

[4] Reed, William E., *Reconnaissance Soil Survey of Liberia*, Agriculture Information Bulletin No. 66, U. S. Department of Agriculture, Washington, 1951.

were noted and period of abandonment determined as nearly as possible; also, new villages not appearing on the 1945-46 aerial photographs were noted.

Although adequate sampling of the average number of occupants per hut for the entire country is a virtual impossibility, the writer estimates this number as seven. On the basis of the meager check secured, together with an adjustment of the total hut count used by the Government, total Liberian population in 1949 is estimated at between 1 million and 1.1 million, or about 28 people per square mile. There are many indications that the population has been greatly reduced in the past two or three decades. Greatest population losses are believed to have occurred recently in the Eastern Province, where abandoned villages are, in some sections, very common.

An impression was gained that, at ages below adolescence, males outnumbered females and that this circumstance was reversed in the adult population. The total labor pool of able-bodied adult males is estimated not to exceed 150,000. It is questionable whether more than a third of this pool could be safely diverted at this time to gainful employment other than subsistence agriculture. West African populations shift readily under economic and social pressures, and the present population would increase rapidly under improved developmental conditions. Any increase in population, however, poses real problems of subsistence because of the low order of food production throughout the country today. Naturally, the population density is lightest in the forested areas, and any large-scale or long-term forest operations would necessitate moving labor and reestablishing it in proximity to the areas being operated.

Of the total population, about 4,000 are foreigners, some 3,000 of whom are West African in origin. Most of the remaining foreigners are American, Dutch, British, French, Lebanese, and Swiss, in that order of predominance. Some 50,000 to 60,000 of the indigenous population are often termed "Americo-Liberians" and represent the descendants of the original American Negro settlers. Roughly 1 million people, or about 95 percent of the population, are aborigines. This group is broken up into dozens of tribal groups employing as many dialects. Although use of the official English language is largely confined to the more civilized areas along the coast and to the more accessible interior settlements, natives with a meager knowledge of English are today found scattered throughout the interior. Only in the more remote hinterland areas are villages found in which no one speaks or understands any English.

With a labor force currently numbering about 20,000 men, the Firestone Plantations Co. dominates the labor picture. Drawing upon every section of the country, recruiters have had no difficulty in enlisting laborers for the Harbel and Cavalla River plantations, even during wartime peaks of employment, until quite recently. The Raymond Concrete Pile Co., the Liberia Mining Co., and several recently organized subsidiaries of the Liberia Co. are the only other large-scale employers, with a combined total employment of less than 2,000 men at present.

Since the reservoir for future labor lies in the tribal areas, it

should be stated that the aborigines are not, by nature, background, or present social level, a promising source for any but wholly unskilled labor. Experience to date in Liberian developments, both by indigenous and foreign operators, clearly demonstrates the limitations of tribal natives in any pursuit with which they are not familiar. Though much can be done to make this labor more effective through education and training, the process is time-consuming and costly and the benefits are difficult to perpetuate. Previous experience in the utilization of such labor is of great value in initiating any new project.

People of most tribes are more naturally inclined toward manual labor in connection with forest operations than toward most other types of employment. The typical bush native appears to become adept with axe, saw, and other simple logging tools much more quickly and naturally than with other hand tools. He is strong of body and has great endurance. More important, he understands felling operations instinctively and appears to enjoy bush work. First-rate native logging crews are at work today on large operations in nearby colonies, and there appear to be no valid reasons why Liberians cannot do equally good work.

Milling presents a greater problem, with most semi-skilled and skilled positions calling for capabilities which most tribesmen do not possess and probably could not attain in a reasonable length of time. There is, however, a small but growing pool of West Africans who have acquired skill in the handling of logging and milling equipment and machinery. Employment of such men, along with Europeans and Americans, in key supervisory and performance positions would be essential to sound forest operations.

Transportation

Liberia lacks transportation of all types to a greater degree than any other West African area. The map (p. 12) shows the present road system in relation to the country's major high-forest areas. It will be noted that existing motor roads reach or traverse only a small portion of the forest area. Furthermore, most of these roads are not of high enough standard today to permit heavy-duty log or lumber hauling. An arterial road system from Monrovia to Ganta, with spurs to Sanokwelle and Tappita, involving a total of 260 miles, dominates the road setup. It is now carrying truck traffic, chiefly in produce, of 10,000 tons or more annually. Any large-scale log or lumber hauling would necessitate more maintenance and structure replacements than are currently being made. The road network on the Firestone Harbel Plantations, privately maintained, is of good quality with about 50 miles of the system carrying public through-traffic.

Another 10 miles of such good through-road occurs on the Firestone Cavalla River Plantations. Another privately maintained road between Monrovia and Bomi Hills, some 45 miles, is of fair quality. Two short sections of public road, maintained by the Government, from Monrovia to Brewersville and from Harper to

Plebo, totaling about 20 miles, are also in good condition. There is thus a total of about 385 miles of road which might be used for year-round transportation of forest products. This major road system is all laterite surfaced, with the exception of about 6 miles of bituminous surface, from Monrovia to Brewersville. Most of the stream crossings on this primary road system are by permanent bridges or adequate ferries, with a few small temporary bridges.

The rest of the existing motor roads, totaling about 325 miles, could not be used, in their present condition, for year-round or even seasonal heavy traffic in forest products. Many require relocation; all have inadequate bridges; most are improperly drained; and none receive adequate maintenance. Grades are excessive on practically all of these roads, which are entirely laterite surfaced. Traffic is very light and is largely confined to passenger cars and light trucks.

The total Liberian motor-road system of about 710 miles now offers usable access, insofar as forest operations are concerned, to approximately 5 percent of the operable high forest. If this entire road mileage were made usable for log and lumber hauling, the portion of the operable forest area thus tapped would still be less than 10 percent. New road construction, to a standard high enough to permit year-round heavy-duty hauling with road location referenced to operable forest areas, is essential to the development of Liberian forest industry.

Because of the limited navigability of the rivers, water transportation at present offers no outlet for forest products except on the lower Morti River at Fishermans Lake and the lower Du, Blohni, Sangwin, and Cavalla Rivers. The forest area tapped by the navigable portions of these streams is trifling, totaling only 1 or 2 percent of the entire operable forest area.

Fluming or blasting appear to offer no solution; for, above their first rapids, Liberian streams are of very bad channel, tortuous, braided, full of rocky outcrops and islands, and subject to great fluctuations in level. These streams are of remarkably low level in the dry season and become badly swollen, far out of their banks, during the torrential rains of the wet season. Any stream used for transportation of forest products would require improvements at the mouth to permit safe ocean entry. There are ample hydroelectric potentialities throughout the country, and electric power for forest industries in remote areas could be developed. Canoe and raft ferries are found at most major foot-trail crossings of streams throughout the interior, and limited stretches of the larger streams bear local canoe traffic.

A deep-water harbor, constructed with lend-lease funds by an American company, was officially opened on July 26, 1948, as the Freeport of Monrovia. Not yet developed to full capacity, the port accommodates 28-foot draft vessels and promises to be of utmost importance in stimulating Liberian development and trade. The port is managed by an American company and, with the facilities already in operation, is equal to any West African port between Senegal and Nigeria. The Farrell Lines operate a coastwise shipping service under the Liberian flag, concentrating cargo at Mon-

rovia. Large vessels are calling at Monrovia with increasing frequency, and there is a corresponding decrease in the calls at other Liberian coastal towns, where cargo and passengers must be handled by surfboat.

There is a tank farm at the Monrovia Freeport, and petroleum products reach interior points by drum or tank trucks. There is ample space available at the Freeport for the development of timber docks and the handling of logs or lumber, but nothing has been done in this matter to date. Harbor access is now being provided by the construction of a dual highway-railroad bridge across the lower St. Paul River, and a paved road from this river to the harbor area and Monrovia will soon be completed.

The Liberian Mining Co., which has an iron-ore concession in the Bomi Hills area, is preparing to start construction of a railroad—Liberia's first—from that area to the Freeport via the St. Paul River bridge mentioned above. The same company recently constructed a motor road to Bomi Hills, and all necessary surveys for the railroad project have been completed. Light, narrow-gage logging railroads appear to offer the most practicable means of transportation for large-scale, long-term forest operations in the major forest areas of the country. Ground conditions generally favor such transportation, if river crossings are held to the minimum compatible with economic operation. For temporary use, such railroads could be very lightly bedded, and suitable timber for such construction, including ties and bridge timbers, would be available at low cost. It is doubtful if such lines would serve any economic purpose other than that for which constructed.

Roberts Field, near Marshall, is a first-class airport, capable of accommodating the largest planes. Usable airfields for medium planes exist at Cape Palmas and Fishermans Lake, the latter being the former R.A.F. Benson Field. Flying boats may land safely at Fishermans Lake, in the Mesurado River at Monrovia, and in the Sangwin River at Sangwin. Other water landing places exist but require intimate local knowledge of conditions for safe use. Small landing strips for light planes are found at scattered interior points, including Zorzor, Sanokwelle, Suakoko, Tappita, Tchien, Grand Bassa, River Cess, Japuken, Japroken, Boah, Webo, Sasstown, Greenville, Buchanan, and Paynesville. With few exceptions, such strips are dangerous for use by those not familiar with local conditions.

Foot trails are the life lines of interior Liberia. They range from wide, smooth, open "big roads," with fair foot bridges, to narrow, rough, poorly brushed paths that are little more than game trails, with no bridges of any description. Over this network of trails moves the bulk of Liberian traffic, human and material.

Headloading is by far the most common method of transportation, though some areas use back-packing almost exclusively, usually with tump line. Loads vary considerably both with sex of carrier and other conditions, but are believed to average about 50 pounds for the country as a whole. Daily travel fluctuates greatly but probably averages 25 miles. Even at the prevailing rate of 25 cents per day, the ton-mile cost of about 40 cents is inordinately

high. Furthermore, there is high risk of damage and loss, particularly during the rainy season, when streams are swollen. With the exception of "big roads" constructed in the present century at Government direction, the native foot trails show little evidence of improvement. Some are obviously traces of great antiquity, worn 3 or 4 feet deep in areas not currently subject to heavy water erosion.

Trails in all sections of the country are remarkably direct in route, but, since no regard is given to gradient, they are of value in road construction only in areas of level or gentle topography. Regardless of brushed-trail width, all travelers use only a well-worn track, barely wide enough to accommodate the feet. Down trees are common in forested areas and are only rarely cut through. Typically, a detour loop around the obstruction is used. With infrequency of use, the trails become choked with brush and require cutting to provide clearance for head loads. Most major trails are cleaned annually, on a village-to-village basis. Bridges range from felled trees, lashed longitudinal poles, corduroy walkways, and other simple designs, up to the elaborate "monkey bridges" of suspension type, employing lianas and raffia.

Hammock travel of Government and tribal officials is fairly common on the main trails, usually by four-man hammock with canopy. On lesser trails, two-man pole hammocks without cover are sometimes employed, but on poor, little-used trails, hammock travel is impractical. Beasts of burden have not been used in Liberia, though unsuccessful attempts to introduce horses and donkeys have been made. Simple sleds are occasionally used, but wheeled equipment has never been employed. Use of draft animals in logging appears to be impossible. The tsetse fly would offer a problem, there would be other causes of disease, feeding would be difficult and costly, strength would be greatly reduced, and ground conditions would be too difficult for any animals other than oxen. Indian elephants could probably be introduced, but the expense and risk might well be prohibitive. Since manpower is highly inefficient in logging and in short supply, purely mechanical methods of skidding, loading, and transporting logs are strongly indicated.

Forest utilization, products, and markets

Liberia has never had a significant forest industry. During the nineteenth century, camwood, known also as logwood or red dyewood, was in great demand in world markets, and considerable quantities were exported from Sierra Leone. Two species of the concerned genus *(Baphia)* occurred in Liberia, and a fluctuating output of camwood represented the only Liberian trading in forest products during this period. Production was always in the nature of an entrepreneur enterprise, with the small quantities cut by individual native farmers in conjunction with forest clearing for agricultural purposes being headloaded to coastal points. The market subsequently disappeared as other dyewoods replaced camwood in world trade.

Timber explorations were conducted by Europeans in the early twentieth century but were confined to coastal areas and lower stream courses. There is no record of actual export of timbers prior to the period between World Wars I and II, during which very limited shipments of logs of a few species were made to European markets. It is known, however, that in the early twentieth century timber was cut on the Cavalla River, in conjunction with Ivory Coast operations, and shipped from Harper. Some additional timber was probably shipped from Robertsport at about that time. Production of export logs was always on a small-scale, individual-producer basis, and very sporadic. Since World War II a few small shipments of logs have been made, chiefly of secondary woods for experimental purposes. Several European users received sample log shipments from River Cess, Buchanan, and Robertsport in recent years.

During 1948 an American furniture manufacturer sponsored a timber-sampling operation in the Webo area with a view to determining the feasibility of entering into large-scale Liberian operations. Adequate volumes of 23 species were shipped from Harper in the log and tested in the company's plants. Although delayed shipment and improper handling of the green logs resulted in deterioration, the company interpreted the results of the test as not justifying further activity. European testings of Liberian woods have also resulted in no extraction operations to date.

There are no records of shipments of sawn lumber from Liberia on a commercial basis. During the past 25 years, a few small circular sawmills have operated intermittently in scattered localities. Until 1946 their output of sawn lumber was used by their owners—interior missions, private commercial groups or construction companies, or public agencies. Since 1946, a single private circular sawmill operator has produced limited quantities of lumber on a commercial basis, for marketing in the Monrovia and Robertsport areas.

In the summer of 1949, operation of a circular sawmill in the interior was begun by a subsidiary of the Liberia Co., but production cannot be gaged as yet. It is probable that private needs for housing personnel will delay production of lumber for the general domestic market. The same company plans to operate a small woodworking plant, supplying it with lumber from the sawmill. Another private non-American agency is also planning the operation of a woodworking plant in the Monrovia area. Of the several circular sawmills which have operated in Liberia in the past, only the two mentioned above, plus a third operated by the Ganta Mission, are now active.

The value of Liberian timber exports in 1946 was recorded as $12,046, as contrasted to imports of wood manufactures totaling $73,454. In 1947, timber exports were valued at $7,935, but data for imports of wood manufactures are not available. The 1949 timber-export figure is not available but will probably be lower than the 1947 figure. Timber export data for earlier periods do not exist. It is estimated, however, that the entire volume of Liberian timber exported prior to 1946 did not exceed 1 million cubic feet, or

about 22,000 short tons. It is also estimated that the total production of sawn lumber by all the circular sawmills that have ever operated in Liberia did not exceed 10 million board feet, or approximately 1.5 million cubic feet in the round, through 1948.

Total domestic use of timber has varied little in the past century. Volumewise, consumption of fuelwood, including wood for charcoal, dominates all other uses. Being largely dead material, salvaged at no cost from clearings made under shifting agriculture, fuelwood has little economic value. Only in coastal areas or along major motor roads is there any business in fuelwood, and it is of little consequence in the national economy. Throughout the interior, procurement of fuelwood is a day-by-day activity, the supplies for each family unit for a day or two being headloaded into the villages from the farms, largely by the women and children. Since fuel supplies are not stored ahead and since rate of consumption is difficult to determine, only a very rough estimate of annual consumption may be made. On the basis of observation throughout Liberia, it is estimated that annual consumption of fuelwood totals 45 million cubic feet, of which 95 percent comes from dead and down material on farm clearings, the rest coming from trees in other areas cut for other purposes.

Secondary domestic uses of wood, such as for house poles, hand-sawn lumber, canoes, mortars, pestles, utensils, and furniture, are estimated to total 2 million cubic feet annually. As with fuelwood, practically all utilization for these secondary purposes involves no purchase of stumpage or sale of product; hence it makes no appreciable contribution to national wealth. Limited quantities of hand-sawn lumber produced over the past 50 years have been marketed in developed areas, most of it with no exchange of money. Production of such lumber of very low quality and poor manufacture has been largely confined to areas immediately tributary to the coast or to the motor roads. Pit sawing is not practiced in Liberia, all logs and timbers being sawn into planks on racks constructed of poles.

During World War II and thereafter, accelerated construction activities in connection with military operations and economic-development projects have resulted in some increase in hand-sawn lumber production, but the total volume produced annually does not exceed 0.5 million board feet, representing about 70,000 cubic feet in the round. The cutting of timber for all secondary uses involves small understory trees of little potential commercial value, or widely scattered trees of larger size, removal of which has no effect upon stand operability.

A wide variety of minor products is taken from the forests in connection with native subsistence, medicine, and household activities. Fruits and seeds of many arborescent species are gathered, along with twigs, bark, roots, gums, and flowers. In the aggregate, removal of these products has no effect either upon the forests as a whole or upon the national economy. In former years, a few such products found their way into trade, and several were exported in very small quantities. Examples of the latter were kombo oil or kafu, extracted from the seeds of *Pycnanthus kombo*,

locally called white cedar, and copal, the gum yielded by several species of timber trees, including *Daniella thurifera* and *Canarium schweinfurthii*. There has been no preparation or sale of these products on a commercial scale in recent years.

