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ASSISTANCE TO THE FORESTRY DEVELOPMENT AUTHORITY OF LIBERIA

FOREST RESOURCES MAPPING OF LIBERIA

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ASSISTANCE TO THE FORESTRY DEVELOPMENT AUTHORITY OF LIBERIA
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RESUME

This report covers the work of forest resources mapping undertaken by the Remote Sensing Unit of the Forestry Development Authority of Liberia between March, 1982 and June, 1984.

Its principal aim is to reassess the actual forest cover area of Liberia by interpretation of recent aerial photography and the subsequent transfer of this photo detail to 1 in 125,000 map series.

The procedures adopted for this mapping study are detailed. In conjunction with this work a deforestation study was also carried out using the same selected areas from each of the 1953, 1969 and 1979/82 aerial photography series.

The results of these studies are discussed and related to previous estimates that have been made.

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FOREST RESOURCES MAPPING OF LIBERIA

1. BACKGROUND

1.1. Previous Studies

Two major previous surveys of the forest resources of Liberia have been made:

(a) 'Forest Resources of Liberia' 1951 by Karl R. Mayer which was based on field work undertaken in 1947 to 1949 and using 1945-46 aerial photography. Results of this investigation were:

High forest	*3,622,000*	*Hectares*
Broken bush	*1,963,000*	*Hectares*
Sub-total	5,585,000	Hectares
Low bush	2,125,000	Hectares
Non forest areas	1,922,000	Hectares
Total	9,632,000	Hectares

The term broken bush was defined as 'forest with a broken canopy and a gross volume per acre of 5,000 board feet or less in trees of all species 2 feet over bark or more in diameter and containing at least one merchantable 16 feet log'. The term high forest was similar but with a completely closed canopy and greater than 5,000 board feet per acre.

(b) 'General report on national forest inventory in Liberia' 1968 by M. Sachtler based on field work carried out between 1960 and 1967 by the German Forestry Mission to Liberia in co-operation with the (then) Bureau of Forest and Wildlife Conservation. Their result on broad forest types were:

Exploitable forest	*1,205,000*	*Hectares*
Unexploitable forest	*1,267,000*	*Hectares*
Sub-total	2,470,000	Hectares
Others not defined	8,667,000	Hectares
Total	11,137,000	Hectares

Aerial photographs flown in 1952-53 were used as a guide for the general inventory though photo quality was poor due to excessive cloud and haze cover.

This inventory did not cover all of Liberia, but rather those major forest areas including all declared national forests. This fact is often overlooked and the results have been applied on an overall national basis.

Other estimates of the forest are have been made, Atlanta in 1976 estimated the total forest area to be 4.8 million hectares of which 2.5 is broken high forest, whilst the planning and development atlas states the closed high forest area in 1984 to be 2.02 million hectares.

Tropical forest resources assessment project using the German Forestry Mission figure and updating it has a figure of 2 million hectares for the total closed broadleaf forest area of which 1.33 is considered productive and the remainder non productive.

Not only is there considerable divergence in forest area figures but also in total area of Liberia figures. Just from (a) and (b) sections before, the two figures for total area are respectively 9.6 and 11.1 million hectares, the correct figure is nearer the former. Naturally when applying the inflated area figure the percentage of forest cover will be misrepresented. A recent publication by FAO 'Forest Resources 1980' prepared for the International Year of the Forest show the forest cover percentage of total land area as 18.9%. This present study shows this in fact to be close to 50%.

1.2 Project Structure & Staffing

During the formulation of the loan package 'Forestry Project Liberia' the three co-financiers - IDA (International Development Association), ADB (African Development Association) and GTZ (German Agency for Technical Co-operation) recognized the need for up-to-date factual information on the forest resources of the country. To this end provision was made for the procurement of aerial photography and the inclusion in the technical assistance scheme of a Forest Resources Survey Officer to assist and guide resources studies. This particular section of the project would be funded by the ADB portion of the loan.

Infrared false colour photography at a scale of 1 in 70,000 covering approximately half of Liberia was flown in January and December of 1979 on contract to the FDA (Forestry Development Authority). The complete country coverage could not be achieved due to persistent haze or cloud cover.