In the interest of providing a starting point from which future Liberian forest products statistics might be developed, the following forest products, as they are generally defined and recognized throughout the world, have not been produced in any quantity in Liberia to date: Bark for tanning, fiber or insulating boards, newsprint, paperboard, pit props, plywood, pulpwood, crossties, veneer logs, staves and headings, wood for tanning, veneers, and wood pulp of any type. Forest products which have been produced to date include fuelwood, wood for charcoal, sawlogs, lumber, piling, poles, and posts among wood products proper; and gums and resins, charcoal, and bamboos and canes among products other than wood.

Liberian domestic markets for forest products today are not great. It is true that there is an unfilled demand for some products, particularly lumber, but it is confined to the developed areas or the sites of construction projects. This demand is a growing one but has not yet reached such proportions that it could not be filled by a few efficient small sawmills. Future demand for forest products will depend almost solely upon the extent of economic development.

Tribal Liberians, who constitute over 90 percent of the potential consumers of forest products, are not by nature good prospects for the purchase of any type of forest product. Although the civilized element, which is steadily extending its influence in the interior, is much more likely to increase its rate of consumption of forest products, the significant domestic markets will derive from the organized activities of private and public groups engaged in projects for over-all economic betterment of the country. Although substitutes for wood are already being used in the major developed areas, particularly for house construction, it is unlikely that wood will suffer greatly in near-future competition over the country as a whole.

There is no lack of raw material for large-scale commercial forest operations in Liberia. Since the available stumpage does not include large volumes of precious woods or of woods of present high market value and established demand, the crux of future Liberian timber operations will be the marketing of species of lesser value, the "secondary woods," many of which will undoubtedly move up into the higher price class as their merits are recognized. During the past 10 years, the number of West African woods which have gained recognition, especially on European markets, has more than equaled the total of West African species which previously entered world trade.

Both the British and the French are today engaged in a thoroughgoing program of experimentation with additional West African woods. Relatively little has been published concerning findings, but valuable information on the technical, mechanical, and use qualities of dozens of heretofore unknown West African

woods is being assembled by both private and public agencies. In general such information in connection with woods of adjacent areas will be applicable to Liberia, since forests there include practically all species of timber trees found in Sierra Leone, Ivory Coast, and Gold Coast.

It is, of course, not enough to know the potential commercial value of a timber. Someone must develop an initial market for it, produce it, standardize the production, and sell it profitably in competition with other species.

Within another decade, recognition in European markets is expected to be gained by so many species of timber trees indigenous to Liberia that their combined merchantable volume on the average acre of Liberian high forest will considerably exceed the volume of the "unknown" species. The removal of a smaller proportion of total stand volume is today the basis for profitable operations in other West African areas, with but little more volume of precious woods in the cut than Liberian forests can produce. The day of highly selective cutting in West Africa is fast passing, and in near-future timber operations Liberia offers prospects comparable to those of any other area, as far as raw material is concerned.

Forest History

There are no recorded sources of information concerning the history of the interior forests of Liberia. It is possible to gain a fragmentary picture of the coastal forests over the last few centuries. Although long stretches of the Liberian littoral in all probability never supported hardwood forests, there were frequent protrusions of the interior forests that reached points on or near the coastline. Most of these forests were destroyed during the period of colonization and early development. Today there are only a few small coastal forest areas, notably in the vicinity of Marshall and Sangwin. In general, heavy forests appear to have reached the coast at the major promontories, probably as a result of favorable soils, but, with the exception of scattered stands on Cape Mount, nothing remains of these forests today. As the coconut and oil palms gained footholds, stands of these species became established in the vicinity of coastal villages. Elsewhere in the sandy littoral, scrubby stands of inferior tree species mingled with mangrove swamps and brackish marshes. There is nothing to indicate that these littoral forest types have been appreciably altered for centuries.

Disregarding the minor influence of timber utilization, the hardwood forests of the Liberian hinterland are today a reflection of the noncommercial human activities of a succession of societies over many centuries. It is estimated that 90 to 95 percent of Liberia's present area once supported high forests, or forests with a closed canopy, which represented a climax type for the concerned soils. Today little more than a third of this area is in high forests.

The shrinkage resulted almost solely from agricultural and occupancy activities, which carried with them the felling and burning of vast areas of high forest. Although some areas so cleared have restored themselves to high-forest condition, most such areas are today in tree cover inferior to high forest, or remain nonforest in nature. In traveling throughout Liberia today it is difficult to determine the extent of these age-old encroachments upon the original forest cover.

A most significant factor in the process of deterioration of the virgin forests is believed to have been a population far greater than that of today. The pressure upon the land of a population double or triple the present one, coupled with the emergence of an agricultural society from a more primitive forest society, would have resulted in a very extensive and quite rapid clearing of forests. When it is recalled that practically all plant foods upon which Liberians subsist today were introduced to the country in relatively recent times, it is not difficult to conceive of an earlier Liberia being essentially a land of unbroken forests.

During the period of early agricultural societies, major migrations probably occurred, largely as a result of the steady pressure of more aggressive groups to the north. In a sense, Liberia was a funnel through which great masses of people moved in their retreat to the coast; and, as a result, the parts of Liberia which today show no signs of occupancy during recent centuries are few and scattered. Similarly, there are sizable areas in Liberia that evidence the characteristics of an over-used, worn-out country of great antiquity.

It is possible that as recently as 300 years ago there was considerably less high-forest area in Liberia than is found today. The subsequent sharp decline in population, as heavy tribal warfare and slaving activities exerted their drain, possibly coupled with the ravages of new diseases, would have permitted many cleared areas to complete their reversion to high forest. Over a period of several centuries, stands such as now occur throughout much of Liberia would probably develop. Their composition would differ notably from primeval stands in the same general area, but their density would be very similar. Only by such an hypothesis can the writer explain the over-all compositional inferiority of Liberian high forests as compared with those considered typical of the Ivory Coast and the Gold Coast.

In general, the most mountainous Liberian areas appear to be in virgin condition. Examples are the Walo and Khakagissih Mountains of the Western Province, the Nimba Mountains of the Central Province, and, less impressively, the Satro and Niete Mountains of the Eastern Province. Aside from mountainous areas, which did not encourage occupancy and clearing, the most primitive high forests were found in a belt lying between 30 and 50 miles inland across the Eastern Province, from the River Cess to the D'Bor River drainage. It is probable that this area, some 1,500 square miles in extent, constitutes a core of the original forests which was never disturbed and is quite representative of the ancient forest cover. Other much smaller remnants of virgin

timber were noted in remote nonmountainous areas, as near Bomi Hills, Tawata, and Tinsou Island in the Western Province; along River Cess in the Central Province; and near Sangwin, Webo, and Tempo in the Eastern Province.

Forest Areas

Forest area estimates are based upon aerial-photo determinations supplemented by ground sampling. While more reliable than forest-volume estimates, they are nevertheless extremely rough and will be subject to much alteration as more detailed knowledge of individual areas is obtained. Preliminary forest area estimates have been modified in several respects. Not until February 1949 was field work in the northern section of the Western and Central Provinces completed. A reflying of parts of Liberia by American military photographic planes was awaited in the hope of strengthening forest-area determinations in sections of the country not previously covered. The most significant changes in final area estimates result from use of the United States Economic Mission preliminary 1:500,000 base map of Liberia. (See tables 2-4.)

Only for high forests is there any basis for breakdown of country area by Provinces. The accurate location of the St. Paul River boundary between the Western and Central Provinces awaits further study; hence, Provincial area breakdowns here are weaker than for the Eastern Province, whose entire boundary, including the River Cess throughout the interior, is now well-established. The approximate boundaries of the major high-forest areas of Liberia are shown on the map (page 12). Exterior boundaries of these areas are largely derived from aerial photography but in some instances are based solely upon very crude field checks. The fraction-of-1-percent intensity of total field sampling is indicative of the low order of accuracy, which must be borne in mind in any application of either area or volume estimates. Forest surveys can and should be as intensive and reliable as the planned use of information secured from them dictates. The present study data permit none but the grossest of estimates, but every effort has been made to assure conservative methods and results.

Estimates of the acreage of high forest exclude areas of broken bush if these are larger than 10,000 acres. Similarly, high-forest areas of less than this minimum size, lying detached from the main forests, are ignored. Principal occupied, farmed, and other nonforest areas within the main forests have been excluded. To allow for small, scattered exceptions—such as farms, low bush, and village area—all gross high-forest area estimates were reduced by 15 percent in the Western and Central Provinces and by 10 percent in the Eastern Province in preparing the final estimates. Planimetric determination of high-forest acreage was made in Washington by the Coast and Geodetic Survey in July 1949.

Broken-bush area estimates are based upon the summarized field notes for condition classes procured on all field trips, supplemented by a cursory examination of aerial photographs cover-

ing most of the country. It was impossible to attempt delineation of this category in the time and with the facilities available. It is believed that the greatest percentage of the total estimated area of broken bush is in the Central Province; the lowest percentage, in the Eastern Province.

TABLE 2.—*Estimated Liberian area by land condition classes*

Condition class	Total area in acres	Percent of total land area
High forest [1]	8,950,000	37.6
Broken bush [2]	4,850,000	20.4
Low bush [3]	5,250,000	22.1
Nonforest [4]	4,750,000	19.9
Total	23,800,000	100.0

[1] See table 3, footnote 2.
[2] Forests with broken canopies and a gross volume per acre of 5 MBF or less, International ¼-inch log rule, in trees of all species of the minimum size described in footnote 2, table 3.
[3] Areas recently farmed, without true canopy, merchantable trees scattered or absent, dominant stems 10 to 50 feet in height.
[4] Includes all cleared areas, whether occupied, cultivated, or otherwise used, as well as plantations and inland waters.

TABLE 3.—*Estimated Liberian total and high-forest areas, by Province*

Province	Total land area [1]		High-forest area [2]		Percent of total land area in high forest
	Acres	Percent	Acres	Percent	
Eastern	7,950,000	33.4	4,515,000	50.4	56.8
Central	8,830,000	37.1	1,875,000	21.0	21.2
Western	7,020,000	29.5	2,560,000	28.6	36.5
Total	23,800,000	100.0	8,950,000	100.0	37.6

[1] Exclusive of Fishermans Lake and large estuaries, but including all interior stream channels.
[2] Forests with completely closed canopies and a gross volume per acre of more than 5 MBF, International ¼-inch log rule, in trees of all species 2 feet or more in diameter outside bark (at a point 4½ feet above ground, or 1 foot above butt flare) and containing at least one merchantable 16-foot log.

Total foot travel, during which a 1-chain-wide strip was used for forest-condition class sampling, was about 2,300 miles, or 184,000 chains. The 18,400-acre sample strip is approximately 0.08 percent of the total land area. Since field travel was confined to forest areas as much as possible, total sampling was of somewhat greater intensity in the high-forest and broken-bush areas. For high-forest areas, total foot travel involved 86,480 chains, or 8,648 acres, of sampling, which is about 0.1 percent for the total

high-forest area as finally estimated. For broken-bush areas, total foot travel involved 51,520 chains, or 5,152 acres of sampling, which is slightly over 0.1 percent of the total broken-bush estimated area. For low-bush areas, foot travel totaled 27,600 chains, or 2,760 acres, sampled for an intensity of only 0.05 percent. For all other nonforest areas—occupied, cultivated, etc.—foot travel totaled 18,400 chains, or 1,840 acres, slightly less than 0.04 percent of total estimated area in this class.

TABLE 4.—*Estimated areas of major Liberian high forests*

Forest unit [1]	Estimated net high-forest area in acres [2]				Percent of total
	Eastern Province	Central Province	Western Province	Total	
Great Eastern	4,275,000	800,000		5,075,000	56.7
Iboke	240,000			240,000	2.7
Nimba		150,000		150,000	1.7
Sanokwelle		80,000		80,000	.9
Gio		275,000		275,000	3.1
St. John		180,000		180,000	2.0
Bong		170,000		170,000	1.9
Salala		120,000		120,000	1.3
Bassa		85,000		85,000	.9
Du River		15,000		15,000	.2
Walo			100,000	100,000	1.1
Gola-Maher-Kondessu			2,430,000	2,430,000	27.2
Morti River			30,000	30,000	.3
Total for all units	4,515,000	1,875,000	2,560,000	8,950,000	100.0
Percent of total for all Provinces	50.4	21.0	28.6	100.0	100.0

[1] Unit names are arbitrarily assigned and agree with those shown on the high-forest area map (page 12).

[2] Gross planimetered acreages were reduced by 10 percent for the Eastern Province and by 15 percent for the Central and Western Provinces to secure net forest area estimates.

Low-bush area estimates were prepared as described above for broken-bush estimates. Again, there were no facilities for delineation, which would require a tremendous amount of work as this condition class is widely dispersed in small areas throughout the country. It is believed that the greatest percentage of total estimated low-bush area is in the Central Province and the lowest percentage in the Western Province.

Nonforest-area estimates actually represent the residue after preparation of all forest-area estimates. While readily recognized on aerial photographs, this class is so broken up into thousands of small, irregular areas that delineation and measurement would be a project of long duration for many technicians. It should be

noted that all plantations—rubber, cocoa, etc.—are included in this class. There are probably some 100,000 acres in such plantations throughout Liberia. It is believed that the greatest percentage of total nonforest area is in the Central Province, and the lowest percentage, in the Eastern Province.

Forest Composition

Vegetational zones

The recognition of forest composition as to associations, types, and vegetative communities in general was found to be second in difficulty and complexity only to recognition of individual tree species. After many years of investigation, no satisfactory, simple, readily applied system of type classification for West African high forests has been evolved by foresters and ecologists working in this area. It is impossible to include even the roughest sort of ecological studies in a forest reconnaissance of the type upon which this report is based.

Many years of intensive study of individual small forest areas spread throughout the country must precede any worthwhile attempt to work out an ecological classification applicable to Liberia. The factors of hundreds of species of timber trees, difficult working conditions, extremely restricted visibility, and high variability of species, in localized areas are formidable obstacles. Yet, without ecological foundation, there can be no silvicultural treatment of cut or uncut stands except by trial-and-error methods.

Other tropical forestry agencies have usually begun ecological studies as corollary to experimental treatments of newly cut-over areas and gradually accumulated sufficient knowledge of the reaction of residual stands to various treatments to avoid serious future mistakes. It is essential eventually to recognize the stage of succession to a climax type which each cut-over area is in and what species naturally fit into that succession stage. Efforts toward regeneration must then be concentrated on such species to the exclusion of others. It is highly desirable to have trained ecologists and systematic botanists undertake type-classification projects, but much that is useful and practical can be learned at a lower level in connection with the administration of timber operations by forest officers and other qualified observers.

In the absence of knowledge of the identity, composition, frequency, location, and importance of a large number of forest types, recourse is taken to a simple breakdown of Liberian vegetation into five broad zones which appear capable of supporting the forests described under each. A summary of total Liberian land area by these vegetational zones is given in table 5.

TABLE 5.—*Estimated Liberian area by vegetational zones*

Vegetational zone [1]	Area in acres	Percent of total land area
Costal forest and mangrove swamp	500,000	2
Evergreen rain forest	11,200,000	47
Transitional forest	2,400,000	10
Deciduous forest	9,500,000	40
Savannah and park forest	200,000	1
Total	23,800,000	100

[1] See following section for description of vegetational zones. These zones are ecological classifications and the areas ascribed to them have no direct relation to present forest condition classes.

Coastal forests and mangrove swamps.—Much less extensive than in neighboring territories, the coastal forest and mangrove-swamp zone is restricted to a narrow belt, from 1 to less than 10 miles in width, paralleling the seacoast and extending up the rivers for short distances. Dunes cover most of the Liberian coast, often accompanied by lagoons and narrow salt marshes, and behind them lies an economically unimportant, scrubby forest cover, usually very sparse, which makes up most of the area in this category. Coconut plantations are frequent near coastal settlements, but no other economically significant species except oil palms occur. Mangrove, both red and white, associated with other small trees, borders the estuaries and lower courses of streams, but there are no extensive coastal mangrove swamps. The mangrove areas extend inland to the level of high tides and are practically impenetrable.

In a few places, as on the Morti, Du, and Blohni Rivers, high forest today extends practically to the coast, limiting this coastal-forest zone to less than a mile. The occurrence of higher land along the coast is variable, but it immediately results in the presence of rain forests. Salinity and sandy soils, which are characteristic of the coastal-forest zone, preclude the development of commercially important timber stands, assuming that the operation of mangrove for tanning material or other purposes will never prove feasible. In general, the inland extension of this zone is greatest in the southeast, narrowing to the northwest. As an extremely rough approximation, not supported by field survey, it is estimated that 2 percent, or about 500,000 acres, of Liberia's gross area is within this zone.

Evergreen rain forests.—As the coastal and mangrove forests reach higher ground inland, the evergreen rain-forest zone begins. It cannot be delineated with reasonable accuracy at this time, largely because of the disappearance of high forest from so much of the country and the inability of the scientist to devote the necessary time to zonal boundaries during field reconnaissance. Furthermore, there is a transitional zone, from this to the deciduous-forest zone, which is most difficult to recognize in traveling through

it. In the evergreen rain forests, the hardwood or broadleaf trees which comprise the stands have no definite and seasonal leaf-fall. The foliage of these trees is of course deciduous, but the shedding of leaves is year-round and inconspicuous, and the trees are never wholly defoliated. As discussed earlier under climate, rainfall appears to limit the inland extension of this zone more than any other factor.