A 'Remote Sensing Unit' or more correctly, a forest resources unit was set up within FDA in 1980 with two professionals and 4 technicians. These personnel were later sent for one year's training course in the Netherlands on air photo interpretation, mapping and inventory. Ancillary shorter courses have been undertaken by staff members at the Regional Remote Sensing Center at Ougadougou, Burkino Faso. A total of 8 persons were attached to the unit and available for this study.

1.3 Scope of Study

As an initial (re)evaluation of the forest resources of Liberia it was determined that a national forest type map series was necessary. This would give an overall appreciation of the location and extent of the remaining forests of the country and thus form the basis for future detailed ground inventories of specific (priority) areas.

In the absence of any national land use study maps (an area in the Mano River region was so mapped in 1976) - it was further determined that vegetation types other than forest would be demarcated. This would be of use in other disciplines and could prove to be a forerunner to land use planning studies. To assist in forest exploitation studies, areas of high forest should be categorized into slope classes and whether logged or unlogged.

The overall work would be carried out by FDA Remote Sensing Unit with the guidance and assistance of the Forest Resource Survey Officer.

2. AERIAL PHOTO INTERPRETATION

2.1 Available Aerial Photography

Due to the rainfall pattern in Liberia excessive cloud cover during the period mid April to mid November virtually precludes any chance of photography during these months. The remaining five months can have periods somewhat free of cloud cover. However, this is the time of the harmattan which causes a deep dust haze over much of the country. This makes it difficult to obtain quality photography at relatively low levels let alone at 35,000 feet for smaller scaled aerial photography.

FDA commissioned Mark Hurd Aerial Surveys, Inc. to obtain a complete coverage of Liberia of 1 in 70,000 infrared false colour aerial photography. Unfortunately, even in two 'bites' it was possible to gain acceptable coverage of only a little over half of the country, the western section.

However, in 1982 the Liberian cartographic Service obtained 1 in 60,000 infrared black and white photography for the eastern section of Liberia flown for the Directorate of Surveys. FDA were able to obtain copies of these which fortunately complemented the already held coverage.

These two sets of photography formed the basis for the study. Where the two sets overlapped the 1982 series, being the more recent, was used. A number of gaps in the above were 'filled' by 1979-81 1 in 50,000 in limited areas in the north and the remainder from the 1969 1 in 40,000 series. The map in attachment 1 shows the photography utilized in this forest resources mapping exercise.

Complete coverage of Liberia was obtained in '1953 and 1969. However, the prints presently available are of poor quality duo to deterioration through adverse climatic and storage conditions. Other photography such as that of 1975 has been flown for specific work and are thus limited in coverage, the 1975 photos being for the Mano River land use mapping project.

Also, the whole country has been flown with SLAR (side looking air-borne radar) though this is not presently available as portion was for a private company and the remainder flown on 'spec". Due to availability of aerial photography, the purchase of SLAR coverage was not followed up.

2.2 Vegetation Type Legend Determination

As stated in Section 1.3 though the main object was to determine the area, location and type of the forest cover it was considered prudent to identify various non forest areas as well.

In determining the level of detail possible for the interpretation, the quality of the photos, differences between the sets of photographs, equipment available and the experience of the project staff had to be taken into account. Generally, the FDA 1 in 70,000 series was clear and sharp though colour rendition was not consistent due to the effect or haze. The 1 in 60,000 1982 series black and white was also somewhat haze affected and vegetation boundaries were not always sharp and distinct

To allow for some indication of logging accessibility within the forest 'different types of slope categories were investigated. Three categories were finally chosen, 0-15%, 15-30% and 30%+. An attempt was made to delineate logged from unlogged areas. Due to the selective and light harvesting pattern (between 3—8 cubic meters per hectare) canopy opening was insufficent to be noticeable. The only consistent indication of logging was the presence of access roads. However, during field checking it was found previously logged areas were not being consistently recognized. This was particularly noted in other than recently logged area where the skid tracks and secondary roads had become overgrown and indistinguishable at this scale of photography. The division into logged and unlogged was therefore discontinued.