Numerous species make up the stands here, and only rarely is a single species more than occasional in occurrence. When groups of one species do occur on areas of a few acres in extent, they are still mixed with dozens of other species. Volumewise, less than 10 species were ever noted to comprise as much as 25 percent of the merchantable stand, and that but rarely at widely scattered locations.

It should be noted that the descriptions of forest zones used herein are not only extremely general but presuppose that defections resulting from human influence on the forests are ignored. Thus, within the zone under discussion, there are stands adjacent to cleared or low-bush areas which do not appear to be in typical rain-forest condition. In all such cases and similar ones in other zones, ecologically sound type descriptions are essential to any classification of the tree cover.

The term "jungle" is more applicable to this zone than to any other. The trees forming the closed canopy are from 75 to 175 feet in height, but the space beneath their crowns is so choked with lesser vegetation that the tops of the taller trees are only occasionally visible. In addition to a stand of intermediate and suppressed trees, there is a welter of shrubby and herbaceous vegetation. Finally, a tangle of lianas, creepers, palms, ferns, and so forth add to the complexity of the flora. Lowland areas have denser cover than upland areas, making progress virtually impossible without the cutting of a trail; most upland rain forests can be traversed without cutting, but not without considerable difficulty.

As a gross indication pending further field work, the inland extension of the evergreen rain-forest zone is suggested to be along a line which, from east to west, leaves the Cavalla River in the vicinity of Bahliken, passes south of Tchien along the upper Quanabo River, thence through the Satro Mountains, passes near Gawin and crosses the St. John River near Quegah, thence through the vicinity of Salala and Bomi Hills, to Genne Liberia on the Sierra Leone boundary. As a rough approximation, it is estimated that 47 percent, or about 11.2 million acres, of Liberia's gross area is within this zone.

Transitional forests.—As previously indicated, transitional forests are borderline, exhibiting some of the features of both evergreen rain forests and deciduous forests. In general, they occupy a narrow belt, from 5 to perhaps 15 miles wide, lying inland from the northern limits of the evergreen rain forests. The earliest indication of the transitional-forest zone, in northward travel, is in composition rather than in deciduousness. Leguminous species become more prevalent, and a number of other timber species never found in the rain forests appear occasionally. Total vegetative cover

gradually thins out, and typical rain forests become confined to extensions up drainages.

In the interior of this zone, true deciduousness of individual trees begins to appear. The dominant and codominant trees first exhibit this feature, but at a given time only a fraction of the stand is shedding leaves or is leafless. Strangely, it appeared that understory trees, even in true deciduous forests, did not follow the pattern of leaf shedding of the upperstory trees, even for the same species. In the absence of year-round observations in the same localities, it cannot be stated to what extent the many species comprising forest stands in this zone become defoliated. It is probable, since it is a transitional zone, that about half the timber species remain evergreen. Roughly approximated, some 10 percent, or about 2.4 million acres, of Liberia's gross area is estimated to be within this zone.

Deciduous forests.—The nature of the deciduous-forest zone has been indicated in discussing the transitional forests. Deciduous forests are believed to occupy most of the Western Province, the northern half of the Central Province, and a very limited area along the Cavalla River north of the Satro Mountains and Tchien in the Eastern Province. Here the forests are definitely more open, and deciduousness is marked among species at various seasons. It is difficult to decide whether the over-all poorer form, poorer composition, and lower average volumes per tree and per acre in this zone result primarily from zonal differences in site factors, or from differences in history. Neither cause can be adequately evaluated, but it is believed that there are definite site deficiencies in parts of this zone.

Where there has certainly been no human influence, as in the rugged mountain country of this zone, there is little choice between these forests and good evergreen rain forests insofar as tree and stand volume and quality are concerned. On the other hand, the Western Province area that is often termed the Gola Forest, large and uninhabited today, is mediocre as compared with Eastern Province rain forests, but it also appears to have been influenced greatly by human activities. The northern limit of the deciduous-forest zone is the Liberian frontier, with the exception of the most northern extension of the country, in the Voinjama-Kolahun area of the Western Province. Here the deciduous forests border rather sharply on the savannah and park-forest zone described below. Roughly approximated, about 40 percent, or some 9.5 million acres, of Liberia's gross area is estimated to be within this zone.

Savannah and park forests.—The savannah and park-forest zone is so limited in Liberia that it has negligible significance at present. Only in the area generally north of an east-west line through Voinjama in the extreme northern portion of the Western Province is there a sufficient area of this zone to be recognized. Elsewhere it occurs in very small localized patches, as near Kpandemai and in the Sanokwelle section of the Central Province. Grasses and canes, such as elephant grass, form the savannahs,

and scattered trees of poor form occur singly or in clumps, only rarely forming thickets or weak stands.

The so-called inland swamps of northern Liberia are not true savannahs but are merely lowland along water courses on which the original forest cover has been replaced by a lower vegetational stage, probably as a result of repeated heavy burnings. Thorn bush, acacia, and other trees which occur in this zone are never found in the deciduous forests. As an extremely rough approximation, not supported by field survey, it is estimated that only 1 percent, or about 200,000 acres, of Liberia's gross area is within this zone.

Forest classes

As distinguished from vegetational zones based upon broad ecological considerations, the forest classes recognized in the field work of this study are strictly forest-condition classes. In other words, they involve the quantity, size, density, and age of the tree cover actually present today on the concerned areas. In rough reconnaissance work, such classification is the only one which can be readily combined with hasty coverage of large areas. Since the prospects for commercial timber operations depend on the answers to questions concerning the location of merchantable timber stands, their composition, and their volume, simple condition classes of the type employed are indicated.

Three condition classes were recognized. To repeat briefly, low bush included all areas recently farmed, without true canopy, with merchantable trees absent or scattered and most dominant stems 10 to 50 feet in height. Broken bush included all areas on which dominant, codominant, and intermediate trees did not form an unbroken upper-level canopy and on which gross volume per acre in merchantable trees of all species was 5,000 board feet or less. High forest included all areas on which dominant, codominant, and intermediate trees formed an unbroken closed canopy and on which gross volume per acre in merchantable trees of all species exceeded 5,000 board feet.

The use of minimum merchantable-tree requirements of 2-foot diameter, outside bark, at 4½ feet above ground, or at a point 1 foot above butt swell, and 1 merchantable 16-foot log, may raise questions as to why such high requirements were considered necessary. Primarily, these requirements were used in the belief that they were practical insofar as future forest operations involving controlled cutting were concerned, and that lower requirements would indicate operability for stands which could not be economically operated under selective logging or for certain forest products. A considerable margin in such matters is the only safe one under tropical conditions, particularly in a country which has no forest industry background. Girth limits used to control cutting in French and British West African areas vary by species, but the minimum girth averages about 6 feet.

It is felt that the country's low-bush areas should be considered

lost, insofar as permanent forests are concerned. All of this area will probably be needed to contain the demand for agricultural land over the next 50 years. If, during the same period, the encroachment of farming on high forest and broken bush can be completely terminated, Liberia will still have an adequate forest area, covering roughly half of the country. There is little reason to believe, at this time, that any forestry work could be justified in low-bush areas which might not be needed for farming in the next 50 years. Untouched, they will at least improve in some degree over such a period.

Arbitrary division of high forests into a primary subclass if containing more than 15,000 board feet per acre in merchantable trees, and a secondary subclass if containing 15,000 board feet or less per acre, was for the purpose of estimating how much of the high forest would probably support a selective, high-grading operation requiring relatively few species and large sizes, in which half the merchantable stand might be left uncut. It is natural to assume that a sampling of forests along trails is not typical of the forests the trails traverse. Since the field work was done without previous tropical experience and since visibility is very limited in high forests, this point was checked many, many times. Short offsets from the route of travel were made for various reasons on an hourly average during most days of travel. Coupled with other observations and inquiries, as well as with stereoscopic study of aerial photographs, these checks indicated that a trail-sampling route was as good as an off-trail cruise line for all practical purposes. Native trails never deviate appreciably, and there is no trail-side cutting or other alteration of conditions in high-forest areas. Sampling done while cutting trail and making bush camps was probably less accurate than that done along established trails, as progress is too slow for good mileage estimates, more distractions occur, and visibility is even poorer.

Tree species

The entire herbarium collection, upon which identification of tree species was largely based, was taken to the Royal Botanic Gardens, Kew, England, in 1949. There the specimens were compared with authentic material in the herbarium files. All specimens concerning which some doubt existed were handled first. Subsequently, all except a few dozen species of obvious identity, due to unique distinguishing features, were checked against the Kew specimens. The retention of determinations, originally made after Aubréville, [5] for a few species which have not yet been fully described and classified appeared justifiable. Five of the original field identifications were discarded as erroneous, and four new identifications were made of specimens previously unidentified.

The collection of Liberian herbarium material has now been accessioned by the Smithsonian Institution. Sets of enlarged prints of specimen photographs are now available in Liberia and should

[5] Op. cit.

serve a useful purpose for local reference. Duplicates of herbarium material for a number of species were left at Kew.

The 235 Liberian tree species identified are tabulated in appendixes I, II, and III. Table 6, which includes the same tree classes as in appendix I, indicates the extent to which the work of the United States Economic Mission has broadened the knowledge of Liberian trees since the 1928-29 Yale study (see footnote 2). The tree classes in table 6 have been applied by using the same estimated classification for any species occurring in both the Yale listings and the present study. For species that occur in one and not in the other study, classes were assigned on the basis of all available information.

TABLE 6.—*Comparison of Liberian species identified by U. S. Economic Mission, 1947-49, and those identified from 1928-29 Yale University collections*

Species class	Species	
	Identified by USEM	Identified in Yale study
Trees: [1]	*Number*	*Number*
Class I	35	17
Class II	58	37
Total, Classes I and II	93	54
Class III	68	28
Class IV	39	56
Class V	32	24
Total, Classes I–V	232	162
Shrubs	3	84
Climbers or vines	None	26
Herbs or weeds	None	24
Total	235	296

[1] Class I: Trees attaining 2-foot or greater diameter outside bark at breast height or at a point 1 foot above butt flare, of recognized and established commercial timber value, and accepted at present in world timber markets.

Class II: Trees attaining Class I size, having at present no established commercial timber value in world markets, but considered promising for future general commercial use, foreign or domestic.

Class III: Trees attaining 1-foot or greater diameter outside bark at breast height or at a point 1 foot above butt flare, of no present commercial timber value, but considered promising for future specialized foreign or domestic use.

Class IV: Trees attaining Class III size, having no present commercial timber value, and considered of doubtful future value due to size, bad form, poor wood qualities, scarcity, or other unfavorable factors.

Class V: Trees of small size, usually below Class III size, of no consequence as a merchantable timber species, but of interest from other standpoints, such as medicinal properties, rarity or abundance, local uses, unique botanic features, or value as indicator species.

It will be seen that the number of tree species of known Liberian occurrence in the first three classes, which represent those of

major importance from a utilization standpoint, has been roughly doubled. No serious effort was made to identify lesser forms in the field work that was the basis for this report, although a number of palms, exotics, shrubs, and vines were identified, but not included in the listings. The present study records for the first time many of Liberia's timber trees. The 18 Class I trees identified in addition to the 17 species of this class which were found during the Yale study are as follows:

Afzelia africana
Alstonia congensis
Antiaris africana
Baphia nitida
Brachystegia leonensis
Chlorophora regia
Cistanthera papaverifera
Cylicodiscus gabunensis
Distemonanthus Benthamianus
Entandrophragma Candollei
Entandrophragma macrophyllum
Entandrophragma utile
Khaya anthotheca
Khaya ivorensis
Lovoa Klaineana
Mimusops Heckelii
Terminalia ivorensis
Triplochiton scleroxylon

In order to provide a size, quality, and use guide to the trees identified in the present study, an alphabetical listing of species by tree classes is given in appendix III. More detailed descriptions of individual trees and their woods are best secured from the sources cited in the bibliography. No original work in relation to wood characteristics or potential uses is included in this study. The picture in regard to suitability of West African woods for various uses is constantly changing, as experimentation with such woods continues.

In addition to the forest trees identified during the study, certain other exploitable trees are believed to occur in Liberian forests. It might be assumed, since reasonably good coverage of forest areas was obtained during field trips, that such additional species are rare. This may not be the case, as individual species could easily be overlooked in such broad reconnaissance work. Other species may be fairly common in localized areas which were not visited. The following are tree species which were not identified but are believed to occur in Liberia and to be of present or potential commercial importance:

Celtis Soyauxii
Afrormosia elata
Erythroxylum Mannii
Guarea cedrata
Entandrophragma cylindricum
Mansonia altissima

There are, of course, other unrecorded, less important tree species in the Liberian forests, for which commercial demand is unlikely to develop. It should be noted that teak *(Tectona grandis)* does not occur naturally anywhere in Africa. In Liberia, it occurs in some young plantations made by Firestone in the Harbel area. The tree usually called mulberry in Liberia *(Chlorophora excelsa)* has at times been called African teak in other West African areas, but it is not even remotely related to true teak.

Forest Volumes

Estimates of forest volumes given herein must be clearly understood to be nothing more than guesses based upon several years

of observation and an extremely meager amount of sampling. As such, they are strongest in their aggregate form for the entire country and weakest in their localized form. The intensity of ground sampling, by continuous ocular estimate of volume classes on a chain-wide strip along route of travel, has been discussed under forest areas. In addition, 38 sample plots totaling 42 acres were measured at points scattered throughout the country. All such plots were in high-forest areas, none in broken bush. Summarized and weighted volume data from all sampling combined were considered an approximation of the national average high-forest volumes. It was felt, however, that enough was known of the 13 individual high forests of major importance to justify assignment of volumes to each based upon their estimated average-acre stands. It will be appreciated that such a procedure is very crude, but no alternative was possible under the circumstances.

It is emphasized that the more detailed knowledge of the forests of Liberia — essential to sound planning of individual forest operations—can be secured only by localized surveys of far greater intensity than the one reported here. Throughout the world in forest areas newly exploited, it is customary for private operators to make such surveys, for they are in the best position to consider the many questions regarding methods, costs, and extent of actual operations, from a practical standpoint. Areas wholly inoperable for one type of cutting may be highly desirable and operable for another. It is visionary to discuss any type of operation in the absence of intimate knowledge of all the forest and operating conditions existing in an area.

Since the high-forest areas are those of greatest economic interest and since their limits have been roughly delineated, estimates were first prepared for each of the 13 high-forest areas designated on the map (page 12). These volume estimates are shown in table 7. They were arrived at by applying a single average-acre net-volume assumption to the estimated net acreage of each forest. There is a remarkable uniformity of stand volume over much of Liberia, which lends some support to such a procedure. It should be borne in mind that the reductions of gross high-forest acreages to allow for interior exceptions are relatively heavy and tend to make both area and volume estimates conservative. On the other hand, defect may be found to exceed the flat 10-percent factor applied to cover loss of gross volume in unsound or unusable material.

That portion of high-forest stands representing trees falling between the minimum merchantable size class recognized in temperate zones and the minimum used in Liberian field work is of great importance, from both a forestry standpoint and that of an operator. An attempt was therefore made to estimate, in regional terms, the net volumes represented in the 12-inch to 22-inch diameter classes. Actually, this part of the stand includes trees having diameters of from 11.0 to 22.9 inches. There was insufficient basis for estimating this portion of the stand for individual forest areas. All ocular estimates of volume classes in the course of travel pertained to the volumes in trees in the 24-inch and larger diameter

TABLE 7.—*Estimated operable volumes in major Liberian high forests*

Forest unit [1]	Estimated net high-forest operable volumes in MBF [2]				Percent of total
	Eastern Province	Central Province	Western Province	Total	
Great Eastern	85,500,000	13,600,000		99,100,000	69.5
Iboke	5,280,000			5,280,000	3.7
Nimba		2,400,000		2,400,000	1.7
Sanokwelle		1,120,000		1,120,000	.8
Gio		4,400,000		4,400,000	3.1
St. John		2,340,000		2,340,000	1.6
Bong		2,040,000		2,040,000	1.4
Salala		1,320,000		1,320,000	.9
Bassa		850,000		850,000	.6
Du River		180,000		180,000	.1
Walo			1,400,000	1,400,000	1.0
Gola-Maher-Kondessu			21,870,000	21,870,000	15.3
Morti River			360,000	360,000	.3
Total for all units	90,780,000	28,250,000	23,630,000	142,660,000	100.0
Percent of total for all Provinces	63.6	19.8	16.6	100.0	100.0

[1] Unit names are arbitrarily assigned and agree with those shown on the high-forest area map (page 12).

[2] Volume estimates, in thousand board feet, include trees of all species 2 feet or more in diameter outside bark (at a point 4½ feet above ground level or 1 foot above butt flare) and containing at least one merchantable 16-foot log. Volumes computed by International ¼-inch log rule, for average all-species form class of 85. Gross volumes reduced 10 percent to secure net volumes.

classes. As a rough guide, it is believed that the portion of stand volume in the 12-inch to 22-inch diameter classes averages (in terms of net stand volume in the 24-inch and larger diameter classes) 20 percent in the Eastern Province forests, 25 percent in the Central Province, and 30 percent in the Western Province. The concerned estimates, shown in table 8, were made on this assumption.