High forest was considered to be forest of a primary or old secondary nature with a closed or almost closed canopy exceeding 30 meters in height. It may or may not contain emergents. It was divided into two categories, those areas occuring on swampy sites and those on dryer sites. It was not thought feasible to separate the often described evergreen and moist semi-deciduous forest occuring within Liberia.

However, some differences were noted in the dryer high forest areas. On the IRFC photographs a greyish-blue hue was noticed - this proved to be *parinari excelsa* dominated forest, most likely of an advanced or older secondary nature. It occurs or at least was recognized only in the central west and southwest parts of Liberia.

Also noted were areas of small crowned forest normally on more rugged terrain and possibly associated with skeletal soils and/or forests of a more primary nature. Due to its location and

relatively small area it was not extensively field checked. It was not always consistently recognized by all interpreters and accounts for a very minor proportion of the total forest area.

Various plantations types were recognized and demarcated. It must be stressed that these are gross areas including roads, firebreaks, unplanted small swampy areas as well as what is probably failed and unproductive areas. Therefore, net plantation areas should be obtained from other sources or more detailed studies.

Of the non forest portion most areas fell in the farmland and regrowth type, a group comprising present farmland as well as all regrowth areas resulting from, or thought to have resulted from, such farming. It also undoubtedly included 'low bush' degraded areas that could not in the short to medium term attain high forest status again.

Natural and induced savannah areas occuring in both the coastal and northwest areas were readily recognized as was grassland areas.

The final vegetation legend selected was:

1	High forest	1 mixed crown sizes	
	(on dry land)	2 small crown sizes	
		3 *Parinari excelsa* dominated	
2	Swamp forest	1 Fresh water	
		2 Mangrove	
3	Plantations	1 Forest	
		2 Agriculture	1 Rubber
			2 Oil palm
			3 Others
4	Other lands	1 Farm & regrowth	
		2 Swamp	
		3 Savannah	
		4 Grass land	
		5 Others e.g. towns, mining areas etc,	

Slope categories were applied to all high forest areas on dry land:

a	0-15%
b	15-30%
c	30%+

Definitions of these vegetation types - see attachment 2.

2.3 Interpretation Method

All photographs selected had principal points and stereoscopically transferred principal points marked. By using these as a guide the effective area of each photograph, in the run direction was marked. Interpretation was limited to this area to minimize distortion in later transference of detail to the map by using a shetchmaster. Due to lack of sufficient sidelap on some runs it was not always possible to follow the same procedure to limit distortion in the between run direction.

Transparent overlays were attached to each photograph used and all detail was marked on these. In order that overlay could be properly repositioned the principal points and transfered principal points were permanently marked on it as were the run and photo number.

During the preliminary phase of ground truthing the vegetation types, typical areas of each type were selected and these in effect acted as stereograms for reference purposes.

Certain limitations as to minimum size were required. Though the data this time was transferred to a 1 in 125,000 map, it was thought appropriate to delineate areas in such detail that could, at some future time, be suitable for 1 in 50,000 mapping. Thus, an area of 0.25 square centimeters (approximately 12 hectares) was to the smallest area outlined. Some areas of unproductive swamp were long and attenuated and it was desirous a lower limit of 0.2 centimeters was used as a width category.

In order to later transfer data (using a shetchmaster) from photo to map, it was essential to mark certain roads and rivers on the photo that were also shown on the map.

The mirror stereoscope with an X3 Binocular attachment was the basic instrument used for interpretation. Various colour inks and pen sizes suitable for viewing and transfer by the shetchmaster were used.

During the exercise 5 interpreters worked, each being allocated a number of adjacent runs. It was thus the individuals responsibility to ensure between run boundary matching for his area and with his fellow interpreter in other cases.

The typing of slope categories was of course somewhat subjective and was done on a broad basis only. It was found that considerable attention was required to ensure some degree of uniformity between individuals. As this information was principally aimed at determining logging accessibility it was carried out over high forest areas only.