To offer some picture of the total volumes in all the potentially productive forests of Liberia, high forest and broken bush combined, estimates of volumes in broken-bush areas are necessary. Insofar as the part of stand volume in the 24-inch and larger size classes is concerned, it is believed that broken bush averages very close to 3,000 board feet per acre net; this figure has been applied to the total estimated broken-bush area. Assuming that two-thirds of this average-acre volume is about the additional volume in the 12-inch to 22-inch diameter classes, an estimate for these classes was made by applying 2,000 board feet per acre net to the same broken-bush total area. These broken-bush volume estimates are included in table 8.

TABLE 8.—*Estimated total volumes in Liberian forests*

Condition class [1]	Size class [2]	Estimated total net volumes in MBF [3]				Percent of total
		Eastern Province	Central Province	Western Province	Total Liberia	
High forest	24" and up	90,780,000	28,250,000	23,630,000	142,660,000	71.6
High forest	12" to 22"	18,150,000	7,060,000	7,090,000	32,300,000	16.2
Broken bush	24" and up	[4]	[4]	[4]	14,550,000	7.3
Broken bush	12" to 22"	[4]	[4]	[4]	9,700,000	4.9
Total	12" and up	108,930,000	35,310,000	30,720,000	199,210,000	100.0

[1] See table 2, footnote 2, and table 3, footnote 2.
[2] Diameters, outside bark, at a point 4½ feet above ground level, or at a point 1 foot above butt flare. Trees of all species of the diameter classes indicated and containing at least one 16-foot log are included in volume estimates.
[3] Volume estimates, in thousand board feet, computed by International ¼-inch log rule. Gross volumes reduced 10 percent to secure net volumes.
[4] Unknown.

The distribution of stand volume by tree-size classes is of interest to forester and operator. Similarly, stock and stand tables, showing the average number of trees by size classes and their volume on theoretical average acres of various types and conditions of forest, are of great value in forest management. Unfortunately, it was impossible to secure enough data to prepare such tables. Neither was it possible to make any studies of mortality. For whatever value it may have, the distribution of gross volume by tree-size classes on the 38 sample plots has been summarized in table 9. Although all sample plot volume computations were summarized and preserved, some of the original tally sheets were lost, so that the number of trees cannot be similarly shown as to distribution among size classes. The total weight of these data is not great enough to permit any use other than comparison with more intensive cruise tallies made in the future. The 38 plots fell within all but 4 of the major high-forest areas and were about evenly distributed by Provinces. In each instance, plots were taken in what was considered an average stand for a large adjacent area. To avoid atypical sampling, most plots were taken by back-tracking through forest traversed the previous day to a stand which the summarized field notes indicated was average for the area as a whole.

It should be noted that the largest forest tree measured, though not on a sample plot, was 26.8 feet in girth, or 8.5 feet in diameter, outside bark, at a point 8 feet above average ground level. It was a *Brachystegia leonensis*, containing four logs below the first limb, with a total height of 165 feet. Larger cottonwood trees, near villages, were observed but not measured. The heaviest volume on any sample plot, 12-inch class and up, was 37,060 board feet per acre gross, but much heavier stands, up to about 55,000 per acre, were occasionally observed. In all field travel, stands of as much as

TABLE 9.—*Distribution of volume by tree size classes on 42 acres of sample plots scattered throughout Liberian high-forest areas* [1]

Diameter class (inches) [2]	Total gross volume in class (board feet) [3]	Percent of total
12	10,200	1.08
14	16,400	1.73
16	24,300	2.57
18	28,900	3.05
20	35,500	3.75
22	40,100	4.24
24	44,400	4.69
26	47,200	4.99
28	49,700	5.25
30	58,100	6.14
32	67,700	7.15
34	65,400	6.91
36	71,100	7.51
38	52,200	5.51
40	45,200	4.78
42	50,600	5.35
44	61,800	6.53
46	52,900	5.59
48	48,200	5.09
50–64	76,600	8.09
Total	946,500	100.00

[1] Combined volumes from 1-acre circular plots and rectangular plots averaging 1 x 10 chains.

[2] Diameter outside bark, at 4½ feet above ground or at point 1 foot above butt flare.

[3] By International ¼-inch log rule, rounded to nearest hundred board feet, for average form class of 85.

50 acres in extent and averaging more than 40,000 board feet gross per acre were not observed more than a dozen times.

In dense forests with occasional trees of very large dimensions, it is difficult to avoid overestimation by ocular means, as well as abnormally high volume estimates on any but carefully measured sample plots. Most mature Liberian timber trees are not excessively large for tropical areas, though by comparison with average temperate-climate trees they appear huge. It is almost typical in Liberia for Americans other than those familiar with West Coast timber to overrate the forests, especially as to volume. Measuring of sample plots, if properly done, is a very tedious, time-consuming job, more difficult in tropical rain forests than elsewhere in the world.

Growth and Drain

Drain has been discussed under the heading, Forest Utilization, and a discussion of growth and drain is included here only to em-

phasize the need for early consideration of means whereby this vital question may be approached in Liberia. In many respects, the question is comparable to deposits and withdrawals in a bank account. The bank deposits resemble the increment through rate of growth on the forest inventory, and the withdrawals resemble the losses of forest volume which make up drain. When drain exceeds growth, the forest volume shrinks. In most countries, all forestry efforts are being bent toward increasing the total volume of forests which have been reduced below safe proportions by reason of many factors working against sound forest management. In tropical areas, the most valuable tools for estimating forest growth in temperate areas are of reduced value. The boring of individual trees, to remove a core of wood displaying the annual growth rings from which annual and periodic increment may be computed, means very little in areas with a year-round growing season. Though layers of growth are distinguishable in some Liberian species, they are not always true annual layers. Alternative methods involve the establishment of permanent growth plots, on which the individual tree and the total stand increment are determined over a long period of years by remeasurements of diameter and height to determine volumes present.

Old timber grows more slowly than young timber and, despite its greater size, shows much lower annual net volume increment than younger stands. Eventually, as loss of volume through defect and overmaturity exceeds increment, timber deteriorates and net volume losses occur. Much of the timber in the high-forest and broken-bush areas of Liberia is mature to overmature. Because of the tightly closed canopy, younger and smaller trees are unable to make satisfactory growth. The opening up of such stands by removal of the mature trees results in an increase in rate and volume of growth on the part of the residual stand. These comments are made to explain the basic importance, in even the crudest types of forest management, of knowledge of growth of and drain on the forest growing stock.

Not only does the over-all trend in total forest resource volume hinge upon the relationship of total growth to total drain, but the quality and species composition of the resource can also be greatly affected by the nature of growth and drain. Increment of species which may prove of low desirability, if greatly exceeding increment of desirable species, would lower total resource value unless drain can be controlled and directed toward maintaining and subsequently increasing that value. It should be understood that, in the broad sense here used, drain represents the sum total of all wood losses, and growth the sum total of wood formation. If growth can be made to exceed drain, forests are perpetuated and forest industries may be stabilized.

Growth rates probably vary tremendously among the hundreds of species comprising Liberian forests. It is natural to assume that average growth rates would be high, but no evidence to this effect can be offered at present. The longevity of Liberian species, while not known, is probably quite high on the average. Relatively few

decadent, overmature trees dying of old age were observed, but the proportion of trees fully mature, yet apparently healthy, is quite high. In order to consider the position of Liberian forests in the matter of growth and drain, an annual average increment of 7 cubic feet per acre per year has been assumed. It may be found that actual increment is somewhat higher, but this figure is believed reasonable for the forests concerned in their present condition. On an estimated 13.8 million acres of high forest and broken bush, a figure of some 97 million cubic feet of annual growth would result from such an assumption.

Of the estimated annual fuelwood drain, some two-thirds may represent annual drain on growing stock, the balance being top wood or wood removed from clearings of previous years. Annual drain for fuelwood is therefore assumed to be about 30 million cubic feet. Practically all of the drain for secondary human uses represents growing stock, so that a 2-million-cubic-foot figure may be assumed. Using an estimated 50,000-acre-per-year rate of destruction of high forest and broken bush for agriculture, and an average merchantable volume destroyed of 10,000 board feet per acre, an additional 75 million cubic feet may be assumed destroyed, since little fuelwood is taken from the trunks of larger trees. All other drain, including that from windthrow, lightning, animal damage, disease, insects, and the light commercial cutting to date, probably would not exceed 3 million cubic feet annually. The total annual drain indicated by these assumptions is about 110 million cubic feet.

While wishing to emphasize that the excess of drain over growth by these rough estimates is hypothetical, it is probable that, regardless of the true level or degree, a very near balance of growth and drain exists in Liberia at present. This situation is not good, for Liberia is only now entering upon a program of development which will probably carry with it the first sizable commercial cutting operations in its forests. Unless this new drain is offset by reducing the loss of growing stock that occurs in annual burning for farms, there can be no hope of maintaining a balance. The increased growth rate on cut-over areas, assuming reasonable control of cutting and other protective measures necessary to keep such areas productive, will not go far in closing the gap between growth and drain unless farm clearing is reduced. It is the opinion of other West African foresters that the latter problem, which is universal in the area, is primarily a problem to be solved, if possible, by agriculturalists.

Conservation Problems

Exploitation

Only in connection with the establishment of Firestone rubber plantations in the Harbel and Plebo areas have Liberian forests been felled on a large scale for commercial purposes. All Firestone

rubber plantings were made on areas clear-cut and burned for that purpose. Some additional forest was cleared for small private rubber plantations established by Liberians, but for all practical purposes it may be said that forest exploitation for commercial use has not yet become a problem in Liberia. The small, scattered areas cut selectively to supply the few portable commercial sawmills which have operated in recent years are so minor a component of the total forest area as to be of no consequence. It is in the future, rather than in the past or present, that control of forest exploitation will assume the role of the most significant factor in the rational development of the forest resources.

Enough groundwork, particularly in connection with concessions granted to foreign interests in recent years, has been done to permit a fair, practical, and adequate control of timber extraction and processing operations. Technical advice offered in connection with the proposed opening up of large forest areas for exploitation by modern methods has been followed in principle. Although planning for the businesslike and sound development of forest operations is in the earliest stages, there is evidence that the mistakes, from the standpoints of national economy and welfare, made in other West African areas will be recognized and avoided insofar as circumstances permit.

Most important to both the country's and the future operator's well-being is the early establishment of an adequate and permanent forest estate to serve as a continuing and improving source of timber for supplying both domestic needs and export markets. In general, the pattern of forest exploitation in Liberia should, and probably will, resemble that of neighboring French and British territories as it exists today. The profitable forest operations in these territories offer ample evidence that the exploitation controls arrived at after many years of trial-and-error methods create conditions conducive to good business for both the governments and the operators concerned.

Farming

Losses of forest values, direct and indirect, as a result of wasteful agricultural practices have accounted almost wholly for the shrinkage and deterioration of Liberia's original forest resources. The basic problem consists of inability to develop a satisfactory system of permanent aboriginal subsistence agriculture under West African forest conditions. Neither the British nor the French, after many years of study, have made much progress in providing a substitute for shifting or bush-fallow agriculture. There are indications that a substitute will never be found. Rainfall alone, with its scouring and leaching of exposed soil, presents limitations which have not yet been overcome in farming systems adapted to permanent practice by aboriginal people. On the basis of experience to date in other West African areas, growing a new crop of trees along with food appears to be the best alternative.

The details of procedures which will best serve to bring about

the production of tree crops on land previously cleared, burned, and subsequently cultivated on short rotations can be determined only through long-time experimentation and careful study. As an approach to the problem, all that has been done to date in adjacent areas to counteract the inroads of shifting agriculture should be studied thoroughly by personnel qualified and authorized to tackle the problem in Liberia.

Casual observations in limited areas tend to create an impression that the annual loss in timber resulting from farm clearings is great. It is extremely difficult to evaluate this loss without adequate investigation, which would be a huge and complicated project. Tribal customs in farm clearing are diverse, and local conditions largely determine the year-by-year selection of areas to be cleared. It is believed that, as a result of shrinking population, the encroachments upon high-forest and broken-bush areas have decreased in the past few centuries. The periodicity of successive cultivations of the same areas ranges from a few years to 10 or more, and the continuous use of farmed areas varies from 1 to 3 years.

It is estimated that some 50,000 acres are now being converted each year from broken bush or high forest to farm clearings. Little of the merchantable timber volume on such areas is ever salvaged, but it is a common practice to leave the larger and heavier wooded trees uncut, since the native axes and machetes are too small to fell such trees. Tribal customs often result in leaving certain trees for other reasons.

The volume of timber of merchantable size destroyed in such clearing and burning probably averages about 10,000 board feet per acre. In terms of total forest area and volume, such losses in no way compare to the rates of attrition of the forests of adjacent territories. Nevertheless, unless controlled, shifting agriculture, particularly under population increases and general development of the interior, would eventually reduce the total forest area dangerously. It is believed that a thorough analysis of land use in Liberia would indicate, in the light of West African experience and conservative planning for the future, that about one-half of Liberia's total area should remain in forests perpetually. If the assumed rate of destruction of the forests through agricultural activities proves approximately correct, the danger point for Liberian national welfare will be reached within 35 to 40 years.

Fire

Other than in conjunction with agricultural clearings, fire has not been a problem in Liberian forests up to the present time. Occasionally the firing of cleared farm areas results in break-overs into green timber, but these are always small, dying out quickly because of low combustibility of the stands. A real fire hazard may result from any large-scale, heavy timber cutting, insofar as the residual stands are concerned.

It is probable that in certain extreme northern areas, where de-

ciduous stands give way to savannah and park forests, damage from fire is considerably greater than in the high-forest zones. Observations could not be made during the burning seasons in these areas, but the annual firing of grasslands for cattle forage undoubtedly effectively prohibits any extension of bordering forests, and probably results in a steady encroachment of the savannahs on the deciduous forests. In the aggregate, this damage is small, as the total area of savannah and parklike forests is of little consequence.

Insects and diseases

No investigations of the occurrence of insects and diseases infesting or infecting standing timber or forest products were made. It is apparent, however, that damage from these sources in the forests of Liberia is minor. Infestations or infections of epidemic proportions have not been observed in the forest areas of the country. Furthermore, all of the forests examined were found remarkably free of defect. The great mixture of species in Liberian forests undoubtedly renders them relatively unsusceptible to heavy damage from insect pests and tree diseases. It probably will be found, as commercial forest operations develop, that the important consideration along this line is the protection of logs, lumber, and other forest products, rather than the protection of standing timber.

Very little progress has been made to date in the control of insect and disease damage to forest products in the West African area. This is due largely to limitations of personnel, funds, and facilities for investigation in the adjacent areas having sizable forest-industry projects. It is a problem which will be of first importance to Liberian operators, for the conditions here are conducive to rapid deterioration of logs and manufactured forest products. A review of all that has been done in British and French colonies in West Africa in combating such losses would be profitable to early Liberian operators. Enough examples of loss of log merchantability because of combined insect and fungus damage were observed to clearly demonstrate the significance of this problem.

Damage by wildlife

Little can be said on the significance of damage by wildlife to forests and forest products until investigations can be made. It is certain, however, that the consumption of forest-tree fruits and seeds both by animals and birds greatly influences regeneration of many species. In general, birds appear to destroy seeds to a minor extent, feeding largely on fleshy fruits, the seeds of which eventually reach the ground. It is possible that the numbers of seed-eating birds in typical forests are great enough to influence seed supply, but highly improbable. Ground animals, however, especially rodents, appear to consume large quantities of seeds. Many kinds of rodents are abundant in the high forest, so that trees whose seed is

a favorite food may regenerate with difficulty. Monkeys destroy large quantities of tree fruits and seeds. It is often impossible to find an undamaged fruit or seed of a given species among hundreds of specimens under fruiting trees. In contrast, the fruits of a considerable number of the forest trees identified in the course of field work were never found damaged in any way. Ordinarily, insect and disease damage of seed is believed to occur only following earlier damage by other means. It is unlikely that any control measures will prove practical, except in conjunction with forest-tree nurseries or artificial regeneration by seedings or plantings.

Among the larger animals, only elephants damage forests appreciably. While there is a large population of duikers and other members of the deer family, the profusion of undergrowth and the large number of species comprising it which are not timber species make the resulting browsing of no import in forestry. These animals do concentrated damage only to crops such as cassava. Elephants often pool their feeding and bedding efforts and trample or push down all the smaller trees in restricted areas. In some instances, such areas observed were several acres in extent, but again the total damage is unimportant. Many forest fruits are favorite elephant foods, and the establishment of reproduction of a few species is believed to closely approximate the pattern of elephant travel.

Damage by elements

Violent thunderstorms are occasionally accompanied by winds of high velocity in Liberia and each year some windthrow occurs as a result of such storms. Affected areas are localized and damage for the country as a whole is inconsequential. It is believed that frequency of high winds is greater in the coastal half of the country. The storms which they accompany usually occur at the beginning or end of the rainy season. Few areas where windthrow exceeded some 10 or 20 percent of the stand volume were observed, the mixed nature of the stands and variable root habits of individual species tending to reduce damage. Many Liberian timber trees are leguminous, with foliage and crown characteristics which offer low wind resistance. Similarly, the prop-rooted, flange-rooted, and basally buttressed trees which are common in Liberian forests are naturally quite wind-firm.

There appear to be no special belts for the thunderstorms of the early and late wet season, and observations indicate that lightning damage to forest trees is infrequent. The dense, fairly level canopy of the high forests may account for this fact. Strikes appeared much more common in old farms, on the environs of towns, and in other places where large trees were of isolated occurrence. No other types of damage by the elements occur, excluding minor scorching of seedlings in exposed sites and defoliation during torrential rains.

Commercial Importance of Forests

To what extent Liberian forests will prove to be of commercial importance cannot be predicted with resonable certainty at this time. Two factors will outweigh all others in favoring commercial development of the forest resources—construction of roads or other means of transportation and development of markets for currently unknown or secondary woods. It is improbable, in the light of existing Liberian conditions, that heavy expenses for the construction of transportation networks to be used solely or largely for timber exploitation will be found justifiable if such expenses fall entirely upon operators. In small-scale, localized, temporary operations, this will not be the case. For large-scale, permanent operations in any of the major high-forest areas, however, these opening-up expenses will probably be found excessive in relation to anticipated returns, at least in the next 5 or 10 years.

There are several areas which offer good opportunities for early exploitation on a moderate scale. Such areas include the southern part of the largest Western Province high-forest area, already accessible by road from Monrovia to Bomi Hills and not far removed from the existing road extending above Suen; the forest generally west of Webo, already accessible by road from Harper to Webo; and the several smaller high-forest areas traversed by or near the Monrovia-Ganta-Tappita road.

It is considered practical to recommend that interested operators consider either band-mill or circular-sawmill operations in these areas. It appears logical to consider joint operation of band and circular mills, at the same or different sites, utilizing a single logging operation to supply both types of mill. All species for which foreign markets exist could be manufactured on the band mill, and all other species for domestic markets could be sawn on the circular mills. Shipment of logs and squared timbers to foreign markets has many serious drawbacks, and the trend in other West African territories is toward conversion of all logs at local sawmill or veneer plants so that little but sawn or partly processed material will be shipped to foreign markets. There is a high enough proportion of volume in species for which foreign markets now exist to make such an operation possible in the areas cited. Only a few years ago this was probably not the case.

The strong movement of the British and French to investigate their unknown or little known West African timbers and, after determining as much as can be determined of their mechanical and other qualities, to develop home markets for them, is bearing much fruit. The surface has barely been scratched, and there are scores of timber species which remain to be covered. There is every indication that this project will be steadily pursued and expanded and will open opportunities for conversion of stands which have previously been inoperable because of low volumes of high-value woods or absence of them.

Americans are playing a very minor role in this program, although a few American importers of West African woods and at least one American furniture company, long operating in West Africa, have experimented mildly with poorly known woods. There is no critical hardwood shortage in America, but in Europe the shortage is severe. It is unlikely that the knowledge gained concerning uses for these secondary timbers will reach American consumers very quickly or that markets for them outside Europe will develop in the near future to any great degree. It is inevitable, however, that the large West and Equatorial African supplies of hardwoods of all types will enter world trade in increasing degree in the decades ahead.

It is amply demonstrated by the studies completed that there cannot be a profitable mahogany operation in Liberia. True African mahogany *(Khaya)* does occur, in two species at least, but is so infrequent and scattered that it could not be extracted profitably under any circumstances as a straight mahogany project. If all of the mahogany family are included (*Khaya, Entandrophragma, Lovoa, Guarea, Trichilia,* and *Carapa* are genera of the mahogany family found in Liberia), along with all the other timbers of established value and present demand in foreign markets (such as *Alstonia, Antiaris, Brachystegia, Canarium, Chlorophora, Cistanthera, Daniella, Distemonanthus, Erythrophleum, Lophira, Mimusops, Mitragyna, Ochrocarpus, Piptadenia, Saccoglottis, Sarcocephalus, Tarrietia, Terminalia,* and *Triplochiton,* all found in Liberian forests), export operations could be supported by the stands in much of the country, particularly in the Eastern Province, insofar as raw material alone is concerned. It is believed that such operations would be possible only in limited parts of the Western Province forests. But to make such selective operations profitable, very favorable operating conditions would be required, for nowhere is there an abundance of these high-grade timbers.

The inclusion of additional species, already being marketed in other West African areas but not yet commanding prices comparable to the select timbers, would enable most Liberian forests to better support large operations, again excepting the bulk of the Western Province. There are two fairly good timber areas in the Western Province—the extreme southern forest area and the Walo Mountain area. The remaining forests in this Province are inferior to Eastern and Central Province forests from every commercial standpoint.

If a few roads existed through the Eastern Province high-forest area and access to several coastal points were provided, the best Liberian forests would offer very promising exploitation possibilities. If these forests were to be exploited in the absence of such prior road-building, it would probably be necessary to begin operations in the Sangwin River area, where this timber reaches the coast. Other promising areas on the south side of this large forest are so removed from the coast that deadheading even a light logging railroad over the few reasonably good routes available be-

TABLE 10.—*United Kingdom maximum prices for certain species of imported West African hardwoods* [1]

Lumber [2] (per 1,000 feet B.M.)		Logs [3] (per cubic foot)	
$304:	Iroko *(Chlorophora excelsa)*	$4.15:	Iroko *(Chlorophora excelsa)*
$292:	Albizzia *(Albizzia spp.)* Ayan *(Distemonanthus Benthamianus)* Dahoma *(Piptadenia africana)* Danta *(Cistanthera papaverifera)* Doussie *(Afzelia spp.)* Ekki *(Lophira alata)* Opepe *(Sarcocephalus Diderrichii)*	$3.65:	Dahoma *(Piptadenia africana)* Doussie *(Afzelia spp.)* Ekki *(Lophira alata)* Okan *(Cylicodiscus gabunensis)* Opepe *(Sarcocephalus Diderrichii)*
$287:	African Mahogany *(Khaya spp.)* African Walnut *(Lovoa Klaineana)*	$3.35:	African Mahogany *(Khaya spp.)* African Walnut *(Lovoa Klaineana)*
$233:	Abura *(Mitragyna stipulosa)* Afara *(Terminalia superba)* Assie *(Entandrophragma utile)* Gedu-Nohor *(Entandrophragma macrophyllum)* Guarea *(Guarea Thompsonii)* Idigbo *(Terminalia ivorensis)* Kanda *(Tylostemon Manii)* Landa *(Erythroxylum Manii)* Makore *(Mimusops Heckelii)* Mansonia *(Mansonia altissima)* Sapele *(Entandrophragma cylindricum)*	$3.30:	Ayan *(Distemonanthus Benthamianus)* Danta *(Cistanthera papaverifera)* Guarea *(Guarea Thompsonii)* Mansonia *(Mansonia altissima)* Ogea *(Daniella spp.)* Okwen *(Brachystegia leonensis)* Omu *(Entandrophragma Candollei)*
		$3.00:	Abura *(Mitragyna stipulosa)* Afara *(Terminalia superba)* Antiaris *(Antiaris africana)* Gedu-Nohor *(Entandrophragma macrophyllum)* Idigbo *(Terminalia ivorensis)* Makore *(Mimusops Heckelii)* Sapele *(Entandrophragma cylindricum)*
$208:	Obeche *(Triplochiton scleroxylon)*	$2.80:	Assie *(Entandrophragma utile)* Canarium *(Canarium Schweinfurthii)*
		$2.25:	Obeche *(Triplochiton scleroxylon)*

[1] Maximum prices under British Imported Hardwood Prices order (No. 497), effective April 1, 1949.

[2] Prices shown, rounded to the nearest dollar, are for lumber of prime quality, equivalent to American FAS grade, 1 inch thick, 6 inches wide and up, averaging not less than 10 inches wide, 6 feet long and up, averaging not less than 10 feet long.

[3] Prices based upon Hoppus measure, 144 divisor, for logs of first quality with small end having a diameter of 34 inches and up. No length requirement in the $2.25, $2.80, and $3.00 groups. For all other groups, prices shown are for logs of 20 feet or less in length.

tween drainages would require heavy investment. The problems of loading logs or manufactured material at coastal points could be worked out readily enough, but those of building, operating, and maintaining a logging railroad in what is probably the area of heaviest rainfall in Liberia would be formidable. The best timber observed in immediate proximity to the coast was on the Blohni and Sangwin Rivers, the former a small stream just northwest of the Sangwin River.

Data relative to current market values of timbers found in Liberia are difficult to procure in sufficient quantity to have any weight, except for a few of the best known species. After checking American import data in Washington, which provide wholly inadequate coverage of West African woods, recourse was made to United Kingdom price controls affecting hardwoods imported from West Africa. Table 10 summarizes the maximum selling prices permitted in sales of West African hardwood lumber and logs in the United Kingdom. The latter country is desperately in need of hardwoods, particularly for industrial and general construction purposes. Hence, the prices tabulated reflect efforts to stimulate production of West African timbers, many considered of secondary or no value only a decade ago but recently found suitable for many uses. No longer is mahogany, to the British, a wood to favor over others for which a greater need now exists in the British economy.

Of the 28 species or species groups listed in table 10, all but 3 have been identified in Liberian forests. These 3 are among the 6 species listed in the discussion of tree species which probably occur in Liberia but are not among the 235 species identified in field work. The 10 species considered as Class I in the report treatment of tree species, but not included in table 10, have been or are being marketed from other West African areas. In most instances, these additional Class I species do not occur in or are not being exported at present from British West African colonies.

Associated Resources

Water

In many ways, Liberia's forests influence the country's water supply. The catchment basins of most of the smaller streams are forest-covered in large degree, and the drainages of the larger streams, which have their headwaters in French Guinea and the Ivory Coast, all contain sizable forest areas. The normal climate depends upon the presence of forest cover, and a sharp reduction in that cover would alter climate unfavorably. Every native village has its "waterside," and, without forest cover, water for human consumption would be drastically reduced. The undeveloped hydroelectric potentialities of interior Liberia depend upon the forests for their existence.

There is no planned phase of economic development in Liberia which will not be heavily dependent upon water, either directly or indirectly. In areas of torrential rainfalls and heavy seasonal

run-off, the stabilizing effect of forests on stream flow are invaluable. Unlike parts of West Africa, Liberia is well-watered throughout and need only assure the perpetuation of its supplies within its boundaries to avoid the problems which develop when excessive disturbances of natural balances occur.

Wildlife

Liberia's wildlife has probably been somewhat depleted in the past 50 years. The introduction of firearms resulted for a time in an increased kill, but this trend is probably now reversed.

As a result of the spread of firearms to every section of the country, dependence for hunting is now placed almost wholly on armed hunters. Only rarely were animals other than the smallest, along with birds, noted to be taken by bow, snares, pitfalls, or similar means.

Hunting and trapping, as native arts without civilized aids, seem to be fast vanishing. The kill by armed hunters appeared relatively small. Factors contributing to the small kill are the paucity of ammunition supplies and lack of skill. Excellent stalkers, most tribal natives are not marksmen. They are overcautious with shotguns, probably because of the cost of shells, and no one was observed who handled a rifle well. Shots are never taken at moving targets. Except for monkeys and birds, game must be hunted with firearms at night for reasonable success; and willing, able night hunters are very scarce. Lack of night lights contributes to this scarcity, but deeply ingrained prejudices toward night activities are largely responsible. Other than a hunter or his assistant, no tribal man is to be found astir in the bush after dark, if it can be avoided.

So little is known of the life habits of Liberian fauna that the relationships of forests and wildlife can be but conjecture. Most of the wildlife makes its home in the fringes of the high forest and throughout broken bush. Feeding upon crops, by night and day forays from adjacent forest cover, is a source of considerable loss to native farmers. Monkeys, rodents, birds, and the deer family account for most crop damage. Patrolling of crops by women and children, chiefly to frighten away birds, is a common practice. Little, if any, wildlife makes its home in cleared areas.

Dense low bush supports rodents, small duikers, and a few game birds. Broken bush and adjacent advanced low bush appear to shelter most of the wildlife, including such large birds as plantain-eaters, hornbills, and falcolins, along with dwarf buffaloes, leopards, elephants, the larger antelopes, and monkeys. In the interior of large high-forest areas, game seems relatively scarce, limited largely to monkeys, a few species of antelope, occasional leopards and elephants, and a few large birds, such as wild guineas and hornbills. Because of the low visibility in the bush, little game except monkeys and birds can be observed in the course of daytime travel. A much greater variety of game can be seen by walking trails and clearings with a light by night.

Of the species that are of most interest, elephants appear to

favor good forest cover, but often feed in low bush; leopards prefer mixed cover, from the environs of villages to broken bush, but are scarce in extensive high-forest areas; dwarf buffaloes prefer similar mixed cover but are never far from lowland marshes and thickets; bongos, largest of the deer family, are strictly high-forest residents; the pygmy hippopotamus uses the heaviest cover available along the larger streams; monkeys feed in all types of cover but sleep in broken or high bush; and wild hogs prefer heavy cover near low bush and clearings.

There are no game species of any consequence that do not depend upon true forest cover for existence. It is reasonable to assume that, in the balance of environment and stocking that probably exists in the absence of heavy kills, any drastic reduction of forest cover will result in reduced stocking.

It is believed that game in general is far more plentiful in the Eastern Province than elsewhere, is fairly plentiful in the Western Province, except in the extreme northern part, and is very scarce over most of the Central Province. There are probably more elephants in the forests of the Eastern Province than in the other two Provinces combined, despite a kill which is probably heavier than is usually represented.

Fish

As associated with fresh-water streams, fish are indirectly influenced by forest cover. As previously mentioned, most stream courses in Liberia are forested to some degree. It is common, throughout the country, to find streams well-overhung by trees, even though adjacent stream-bank areas may be cleared. It is difficult for one who has no technical background in such matters to explain the evident deficiency of the fish population in Liberian streams. In heavily populated areas, the shortage might be attributed to overfishing. But time after time in widely scattered locations, streams flowing through unbroken high forest, unoccupied for miles and surely fished rarely if ever, appeared to be equally devoid of fish.

On every field trip, party porters fished at every opportunity, but the total catch in hundreds of such ventures was considerably less than one hundred very small fish. In the absence of hooks, woven traps used in connection with woven weirs were placed in likely looking streams whenever a bush camp was made, always in waters which should have been unfished normally. In addition, streams were fished at night. Only rarely would any catch result, and then only enough to feed a few men. The over-all scarcity of fish is best attested to by the high barter value in the interior of smoked fish, small supplies of which are occasionally found in native villages.

Only in some major streams (Morro, Loffa, River Cess, Sangwin, and Cavalla) did it appear that enough fish were being taken to justify the effort expended. Yet fishing, particularly by women and children, is diligently, if not profitably, pursued throughout

the country. It is possible that centuries of heavy use of fish poisons have so seriously depleted stocking that recovery is impeded or impossible now, even though poisons appear no longer to be so commonly used. Average Liberian streams may be devoid of certain essential foods, or the water may otherwise inhibit fish development. It seems highly improbable that enemies other than man account for the shortage.

In view of the urgent need for protein foods throughout the country, steps should be taken to attempt to solve the problem. Experience in other West African areas would probably be very helpful as a guide. Grubs, termites, snails, and other eagerly devoured protein foods are poor substitutes, in quantity if not in quality, for fresh-water fish and crustaceans. Whatever the reasons for the inland waters providing such inadequate amounts of food, it is certain that the forests will play an important role in any future fish management programs. Without the stabilizing effect of the forests on run-off and stream flow, Liberian streams would probably prove to be wholly unmanageable for any planned use. To the extent compatible with other developments, stream-bank tree cover should be protected in all the nonforest areas in order to control and shade the banks, and provide food for fish.