3. MAPPING

3.1 Selection of Base Map

As FDA has neither the equipment or trained personnel to produce acceptable controlled maps from aerial photographs, an existing map series was sought on which to ‘hang’ the vegetation types.

There was available a 1 in 125,000 quadrangle sheet series of Liberia produced by the United States Geological Services for the Liberian Geological Service - from 1969 1 in 40,000 aerial photographs. These maps had a detailed drainage pattern as well as roads, railways and towns marked. This was selected as our base map. As the large size maps were not suitable particularly for field work they were retraced initially onto an 18 map series grid and then for final reproduction onto a 45 minute grid giving a total of 24 map sheets - see attachment 3.

It was not possible to use these maps in their existing form as to have presented vegetation type boundaries would have ‘cluttered’ the detail making it difficult to decipher. Thus, when the maps were retraced onto stable base, only the major drainage pattern, roads and towns were taken. Care was needed however that the rivers and roads selected for transfer were adequate for accurate later use of the shetchmaster as well as for identification and location purposes.

3.2 Transfer of Detail to Base Map

As stated above a shetchmaster was used for the reduction and transfer of vegetation type boundaries from the various scaled photographs to the 1 in 125,000 base map. Once the appropriate reduction has been achieved (through a combination of lenses) the image of a small area of the photograph is superimposed on the map by matching up the features common to both after doing fine adjustments as required.

All the boundaries as interpreted on the photo (see Section 2.3) were not necessarily transferred, very small areas were deleted Generally the size limitation for area transfer was:

	Photo	Map Equivalent
Area	0.8 sq. cm (39ha)	0.25 sq. cm
Width	0.45 cm (315m)	0.25 cm

The initial transfer from the photograph was carried out onto dyeline prints, edge-matched and then traced onto the stable base sheets. The small error involved due to movement of the dyeline print was considered to be minor.

3.3 Area Determination

Again the dyeline print was used for this operation. Each sheet (of the initial 18 map series) was sub-divided into roughly four (4) equal sections, and areas of all vegetation types within each section measured by planimeter. Such measurements were noted within the individual areas for later checking if required. Each type area was measured at least two times and sometimes, three times or more depending on the variation of the readings.

The total area within each section was mathematically calculated and compared to the total area of all types. Results were tabulated by map sheets for each vegetation type (see attachment 4).

3.4 Checking Routine

During interpretation, routine spot checking was carried out by the senior officer to ensure uniformity of interpretation. Particular attention was given to slope category classes. During transfer it was ensured that correct lens combinations were used for the shetchmaster particularly when moving to photography of a difficult scale.

In the area tabulation sheet (attachment 4) visual observations were made to locate obvious mistakes i.e. mangrove areas on a map sheet covering inland areas, forest and other plantations not in known locations etc. These were normally due to wrong numbering.

4. DEFORESTATION STUDIES

4.1 Purpose of Study

Various estimates have been made of the annual rate of deforestation in Liberia. Mayer thought some 20,000 hectares of (his) high forest and broken forest were destroyed annually. The tropical forest resources assessment project puts this figure at 41,000 hectares for the period 1976/80 rising to 46,000 for the period 1981/85, most of which had or was to be, cleared for upland rice cultivation

This vegetation study gave an opportunity to carry out some ‘continuous area estimation’ for deforestation studies.

There is a generally held feeling that the forests of the country are inexhaustable and whilst this is so, sound conservation measures to protect the forest resources are often given little support. This study was initiated to obtain some factual figures on rate of deforestation both for public aware ness exercises and for long term forestry planning.

4.2 Study Method and Outcome

Partially completed aerial photography is now available for 1953, 1969 and 1979/82, though presently held prints of the 53 and 69 series are no longer of a high quality due to poor storage conditions.

Three areas, each of approximately 200,000 ha were chosen subjectively - the criteria for selection being suitable coverage of each of the three series of photographs as well as a reasonable area of high forest cover (at least on the 53 series). On this basis Bopolu in the central west, Nimba in the north and Sinoe in the central east were chosen. These areas did include some national forest areas though this was not a factor in area selection.