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Appendixes

I. Field Identifications of Liberian Tree Species

Collection No.	Scientific name [1]	Class [2]	Collection date [3]	Collection area Place—Drainage [4]	Sample material [5]				Common and trade names [6]			
					A	B	C	D	Local English	French	Gold Coast	Other trade
1	Garcinia Kola	III	11–15–47	Silikli-Dubwe	A*		C			Aouolié		
2	Monodora brevipes	III	11–19–47	Dodueken-Dubwe	A*	B*		D*	Nutmeg			
3	Saccoglottis gabonensis	I	11–19–47	Dodueken-Dubwe	A*	B*	C*		Cherry	Akouapo		Ozouga, Amuan.
4	Musanga Smithii	III	11–19–47	Dodueken-Dubwe	A	B	C	D*	Corkwood	Parasolier	Corkwood	
5	Anthocleista nobilis	IV	11–19–47	Dodueken-Dubwe	A	B	C			Brobro		
6	Ricinodendron africanum	II	11–19–47	Dodueken-Dubwe	A*		C*			Eho	Wama	Erimado.
7	Canarium Schweinfurthii	I	11–17–47	Dodueken-Dubwe	A*		C*	D	African Elemi	Aiélé	Bediwunua	Canarium, Papo.
8	Caloncoba echinata	IV	11–17–47	Dodueken-Dubwe	A*		C*			Gorli		
9	Erythrophleum micranthum	I	11–20–47	Dodueken-Dubwe	A*		C*	D*	Sassywood	Tali	Potrodom	Alui, Erun.
10	Parkia bicolor	II	11–20–47	Dodueken-Dubwe	A*	B	C		Locust Bean	Lo		
11	Trichoscypha arborea	III	11–20–47	Dodueken-Dubwe	A*					Dao		
12	Anopyxis ealaensis	II	11–21–47	Dodueken-Dubwe	A*	B*	C*	D*	White Oak	Bodioa	Kokoti	
13	Alstonia congensis	I	11–21–47	Dodueken-Dubwe	A*					Emien	Sindru	Pattern Wood.
14	Lophira alata	I	11–21–47	Dodueken-Dubwe	A*	B*	C*	D*	Red Ironwood	Azobé	Ekki	Kaku, Bongossi.
15	Coula edulis	III	11–22–47	Dodueken-Dubwe	A*		C*		Walnut	Attia		
16	Mitragyna stipulosa	I	11–20–47	Dodueken-Dubwe	A*	B*		D*	Poplar	Bahia	Abura	Subaha.
17	Enantia chlorantha	III	11–20–47	Dodueken-Dubwe	A*		C*	D*	Yellow Wood	Baoué		
18	Microdesmis puberula	V	11–20–47	Dodueken-Dubwe	A*	B*	C*	D		Kokoi		
19	Vitex oxycuspis	IV	11–21–47	Dodueken-Dubwe	A*							
20	Uapaca guineensis	II	11–21–47	Dodueken-Dubwe	A*		C*	D*	Red Cedar	Rikio		
21	Phyllanthus discoideus	III	11–22–47	Dodueken-Dubwe	A*		C*			Lié		
22	Myrianthus serratus	V	11–22–47	Dodueken-Dubwe	A		C			Wounian		
23	Pycanthus kombo	I	11–22–47	Dodueken-Dubwe	A*	B	C*		White Cedar	Oualélé	Otie	Akomu, Boxboard.
24	Piptadenia africana	I	11-22-47	Dodueken-Dubwe	A*		C*	D*	African Greenheart.	Dabema	Dahoma	Agboin, Ekhimi.
25	Sakersia africana	V	11–20–47	Dodueken-Dubwe	A*					Poto		
26	Lovoa Klaineana	I	11–23–47	Dodueken-Dubwe	A*		C*	D*	African Walnut.	Dibétou	African Walnut.	Apopo, Tigerwood.
27	Funtumia elastica	III	11–21–47	Dodueken-Dubwe	A		C	D	Rubber Tree	Pouo	Osese	
28	Pentadesma butyracea	II	11–19–47	Dodueken-Dubwe	A*		C*		Tallow Tree	Lami		
29	Uapaca paludosa	II	11–24–47	Diyangbo-Dubwe	A		C		Red Cedar	Rikio des Marais.		

Footnotes at end of table.

Field Identification of Liberian Tree Species—Continued

Collection No.	Scientific name [1]	Class [2]	Collection date [3]	Collection area Place—Drainage [4]	Sample material [5]				Common and trade names [6]			
					A	B	C	D	Local English	French	Gold Coast	Other trade
30	Tarrietia utilis	I	11-24-47	Diyangbo-Dubwe	A*		C*	D*	Whismore	Niangon	Nyankom	Cola Mahogany.
31	Albizzia sassa	II	11-25-47	Diyangbo-Dubwe	A*	B*	C*			Bangbaye		
32	Fagara macrophylla	II	11-27-47	Diyangbo-Dubwe	A*		C	D		Bahé		Olon, Olun.
33	Parinarium macrophyllum	V	11-27-47	Diyangbo-Dubwe	A		C*		Plum	Neou		
34	Pachystela micrantha	II	11-28-47	Diyangbo-Dubwe	A*		C*			Koacé		
35	Oldfieldia africana	I	11-28-47	Diyangbo-Dubwe	A*			D*	African Oak	Dantoué		
36	Afrolicania elaeosperma	V	11-28-47	Diyangbo-Dubwe	A*	B*	C					
37	Pentaclethra macrophylla	II	11-28-47	Diyangbo-Dubwe	A*		C*	D*	Oil Bean Tree	Ovala		
38	Monopetalanthus sp.	II	12- 9-47	Paluken-D'Bor	A*		C*	D*		Toubaouaté		
39	Bombax flammeum	IV	11-29-47	Bweahpoh-D'Bor	A*	B*			Cotton Tree	Oba		
40	Pterocarpus santalinoides	III	12- 1-47	Bafowen-D'Bor	A*	B*	C*			Ouokissé		
41	Macaranga huraefolia	V	12- 1-47	Bafowen-D'Bor	A*					Tofé		
42	Harunga madagascariensis	V	12- 1-47	Bafowen-D'Bor	A*	B*				Ouombé		
43	Ficus Mucuso	III	12- 1-47	Bafowen-D'Bor	A*		C		Fig	Doumbourou		
44	Albizzia Zygia	I	3-10-48	Dimeh-Kpo	A*		C*	D*		Ouochi	Okuro	
45	Neostenanthera hamata	III	12- 3-47	Bolo Newtown-D'Bor	A*		C*					
46	Calpocalyx brevibracteatus	II	12- 4-47	Bolo Newtown-D'Bor	A*		C*			Pétépré		
47	Macrolobium Heudelotii	IV	12- 4-47	Bolo Newtown-D'Bor	A		C*			Rere		
48	Irvingia gabonensis	II	12- 5-47	Bao-D'Bor	A		C*			Boborou		Wild Mango.
49	Trichilia Heudelotii	III	12- 4-47	Bolo Newtown-D'Bor	A*		C*			Banaye		
50	Ceiba pentandra	IV	12- 3-47	Bolo Newtown-D'Bor	A*	B	C*		Cotton Tree	Fromager	Cotton Tree	
51	Ochrocarpus africanus	II	12- 5-47	Bao-D'Bor	A*		C*		Bastard Mahogany.	Djimbo	Bompegya	Mammee Apple.
52	Conopharyngia longiflora	V	12- 3-47	Bolo Newtown-D'Bor	A		C					
53	Randia acuminata	V	12- 4-47	Bolo Newtown-D'Bor	A		C*			Aboké		
54	Sarcocephalus Diderrichii	I	12- 5-47	Bao-D'Bor	A*		C*	D*	Brimstone	Badi	Opepe	Kusia, Bilinga.
55	Protomegabaria Stapfiana	III	12- 3-47	Bolo Newtown-D'Bor	A		C*			Mbraoua		
56	Entandrophragma macrophyllum.	I	12- 9-47	Jlatekpo-D'Bor	A*		C*	D	Brown Mahogany.	Tiama	Gedu Nohor	Edinam.
57	Albizzia ferruginea	II	12- 8-47	Paluken-D'Bor	A*		C*			Iatandza		
58	Vitex rufa	III	12- 9-47	Paluken-D'Bor	A*							
59	Cola mirabilis	III	12- 8-47	Paluken-D'Bor	A					Doloko		
60	Cola digitata	S	12- 8-47	Paluken-D'Bor	A							
61	Antrocaryon Micraster	III	12-10-47	Paluken-D'Bor	A*		C*			Akoua		
62	Dialium Dinklagei	III	12- 9-47	Paluken-D'Bor	A*		C*			Afamběou		
63	Scytopetalum Tieghemii	III	12- 9-47	Paluken-D'Bor	A*		C*		Sourwood	Moussangoué		
64	Spondias monbin	V	12-11-47	Kaytoken-D'Bor	A*		C*			Monbin		
65	Brachystegia leonensis	I	12-12-47	Karkee-Dubwe	A*	B*	C		Bush Mahogany.	Méblo	Okwen	African Rosewood.

66	Baphia nitida	I	12–12–47	Wajae-Dubwe	A*	B	C*	D*	Camwood	Okoué	Camwood	Logwood, Barwood.
67	Cathormion Dinklagei	III	12–12–47	Wajae-Dubwe	A*		C*	D*		Ta		
68	Berlinia acuminata	II	12–12–47	Karkee-Dubwe	A*		C*		Red Oak	Melegba		
69	Parinarium robustum	II	12–12–47	Wajae-Dubwe	A*		C*		Plum	Koaramon		
70	Coelocaryon oxycarpum	II	12–13–47	Karkee-Dubwe	A		C*		Wild Nutmeg	Vieda		
71	Macrolobium diphyllum	IV	12–15–47	Troken-Dubwe	A		C			Medjilagba		
72	Oxystigma Stapfiana	IV	12–15–47	Troken-Dubwe	A		C		Red Pine	Kaoue		
73	Croton macrostachyus	V	12–13–47	Japuken-Dubwe	A	B	C					
74	Allanblackia parviflora	II	12–15–47	Sewoken-Dubwe	A*		C*			Ouotera		
75	Combretodendron africanum	II	12–15–47	Sewoken-Dubwe	A*		C*		Soap Tree	Abalé	Esia	
76	Rhizophora racemosa	III	12–17–47	Sinoe-Sinoe	A*	B*	C		Red Mangrove	Palétuvier	Mangrove	
77	Spathodea campanulata	III	12–15–47	Kanboken-Dubwe	A		C			Tulipier du Gabon.		
78	Distemonanthus Benthamianus	I	11–28–47	Diyangbo-Dubwe	A*			D*	Satinwood	Movingui	Ayan	Bonsamdua.
79	Haplormosia monophylla	II	5–26–47	Gbwamma-Loffa	A*			D*	Black Gum	Larmé		
80	Parinarium excelsum	II	5–24–48	Iboke-Cavalla	A*		C		Rough-skin Plum.	Sougué		
81	Chrysophyllum obovatum	II	5–31–47	Bai-Mano	A*		C*	D				
82	Afzelia africana	I	6– 1–47	Bai-Mano	A		C			Lingué	Papao	Afzelia, Apa.
83	Terminalia superba	I	11–24–48	Yuahpeah-R. Cess	A*		C*	D*		Fraké	Afara (White)	Ofram, Limbo.
84	Cylicodiscus gabunensis	I	6– 1–47	Bai-Mano	A		C			Bouemon	Okan	Denya.
85	Chlorophora excelsa	I	5–31–47	Bai-Mano	A*		C	D*	Mulberry	Iroko	Iroko	Odum, Mvule.
86	Omphalocarpum elatum	V	5–26–47	Gbwamma-Loffa	A*		C*			Aguia		
87	Cynometra ananta	II	5– 1–48	Sangwin-Sangwin	A*					Apomé		
88	Daniella thurifera	I	6– 2–47	Zui-Mano	A*	B	C*		Gum Copal	Faro		Daniella.
89	Morinda geminata	IV	3–10–48	Harbel-Farmington	A*	B*	C*			Ouanda		
90	Tylostemon Mannii	I	6– 7–48	Webo-Cavalla	A*	B*	C*	D	Spicy Cedar	Atiokouo		Bogo, Be-ay.
91	Funtumia latifolia	III	3–10–48	Harbel-Farmington	A*		C*		Rubber Tree	Pouo	Rubber Tree	
92	Syzygium abidjanense	IV	3–10–48	Dimeh-Kpo	A*		C*			Guessiguié Ako.		
93	Syzygium guineense	III	1–19–48	Harbel-Farmington	A*					Kokissa		
94	Afzelia bella	III	3–10–48	Dimeh-Kpo	A*	B*	C*			Azodau		
95	Tetrapleura Chevalieri	III	3–11–48	Dimeh-Kpo	A*		C*			Eséhésé		
96	Bersama paullinioides	IV	3–12–48	Dimeh-Kpo	A*		C*			Kofo		
97	Xylopia Staudtii	III	4–28–48	Blohni-Blohni	A		C*		Bush Pepper	Fondé		
98	Klainedoxa gabonensis	II	4–28–48	Blohni-Blohni	A*		C*			Kroma		
99	Monopetalanthus pteridophyllum.	III	5– 1–48	Sangwin-Sangwin	A*							
100	Bussea occidentalis	II	5– 1–48	Sangwin-Sangwin	A*	B	C*	D*		Nomotcho		
101	Rauwolfia vomitoria	V	8–20–48	Gordi-Kpo	A*		C*		Swizzle-stick	Dechavi		
102	Calpocalyx Aubrévillei	III	5– 4–48	Troh-Sangwin	A*					Guépizou		
103	Symphonia gabonensis var. macrantha.	II	4–28–48	Blohni-Blohni	A	B				Beu		Osol.
104	Memecylon membranifolium	S	5– 4–48	Troh-Sangwin	A*							
105	Drypetes ivorensis	V	5– 1–48	Duoh-Sangwin	A*		C*					
106	Berlinia bracteosa	II	4–28–48	Blohni-Blohni	A*				Red Oak	Pocouli		
107	Uapaca Heudelotii	II	4–30–48	Sangwin-Sangwin	A*				Red Cedar	Rikio		
108	Conopharyngia durissima	IV	5– 6–48	Troh-Sangwin	A*		C*			Piegba		
109	Newtonia insignis	III	5– 6–48	Nyawe-Sangwin	A*		C*			Kétou		
110	Parinarium Aubrévillei	II	5– 6–48	Nyawe-Sangwin	A*					Aramon		

Footnotes at end of table.

Field Identification of Liberian Tree Species—Continued

Collection No.	Scientific name [1]	Class [2]	Collection date [3]	Collection area Place—Drainage [4]	Sample material [5]				Common and trade names [6]			
					A	B	C	D	Local English	French	Gold Coast	Other trade
111	Crudia senegalensis	III	5- 6-48	Nyawe-Sangwin	A*					Haratou		
112	Vitex grandifolia	IV	5- 6-48	Troh-Sangwin	A		C*					
113	Diospyros gabunensis	V	5- 6-48	Nyawe-Sangwin	A*		C*			Sanza-Minika		
114	Ficus Vogelii	IV	5-10-48	Jabuah-Sangwin	A*		C*		Fig			
115	Piptadenia Aubrévillei	III	5-10-48	Jabuah-Sangwin	A*					Atembré		
116	Amphimas pterocarpoides	II	5-10-48	Jabuah-Sangwin	A*		C*			Lati		
117	Cathormion altissimum	IV	5-14-48	Pinetown-Sangwin	A*		C*			Kota		
118	Pachypodanthium Staudtii	III	5-13-48	Kubadi-Sangwin	A		C*			Anioukéti		
119	Myrianthus libericus	V	5-14-48	Pinetown-Sangwin	A*		C			Wounian		
120	Triplochiton scleroxylon	I	5-15-48	Wllebateh-Sinoe	A*		C*			Samba	Wawa	Obeche, Ayous.
121	Monopetalanthus compactus	III	5-15-48	Wllebateh-Sinoe	A*		C*					
122	Hymenostegia Afzelii	IV	5-15-48	Wllebateh-Sinoe	A*					Kouékoué		
123	Myrianthus arboreus	V	5-17-48	Kanwueyken-Grand Cess.	A		C			Grand Wounian.		
124	Ficus sagittifolia	S	5-17-48	Pennoken-Dugbah	A							
125	Enantia polycarpa	III	5-17-48	Kanwueyken-Grand Cess.	A		C			Baoué		
126	Markhamia tomentosa	V	3-12-48	Gordi-Kpo	A		C*	D*		Tomboro		
127	Mimusops Heckelii	I	5-19-48	Jahlaken-Grand Cess	A*		C*		Rubber Tree	Makoré	Baku	Cherry Mahogany.
128	Bombax brevicuspe	II	5-24-48	Iboke-Cavalla	A*			D		Kondroti		
129	Antiaris africana	I	5-24-48	Iboke-Cavalla	A*					Ako	Kyenkyen, Chenchen.	Bark Cloth Tree, Oro.
130	Terminalia ivorensis	I	5-24-48	Iboke-Cavalla	A*		C*	D		Framiré	Idigbo, Emeri	Afara (Black).
131	Fagara angolensis	II	6- 7-48	Webo-Cavalla	A*			D				
132	Lannea acidissima	II	6- 7-48	Webo-Cavalla	A*					Loloti		
133	Morinda lucida	II	5-24-48	Iboke-Cavalla	A*	B		D	Ironwood	Kouaia		
134	Phialodiscus bancoensis	II	5-24-48	Iboke-Cavalla	A*		C*	D		Kaka		
135	Ficus Leprieuri	V	6- 9-48	Bohliken-Gigi	A*							
136	Lindackeria dentata	V	6-13-48	Glarro-Dugbah	A		C			Dédébro-Guissé.		
137	Albizzia Lebbek	II	6-18-48	Nybah-Dugbah	A		C			Lebbek		
138	Khaya ivorensis	I	6-16-48	Kowtee Town-Dugbah	A		C*			Acajou	African Mahogany.	Mahogany.
139	Blighia sapida	III	6-17-48	Nybah-Dugbah	A*		C*	D*	Akee Apple	Baza		
140	Piptostigma Aubrévillei	V	6-17-48	Nybah-Dugbah	A		C*			Baouéfou		
141	Macrolobium chrysophylloides	III	6-19-48	Nybah-Dugbah	A		C			Adonmoteu		
142	Khaya anthotheca	I	7- 7-48	Plennawey-R. Cess	A*		C*			Acajou Blanc		African Mahogany.
143	Treculia africana	IV	7- 8-48	Pudee-River Cess	A		C			Blébendou		
144	Xylopia villosa	III	7- 9-48	Geer-River Cess	A		C			Elo		

145	Macrolobium bilineatum	IV	7– 9–48	Geer-River Cess	A*		C*			Medjilagba		
146	Acioa Barteri	IV	2– 6–49	Gamu-St. John	A*		C*					
147	Bersama leiostegia	V	7– 9–48	B'hai-River Cess	A							
148	Duboscia viridiflora	IV	7– 8–48	Pudee-River Cess	A		C			Otoumon		
149	Cussonia djalonensis	IV	5–15–48	Wlebateh-Sinoe	A							
150	Xylopia rubescens	III	5– 6–48	Troh-Sangwin	A		C*			Fondé des Marais.		
151	Berlinia grandiflora	II	5– 6–48	Troh-Sangwin	A		C*			Melegba		
152	Parinarium chrysophyllum	III	9– 3–48	Clay-Kpo	A*		C*	D*	Rough-skin Plum.	Kioro		
153	Guarea Thompsonii	I	9– 6–48	Bola-Maher	A*		C	D*	Sweet Cedar	Mutigbanaye	Guarea	Black Guarea.
154	Maesobotrya sparsiflora	V	9– 8–48	Gbwamma-Loffa	A*		C			Wouniogpa		
155	Manilkara lacera	II	9– 9–48	Gbwamma-Loffa	A*					Fou		
156	Parinarium subcordatum	III	8–20–48	Gordi-Kpo	A*		C*			Sougué des Rivieres.		
157	Chrysophyllum pruniforme	II	11–30–48	Vuipah-St. John	A*		C*			Boa		
158	Vitex micrantha	III	8–20–48	Gordi-Kpo	A*					Andofiti		
159	Erythrina senegalensis	IV	10–14–48	Monrovia-St. Paul	A					Timeba		
160	Newbouldia laevis	V	11– 1–48	Monrovia-St. Paul	A*	B*				Balié		
161	Parinarium Sargosii	II	10–13–48	Zienshu-Farmington	A*		C*		Monkey Plum	Bombi		
162	Parinarium Kerstingii	II	11– 6–48	Bushrod Is.-St. Paul	A*		C*			Aramon		
163	Anona palustris	V	11– 6–48	Bushrod Is.-St. Paul	A*		C*					
164	Avicennia nitida	V	11– 6–48	Bushrod Is.-St. Paul	A*		C*			Sanar	White Mangrove.	
165	Diospyros Heudelotii	III	11–18–48	Gre-R. Cess	A*		C*			Ngavi		
166	Sterculia Tragacantha	III	11–19–48	Zuatuo-R. Cess	A*		C*			Poré Poré		
167	Caloncoba brevipes	IV	11–19–48	Zuatuo-R. Cess	A*		C*			Dolié		
168	Panda oleosa	III	11–19–48	Tohwe Town-R. Cess	A*		C*			Aoukoua		
169	Tetrapleura tetraptera	III	11–19–48	Tohwe Town-R. Cess	A		C*			Eséhésé		
170	Chidlovia sanguinea	III	11–19–48	Tohwe Town-R. Cess	A*		C*			Bala		
171	Chrysophyllum perpulchrum	II	11–20–48	Tohwe Town-R. Cess	A*		C*			Aninguéri Rouge.		
172	Fagara parvifoliolum	II	11–20–48	Tohwe Town-R. Cess	A*					Mingki		
173	Ficus exasperata	IV	11–21–48	Boongleh-R. Cess	A*				Sandpaper Tree.	Dédé		
174	Hannoa Klaineana	II	11–21–48	Boongleh-R. Cess	A*		C*			Effeu		
175	Entandrophragma utile	I	11–22–48	Potogeh-R. Cess	A		C*		Purple Mahogany.	Sipo	Cedar	Feather Sapele, Assié.
176	Antiaris Welwitschii	II	11–22–48	Potogeh-R. Cess	A*					Akédé		
177	Monodora myristica	V	11–22–48	Boongleh-R. Cess	A*		C*		Calabash Nutmeg.	Moué		
178	Pachystela brevipes	IV	11–23–48	Bewahlee-R. Cess	A*		C*			Koacé		
179	Entandrophragma Candollei	I	11–24–48	Yuahpeah-R. Cess	A*					Kosipo		Heavy Sapele, Oma.
180	Macrolobium macrophyllum	IV	11–24–48	Yuahpeah-R. Cess	A*		C*			Pitiréré		
181	Erythrina altissima	III	11–29–48	Gblogeh-St. John	A*					Ouossoupalié		
182	Voacanga obtusa	IV	11–30–48	Kpowin-St. John	A*		C*					
183	Baphia pubescens	III	11–30–48	Kpowin-St. John	A*		C*		Camwood	Tuibesso		
184	Memecylon Vogelii	IV	11–29–48	Gblogeh-St. John	A*		C*			Arélebossa		
185	Xylia Evansii	III	12– 1–48	Gawin-St. John	A*		C*			Tchiébuessain		
186	Aubrévillea platycarpa	II	12– 1–48	Gawin-St. John	A*					Kléklé		

Footnotes at end of table.

Field Identification of Liberian Tree Species—Continued

Collection No.	Scientific name [1]	Class [2]	Collection date [3]	Collection area Place—Drainage [4]	Sample material [5]				Common and trade names [6]			
					A	B	C	D	Local English	French	Gold Coast	Other trade
187	Xylopia aethiopica	III	12– 1–48	Gawin-St. John	A		C*		Guinea Pepper	Poivrier de Guinée.		
188	Oricia suaveolens	IV	12– 1–48	Gawin-St. John	A*					Iolo		
189	Uapaca esculenta	II	12– 2–48	Zea-St. John	A*		C*		Red Cedar	Borikio		
190	Sterculia elegantiflora	III	11–21–48	Boongleh-R. Cess	A		C*			Bi		
191	Chrysophylum albidum	II	11–30–48	Bememou-Kpo	A*					Koanandio		
192	Pausinystalia Lane-Poolei	II	12– 1–48	Bememou-Kpo	A*	B*						
193	Macrolobium obanense	IV	12– 7–48	Bememou-Kpo	A*					Bapé		
194	Strephonema pseudocola	IV	12– 2–48	Zea-St. John	A*		C*			Poto-poto		
195	Parinarium tenuifolium	II	12– 2–48	Zea-St. John	A*		C			Sougué		
196	Parkia filicoidea	II	2– 6–49	Gamu-St. John	A*					Pipigbalé		
197	Millettia rhodantha	IV	1–24–49	Malemai-Mano	A*		C*					
198	Cassia Sieberiana	III	1–25–49	Kpandemai-Mano	A		C*			Sinedia		
199	Ongokea Klaineana	II	1–27–49	Obeyamai-Loffa	A*				Kosin	Kouéro		
200	Morus mesozygia	II	1–30–49	Darbu-Loffa	A*					Difou	Wonton	
201	Dichrostachys glomerata	IV	1–29–49	Obeyamai-Loffa	A*		C*					
202	Kigelia elliptica	V	1–28–49	Obeyamai-Loffa	A*		C					
203	Xylopia Quintasii	III	1–30–49	Darbu-Loffa	A*		C*			Elo		
204	Copaifera Salikounda	III	1–30–49	Darbu-Loffa	A*		C*			Etimoé		
205	Detarium senegalense	II	1–31–49	Vonehjah-Loffa	A*		C*		Dita	Bodo		
206	Monopetalanthus emarginatus	III	1–31–49	Darbu-Loffa	A*		C*			Sagué		
207	Dialium guineense	III	1–31–49	Vonehjah-Loffa	A*		C*			Kofina	Tamarind	
208	Chrysophyllum metallicum	III	1–31–49	Vonehjah-Loffa	A*		C*					
209	Cola gabonensis	IV	1–31–49	Sabelemah-Loffa	A*		C*			Akéato		
210	Drypetes Afzelii	V	1–31–49	Sabelemah-Loffa	A*		C*					
211	Cryptosepalum tetraphyllum	III	2– 2–49	Lebelibah-St. Paul	A*		C*		Rosewood	Pantou		
212	Carapa procera	I	2– 2–49	Lebelibah-St. Paul	A*		C*			Dona	Crabwood	
213	Chlorophora regia	I	2– 3–49	Wahldessuh-St. Paul	A*				Mulberry	Iroko	Iroko	Odum, Mvule.
214	Pachylobus deliciosa	III	2– 3–49	Wahldessuh-St. Paul	A*		C*			Adjouaba		
215	Pachylobus balsamifera	IV	2– 3–49	Fissabu-St. Paul	A*		C*					
216	Lonchocarpus sericeus	III	1–24–49	Malemai-Mano	A						Samokon	
217	Strombosia pustulata	III	2– 3–49	Wahldessuh-St. Paul	A*					Poé	Afina	
218	Macaranga Barteri	IV	2– 5–49	Belefanai-St. John	A*		C			Tofé		
219	Tetrorchidium didymostemon	IV	2– 6–49	Gamu-St. John	A*	B*	C*			Ouologpaoué		
220	Canthium glabriflorum	V	1–26–49	Obeyamai-Loffa	A					Tekbé		
221	Amanoa bracteosa	III	2– 9–49	Yazoo Town-St. John	A*		C*			Hauto		
222	Chrysophyllum giganteum	II	2–10–49	Yazoo Town-St. John	A*		C*			Koanandio		
223	Syzygium montanum	III	2–10–49	Yazoo Town-St. John	A*							
224	Chrysophyllum africanum	II	2–10–49	Yazoo Town-St. John	A*		C*			Akatio		
225	Ouratea reticulata	V	2–10–49	Yazoo Town-St. John	A*	B*						
226	Diospyros ivorensis	III	2–10–49	Yazoo Town-St. John	A		C*			Ngavi		
227	Millettia hirsuta	IV	2–10–49	Yazoo Town-St. John	A		C*					

228	Premna hispida	V	2–10–49	Yazoo Town-St. John	A*		C*			Alambi			
229	Pterygota macrocarpa	III	1–27–49	Obeyamai-Loffa	A*					Koto			
230	Pachylobus trimera	IV	2–10–49	Yazoo Town-St. John	A*		C			Adjouaba			
231	Aubrévillea Kerstingii	II	1–25–49	Kpandemai-Mano	A*					Kodabéma			
232	Cistanthera papaverifera	I	11–25–48	Yuohlee-R. Cess	A*					Kotibé	Danta		Otutu, Epro.
233	Phialodiscus unijugatus	III	1–28–49	Obeyamai-Loffa	A*		C*			Bébi			
234	Cynometra leonensis	III	3–10–48	Dimeh-Kpo	A*								
235	Bridelia micrantha	III	11–21–48	Boongleh-R. Cess	A*					Tchikué			Benin Ironwood.

[1] All field identifications from Dalziel and Hutchinson's *Flora of West Tropical Africa* or Aubréville's *La Flore Forestière de la Côte d'Ivoire.* (See text footnote No. 3.) Identifications checked at Royal Botanic Gardens, Kew, England, by comparison of herbarium material collected in Liberia with authentic Kew specimens.

[2] Arbitrary classification as follows:

Class I—Trees attaining 2-foot or greater diameter outside bark at breast height or at a point 1 foot above butt flare, of recognized and established commercial timber value and accepted at present in world timber markets.

Class II—Trees attaining Class I size, having at present no established commercial timber value in world markets, but considered promising for future general commercial use, foreign or domestic.

Class III—Trees attaining 1-foot or greater diameter outside bark at breast height or at a point 1 foot above butt flare, of no present commercial timber value, but considered promising for future specialized foreign or domestic use.

Class IV—Trees attaining Class III size, having no present commercial timber value, and considered of doubtful future value, due to size, bad form, poor wood qualities, scarcity, or other unfavorable factors.

Class V—Trees of small size, usually below Class III size, of no consequence as a merchantable timber species, but of interest from other standpoints, such as medicinal properties, rarity or abundance, specialized local uses, unique botanic features, or value as indicator species.

S—Shrubs, not attaining tree size.

[3] Date of original collection of material upon which field identification was based. Present herbarium material collected at different dates and places for some species. All specimens are labeled to show date and place of collection.

[4] Place listed is the occupied place nearest actual point of collection, and drainage listed is the major drainage within which the listed place is located.

[5] A—Leaves, B—Flowers, C—Fruit, D—Wood. Asterisks indicate that specimens are preserved and form part of herbarium material.

[6] Local English names are for Liberia in general, but are often localized in usage. French names largely after Aubréville, op. cit. Gold Coast names largely after Marshall's *Gold Coast Timbers.* Other trade names largely after the Timber Development Association Ltd.'s *Timbers of West Africa* and supplements thereto.

II. Alphabetical List of Tree Species Identified

To facilitate cross-reference to appendix I, the same 235 species listed therein by identification number are listed below, by scientific name only, in alphabetical order. The names of the original describers of each species, not being essential to the average user of such dendrological information, are omitted in the interest of brevity.

Acioa Barteri #146
Afrolicania elaeosperma #36
Afzelia africana #82
Afzelia bella #94
Albizzia ferruginea #57
Albizzia Lebbek #137
Albizzia sassa #31
Albizzia Zygia #44
Allanblackia parviflora #74
Alstonia congensis #13
Amanoa bracteosa #221
Amphimas pterocarpoides #116
Anona palustris #163
Anopyxis ealaensis #12
Anthocleista nobilis #5
Antiaris africana #129
Antiaris Welwitschii #176
Antrocaryon micraster #61
Aubrévillea Kerstingii #231
Aubrévillea platycarpa #186
Avicennia nitida #164

Baphia nitida #66
Baphia pubescens #183
Berlinia acuminata #68
Berlinia bracteosa #106
Berlinia grandiflora #151
Bersema leiostegia #147
Bersema paullinioides #96
Blighia sapida #139
Bombax brevicuspe #128
Bombax flammeum #39
Brachystegia leonensis #65
Bridelia micrantha #235
Bussea occidentalis #100

Caloncoba brevipes #167
Caloncoba echinata #8
Calpocalyx Aubrévillei #102
Calpocalyx brevibracteatus #46
Canarium Schweinfurthii #7
Canthium glabriflorum #220
Carapa procera #212
Cassia Sieberiana #198
Cathormion altissimum #117
Cathormion Dinklagei #67
Ceiba pentandra #50
Chidlovia sanguinea #170
Chlorophora excelsa #85
Chlorophora regia #213
Chrysophyllum africanum #224
Chrysophyllum albidum #191
Chrysophyllum giganteum #222
Chrysophyllum metallicum #208
Chrysophyllum obovatum #81
Chrysophyllum perpulchrum #171
Chrysophyllum pruniforme #157
Cistanthera papaverifera #232
Coelocaryon oxycarpum #70
Cola digitata #60
Cola gabonensis #209
Cola mirabilis #59
Combretodendron africanum #75
Conopharyngia durissima #108
Conopharyngia longiflora #52
Copaifera Salikounda #204
Coula edulis #15
Croton macrostachyus #73
Crudia senegalensis #111
Cryptosepalum tetraphyllum #211
Cussonia djalonensis #149
Cylicodiscus gabunensis #84
Cynometra ananta #87
Cynometra leonensis #234

Daniella thurifera #88
Dentarium senegalense #205
Dialium Dinklagei #62
Dialium guineense #207
Dichrostachys glomerata #201
Diospyros gabunensis #113
Diospyros Heudelotii #165
Diospyros ivorensis #226
Distemonanthus Benthamianus #78
Drypetes Afzelii #210
Drypetes ivorensis #105
Duboscia viridiflora #148

Enantia chlorantha #17
Enantia polycarpa #125
Entandrophragma Candollei #179
Entandrophragma macrophyllum #56
Entandrophragma utile #175
Erythrina altissima #181
Erythrina senegalensis #159
Erythrophleum micranthum #9

Fagara angolensis #131
Fagara macrophylla #32
Fagara parvifoliolum #172
Ficus exasperata #173
Ficus Leprieuri #135
Ficus Mucuso #43
Ficus sagittifolia #124
Ficus Vogelii #114
Funtumia elastica #27
Funtumia latifolia #91

Garcinia Kola #1
Guarea Thompsonii #153

Hannoa Klaineana #174
Haplormosia monophylla #79
Harunga madagascariensis #42
Hymenostegia Afzelii #122

Irvingia gabonensis #48

Khaya anthotheca #142
Khaya ivorensis #138
Kigelia elliptica #202
Klainedoxa gabonensis #98

Lannea acidissima #132
Lindackeria dentata #136
Lonchocarpus sericeus #216
Lophira alata #14
Lovoa Klaineana #26

Macaranga Barteri #218
Macaranga huraefolia #41
Macrolobium bilineatum #145
Macrolobium chrysophylloides #141
Macrolobium diphyllum #71
Macrolobium Heudelotii #47
Macrolobium macrophyllum #180
Macrolobium obanense #193
Maesobotrya sparsiflora #154
Manilkara lacera #155
Markhamia tomentosa #126
Memecylon membranifolium #104
Memecylon Vogelii #184
Microdesmis puberla #18
Millettia hirsuta #227
Millettia rhodantha #197
Mimusops Heckelii #127
Mitragyna stipulosa #16
Monodora brevipes #2
Monodora myristica #177
Monopetalanthus compactus #121
Monopetalanthus emarginatus #206
Monopetalanthus pteridophyllum #99
Monopetalanthus (sp. nouveau ?) #38
Morinda geminata #89
Morinda lucida #133
Morus mesozygia #200
Musanga Smithii #4
Myrianthus arboreus #123
Myrianthus libericus #119
Myrianthus serratus #22

Neostenanthera hamata #45
Newbouldia laevis #160
Newtonia insignis #109

Ochrocarpus africanus #51
Oldfieldia africana #35
Omphalocarpum elatum #86
Ongokea Klaineana #199
Oricia suaveolens #188
Ouratea reticulata #225
Oxystigma Stapfiana #72

Pachylobus balsamifera #215
Pachylobus deliciosa #214
Pachylobus trimera #230
Pachypodanthium Staudtii #118
Pachystela brevipes #178
Pachystela micrantha #34
Panda oleosa #168
Parinarium Aubrévillei #110
Parinarium chrysophyllum #152
Parinarium excelsum #80
Parinarium Kerstingii #162
Parinarium macrophyllum #33
Parinarium robustum #69
Parinarium Sargosii #161
Parinarium subcordatum #156
Parinarium tenuifolium #195
Parkia bicolor #10
Parkia filicoidea #196
Pausinystalia Lane-Poolei #192
Pentaclethra macrophylla #37
Pentadesma butyracea #28
Phialodiscus bancoensis #134
Phialodiscus unijugatus #233
Phyllanthus discoideus #21
Piptadenia africana #24
Piptadenia Aubrévillei #115
Piptostigma Aubrévillei #140
Premna hispida #228
Protomegabaria Stapfiana #55
Pterocarpus santalinoides #40
Pterygota macrocarpa #229
Pycanthus kombo #23

Randia acuminata #53
Rauwolfia vomitoria #101
Rhizophora racemosa #76
Ricinodendron africanum #6

Saccoglottis gabonensis #3
Sakersia africana #25
Sarcocephalus Diderrichii #54
Scytopetalum Tieghemii #63
Spathodea campanulata #77
Spondias monbin #64
Sterculia elegantiflora #190
Sterculia Tragacantha #166
Strephonema pseudocola #194
Strombosia pustulata #217
Symphonia gabonensis var. *macrantha* #103
Syzygium abidjanense #92
Syzygium guineense #93
Syzygium montanum #223

Tarrietia utilis #30
Terminalia ivorensis #130
Terminalia superba #83
Tetrapleura Chevalieri #95
Tetrapleura tetraptera #169
Tetrorchidium didymostemon #219
Treculia africana #143
Trichilia Heudelotii #49
Trichoscypha arborea #11
Triplochiton scleroxylon #120
Tylostemon Manii #90

Uapaca esculenta #189
Uapaca guineensis #20
Uapaca Heudelotii #107
Uapaca paludosa #29

Vitex grandifolia #112
Vitex micrantha #158
Vitex oxycuspis #19
Vitex rufa #58
Voacanga obtusa #182

Xylia Evansii #185
Xylopia aethiopica #187
Xylopia Quintasii #203
Xylopia rubescens #150
Xylopia Staudtii #97
Xylopia villosa #144

NOTE:—The total of 235 tree species listed herein contains representatives of 150 genera.

III. Tree and Timber Guide

Of the 235 species of forest flora identified within Liberia during the reported study, 232 are trees and 3 are shrubs. While some of the forest trees are well known in commerce, most of them are little known or unknown and have never been evaluated for economic use on the basis of adequate testing of their properties. For the better known species, the sources that are cited in the bibliography will provide such information as has been published to date. While there was no work done in connection with timber testing during the survey covered in this report, every effort was made to assemble notes which would furnish some indication of the use possibilities of tree species not already well-known. In addition to such factors as tree size, form, frequency, and habitat, native uses, either as actually noted or as stated in reply to questioning, and botanical affinities to species of known use qualities, were considered.

The last phase of report preparation was a further review of literature available on West African woods and the assignment of Liberian tree species to one of five categories of economic importance, established or predicted. It must be realized that the classifications assigned are tentative and poorly supported for the bulk of the species covered. In general, Class I and Class V listings are considered most reliable under current conditions. Class II and Class III listings may prove interchangeable for some species, more as a result of future wood-use findings than as a result of assigned tree sizes. Some Class IV trees may merit Class III rating as more is learned of them, but very few Class IV trees appear to have any commercial possibilities now or in the future. An alphabetical species listing, by scientific name, identification number, and class, is given following a brief definition of each class.

Class I: Trees attaining 2-foot or greater diameter outside bark at breast height or at a point 1 foot above butt flare, of rec-

ognized and established commercial timber value and accepted at present in world timber markets.

Afzelia africana #82
Albizzia Zygia #44
Alstonia congensis #13
Antiaris africana #129
Baphia nitida #66
Brachystegia leonensis #65
Canarium Schweinfurthii #7
Carapa procera #212
Chlorophora excelsa #85
Chlorophora regia #213
Cistanthera papaverifera #232
Cylicodiscus gabunensis #84
Daniella thurifera #88
Distemonanthus Benthamianus #78
Entandrophragma Candollei #179
Entandrophragma macrophyllum #56
Entandrophragma utile #175
Erythrophleum micranthum #9
Guarea Thompsonii #153
Khaya anthotheca #142
Khaya ivorensis #138
Lophira alata #14
Lovoa Klaineana #26
Mimusops Heckelii #127
Mitragyna stipulosa #16
Oldfieldia africana #35
Piptadenia africana #24
Pycanthus kombo #23
Saccoglottis gabonensis #3
Sarcocephalus Diderrichii #54
Tarrietia utilis #30
Terminalia ivorensis #130
Terminalia superba #83
Triplochiton scleroxylon #120
Tylostemon Manii #90

Total Class I species—35

Class II: Trees attaining Class I size, having at present no established commercial timber value in world markets, but considered promising for future general commercial use, foreign or domestic.

Albizzia ferruginea #57
Albizzia Lebbek #137
Albizzia sassa #31
Allanblackia parviflora #74
Amphimas pterocarpoides #116
Anopyxis ealaensis #12
Antiaris Welwitschii #176
Aubrévillea Kerstingii #231
Aubrévillea platycarpa #186
Berlinia acuminata #68
Berlinia bracteosa #106
Berlinia grandiflora #151
Bombax brevicuspe #128
Bussea occidentalis #100
Calpocalyx brevibracteatus #46
Chrysophyllum africanum #224
Chrysophyllum albidum #191
Chrysophyllum giganteum #222
Chrysophyllum obovatum #81
Chrysophyllum perpulchrum #171
Chrysophyllum pruniforme #157
Coelocaryon oxycarpum #70
Combretodendron africanum #75
Cynometra ananta #87
Dentarium senegalense #205
Fagara angolensis #131
Fagara macrophylla #32
Fagara parvifoliolum #172
Hannoa Klaineana #174
Haplormosia monophylla #79
Irvingia gabonensis #48
Klainedoxa gabonensis #98
Lannea acidissima #132
Manilkara lacera #155
Monopetalanthus (sp. nouveau?) #38
Morinda lucida #133
Morus mesozygia #200
Ochrocarpus africanus #51
Ongokea Klaineana #199
Pachystela micrantha #34
Parinarium Aubrévillei #110
Parinarium excelsum #80
Parinarium Kerstingii #162
Parinarium robustum #69
Parinarium Sargosii #161
Parinarium tenuifolium #195
Parkia bicolor #10
Parkia filicoidea #196
Pausinystalia Lane-Poolei #192
Pentaclethra macrophylla #37
Pentadesma butyracea #28
Phialodiscus bancoensis #134
Ricinodendron africanum #6
Symphonia gabonensis var. *macrantha* #103
Uapaca esculenta #189
Uapaca guineensis #20
Uapaca Heudelotii #107
Uapaca paludosa #29

Total Class II species—58

Class III: Trees attaining 1-foot or greater diameter outside bark at breast height or at a point 1 foot above butt flare, of no present commercial timber value, but considered promising for future specialized foreign or domestic use.

Afzelia bella #94
Amanoa bracteosa #221
Antrocaryon micraster #61
Baphia pubescens #183
Blighia sapida #139
Bridelia micrantha #235
Calpocalyx Aubrévillei #102
Cassia Sieberiana #198
Cathormion Dinklagei #67
Chidlovia sanguinea #170
Chrysophyllum metallicum #208
Cola mirabilis #59
Copaifera Salikounda #204
Coula edulis #15
Crudia senegalensis #111
Cryptosepalum tetraphyllum #211
Cynometra leonensis #234
Dialium Dinklagei #62
Dialium guineense #207
Diospyros Heudelotii #165
Diospyros ivorensis #226
Enantia chlorantha #17
Enantia polycarpa #125
Erythrina altissima #181
Ficus Mucuso #43
Funtumia elastica #27
Funtumia latifolia #91
Garcinia Kola #1
Lonchocarpus sericeus #216
Macrolobium chrysophylloides #141
Monodora brevipes #2
Monopetalanthus compactus #121
Monopetalanthus emarginatus #206
Monopetalanthus pteridophyllum #99
Musanga Smithii #4
Neostenanthera hamata #45
Newtonia insignis #109
Pachylobus deliciosa #214
Pachypodanthium Staudtii #118
Panda oleosa #168
Parinarium chrysophyllum #152
Parinarium subcordatum #156
Phialodiscus unijugatus #233
Phyllanthus discoideus #21
Piptadenia Aubrévillei #115
Protomegabaria Stapfiana #55
Pterocarpus santalinoides #40
Pterygota macrocarpa #229
Rhizophora racemosa #76
Scytopetalum Tieghemii #63
Spathodea campanulata #77
Sterculia elegantiflora #190
Sterculia Tragacantha #166
Strombosia pustulata #217
Syzygium guineense #93
Syzygium montanum #223
Tetrapleura Chevalieri #95
Tetrapleura tetraptera #169
Trichilia Heudelotii #49
Trichoscypha arborea #11
Vitex micrantha #158
Vitex rufa #58
Xylia Evansii #185
Xylopia aethiopica #187
Xylopia Quintasii #203
Xylopia rubescens #150
Xylopia Staudtii #97
Xylopia villosa #144

Total Class III species—68

Class IV: Trees attaining Class III size, having no present commercial timber value and considered of doubtful future value due to size, bad form, poor wood qualities, scarcity, or other unfavorable factors.

Acioa Barteri #146
Anthocleista nobilis #5
Bersema paullinioides #96
Bombax flammeum #39
Caloncoba brevipes #167
Caloncoba echinata #8
Cathormion altissimum #117
Ceiba pentandra #50
Cola gabonensis #209
Conopharyngia durissima #108
Cussonia djalonensis #149
Dichrostachys glomerata #201
Duboscia viridiflora #148
Erythrina senegalensis #159
Ficus exasperata #173
Ficus Vogelii #114
Hymenostegia Afzelii #122
Macaranga Barteri #218
Macrolobium bilineatum #145
Macrolobium diphyllum #71
Macrolobium Heudelotii #47
Macrolobium macrophyllum #180
Macrolobium obanense #193
Memecylon Vogelii #184
Millettia hirsuta #227
Millettia rhodantha #197
Morinda geminata #89
Oricia suaveolens #188
Oxystigma Stapfiana #72
Pachylobus balsamifera #215
Pachylobus trimera #230
Pachystela brevipes #178

Strephonema pseudocola #194
Syzygium abidjanense #92
Tetrorchidium didymostemon #219
Treculia africana #143
Vitex grandifolia #112
Vitex oxycuspis #19
Voacanga obtusa #182

Total Class IV species—39

Class V: Trees of small size, usually below Class III size, of no consequence as a merchantable timber species, but of interest from other standpoints, such as medicinal properties, rarity or abundance, local uses, unique botanic features, or value as indicator species.

Afrolicania elaeosperma #36
Anona palustris #163
Avicennia nitida #164
Bersema leiostegia #147
Canthium glabriflorum #220
Conopharyngia longiflora #52
Croton macrostachyus #73
Diospyros gabunensis #113
Drypetes Afzelii #210
Drypetes ivorensis #105
Ficus Leprieuri #135
Harunga madagascariensis #42
Kigelia elliptica #202
Lindackeria dentata #136
Macaranga huraefolia #41
Maesobotrya sparsiflora #154
Markhamia tomentosa #126
Microdesmis puberla #18
Monodora myristica #177
Myrianthus arboreus #123
Myrianthus libericus #119
Myrianthus serratus #22
Newbouldia laevis #160
Omphalocarpum elatum #86
Ouratea reticulata #225
Parinarium macrophyllum #33
Piptostigma Aubrévillei #140
Premna hispida #228
Randia acuminata #53
Rauwolfia vomitoria #101
Sakersia africana #25
Spondias monbin #64

Total Class V species—32

Shrubs: Low woody plants not attaining tree size.

Cola digitata #60
Ficus sagittifolia #124
Memecylon membranifolium #104

Total shrub species—3

IV. Sample Field Notes

The following copy of field notes for one day of travel during the fourth forest reconnaissance field trip is included in the report as an indication of the generalized type of field data upon which much of the report, particularly in regard to forest areas and volumes, was based. Similar field notes, transcribed each night from pocket notebook entries, were made for each of the 216 days of travel included in six reconnaissance trips. Data of this type were of great value in correlating ground conditions in areas of all cover classes with the aerial photo coverage of the same areas. Quite uniform factors for converting airline distances from photomaps to ground distances under various conditions were arrived at by constant posting of field data to photomaps prepared in advance of travel. Hydrography as taken from aerial photos could be readily checked by reference to field notes. Restudy of photographs by pocket stereoscope, following field travel in concerned areas, was found profitable solely because of such field notes. The same notebooks served many other purposes, some nontechnical, as concerned expenditures, labor, provisions, property, etc.

Explanations of abbreviations, symbols, etc., in the following copy of field notes occur as footnotes, by parenthesized enumeration.

15 (1) 5-6-48 (Thurs.) 204 (2) 281 (3) R-4 (4) 26 (5) 26 (6).

6:30 Lv. Troh; 6:45 thru HT-4(7), retracing 5-4-48 route *0.8*(8); 7:00 thru HT-8, left to Sangwin R., THSE(9)2.8(10) LB&C(11)—Sangwin SW(12), 150′ wide, clear, rocks 100 yds. upstream, 120′ cottonwood just above crossing on S bank. Canoe ferry-over 2nd. trip *0.7*; 7:30 on(13); 7:40 THSE 3.3 LB *0.6*; 7:50 SS-W(14) THSSW 3.2 BB(15) *0.5*; 8:10 THSSE 3.3 BB, several SS-W *1.1*; 8:15 enter HB(16), THSE 3.4 BB *0.3*.

Total, Troh to E. Sangwin HB—*4.0*

8:30 THESE 3.3 15M(17) *0.8*; 8:55 THESE 3.3 15M *1.4*—samples (18); 9:05 on; 9:20 THESE 3.2 15M *0.8*; 10:10 THSE 3.2 10M *2.7*—samples; 10:15 on; 10:30 enter low hills, all prior flat river-bottom, THSE 3.1 10M *0.8*; 11:15 THESE 3.2 10M *2.4*, leave hills—samples; 11:30 on; 12:30 chop(19), THESE 3.2 10M *3.2*; 12:50 on; 1:05 heavy rain begins; 1:50 rain over; 2:00 MS-N (20)TH aver.(21) ESE 3.1 15M *3.6*; 2:15 enter BB, THESE 3.2 10M *0.8*.

Total unbroken HB—*16.5*

2:35 monkeys—shoot 4 lions(22), THNE 3.2 BB *1.1*; 3:00 on; 3:10 ar. new HT-4, THNE 3.3 LB *0.5*; 3:15 on; 4:05 thru FH-1 (23) THENE 3.3 LB *2.7*; 4:30 ar. Nyawe-16(24), C.C.Fahlee's town(25) THNE 3.4 C *1.4*—5 loads passed to Kulu, P.C. town(26) —rain begins.

Total, end of HB to Nyawe—*5.7*

Total, Troh to Nyawe—*26.2*

(Balance of notes concern non-travel activities, purchase of rice, clan set-up, quarters, recalling loads from town ahead, evening rain, work on samples, posting photomap, town people's actions, etc.)

Explanation of travel notes:

(1) Fifteenth day of trip.
(2) Cumulative party mileage through day.
(3) Cumulative personal mileage through day.
(4) Hours of daylight rain.
(5) Day's mileage—party.
(6) Day's mileage—personal.
(7) Half-town, 4 occupied huts.
(8) Miles to point—direction and distance previously recorded.
(9) To here—southeast.
(10) Average miles per hour since last time entry.
(11) Low bush and clearings about evenly mixed. Otherwise, only predominating cover entered. Mileage divided evenly in present case, otherwise credited to dominant cover.
(12) River flowing southwest at point crossed.
(13) Resume travel.
(14) Small stream (up to 10 feet wide) flowing west.
(15) To here, south-southwest, 3.2 miles per hour, through broken bush.

(16) High bush—subsequent high bush entries show only average estimated volume per acre, by 5MBF volume classes, in merchantable trees.
(17) Stand averaged 15 MBF per acre for concerned 0.8 mile.
(18) Stop to secure specimens. Travel delays of few minutes to secure specimens allowed for by adjusting travel rate per hour.
(19) Lunch.
(20) Medium stream (10 to 50 feet wide) flowing north.
(21) Course averaged ESE. During rain, compass used infrequently, and trail believed to vary from average slightly.
(22) Lion monkeys, shot for meat. This is most common high-forest monkey (red and black colobus)—103 shot on this trip, as compared to 18 of all other species combined.
(23) Single occupied hut at farm clearing, beside trail.
(24) Arrive at major village—16 occupied huts. In all larger villages, headman of party counted huts. Used on all six field trips, he was never checked as in error on hut counts.
(25) Clan Chief Fahlee, Tarjazon Clan, lived in the town.
(26) Next town on trail was a paramount chief's town.

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