High forest areas were marked on each series of photography and detail transferred to the appropriate 1 in 125,000 map prepared for each. Areas were then calculated.

It is recognized that this deforestation study is very rudimentary and results can be only a guide to the overall national situation. Unfortunately due to time, quality of older prints available and only partial coverage of the country by all three series of photography, a more wide ranging and complete study could not be undertaken.

A summary of results obtained were:

	Study Area - Areas in Hectares		
	Bopolu	Nimba	Sinoe
Total area	167,546	198,645	202,410
High forest - 1953	135,276	179,231	151,862
High forest - 1969	126,738	169,566	137,654
High forest - 1979*/82	106,700*	158,782*	131,448

Average annual deforestation rate for high forest - three areas combined:

1953 - 1969	0.43%
1969 - 1979	0.78%n
1953 - 1979/82	0.55%

A more detailed analysis is shown at attachment 5.

The relatively high deforestation rate for Bopolu is attributed to the logging activities in the 1970s, this being followed by slash and burn activities for upland rice cultivation along the newly constructed access roads. During the 1969/79 period the rate of deforestation here was 1.58% annually.

Overall the rate appears to be increasing significantly going from 0.43%/annum in 53-69 to 0.78%/annum in 69-79/82. Should this latter figure be applied to the total high forest area

determined in this study (4,790,000 hectares) then the annual loss is a little over 37,000 hectares, a figure similar to other projections.

5. RESERVED FOREST AREAS

The total reserved forests of Liberia are contained within eleven (11) national forests and one national park:

National forest area	1,399,600 Hectares
National park area	130,748 Hectares

Some 93.5% of these national forests are covered by high forest whilst the figure for Sapo National Park is 99%. Attachment 6 gives figures for individual reserve areas. Thus it can be calculated that the reserved forest areas contain some 30% of the total high forest area of the country.

A very small difference will be noted between the proclaimed and actual area derived from this series of vegetation maps. This is undoubtedly due to a different base map being used for area calculation.

6. RESULTS AND DISCUSSION

The high forest area of Liberia was determined to be 47,900 square kilometres (18,494 square miles) or some 49.8% of the total land area which was calculated in this exercise as 96,180 square kilometers (37,134 square miles). This land area compares favourably with the official total area of Liberia of some 97,730 square kilometers which includes inland lakes and waterways.

The following table is an extract from the area of vegetation types at attachment 7:

High Forest	Slope 0-15%	3,443,000	Hectares
High Forest	Slope 15-30%	704,000	Hectares
High Forest	Slope 30%+	620,000	Hectares
High Forest	Swamp Type	22,000	Hectares
Total all high forest		4,790,000	Hectares

It is considered that those areas of high forest over 30% slope will be unsuitable for logging due to terrain whilst approximately half of that between 15% and 30% will also fall into that category.

Using the classification of natural woody vegetation as outlined in the Tropical Forest Resources Assessment project prepared by FAQ the following area classification could be made:

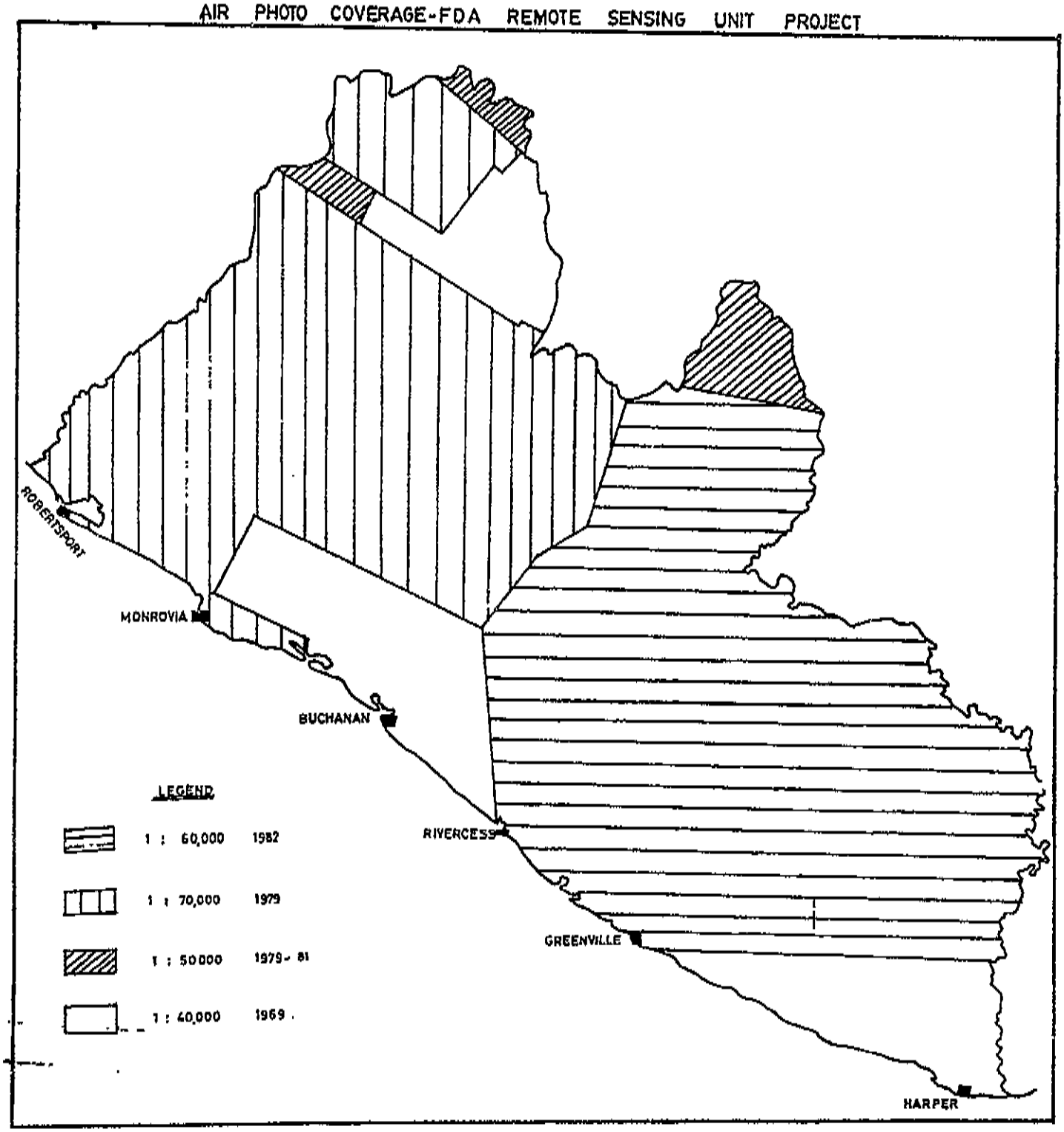
		(Area in thousand of hectares)
NHC flu	Productive closed broadleaf forest not intensively managed. This includes logged over forest but not Sapo National Park.	3,687
NHCf2i	Closed broadleaf forest unproductive for physical reasons stand and terrain characteristics (includes mangroves).	991
NHCf2r	Closed broadleaf forest unproductive for legal reasons.	131
NHCf	Closed broadleaf forest sum of above (includes mangroves).	4,809
NHOa	Forest fallow	4,541
NHc/NHO	Mixed broadleaf forest grassland tree formation	36

Areas corresponding to NHc/NHOa and nH would have been included in the farmland and regrowth type which has been placed under the NHCa classification.

The figure of 4,809,000 hectares for NHCf is considerably greater than that of 2,000,000 hectares as stated in the country brief of the Tropical Forest Resources Assessment Project. This is due to the German Forest Mission inventory area figure (of which the 2,000,000 figure is an update) covering only portion of the high forest areas of Liberia and then only those areas in large contiguous blocks. This study de1ineated all forest areas down to a minimum of 39 hectares on 1 in 125,000 map.

There is thus, surprisingly, a greater area of high forest• cover in Liberia than was previously thought, though Mayer in 1950 put the figure at 5,600,000 hectares, including 2,000,000 of so called broken forest.

ATTACHMENT No. 1

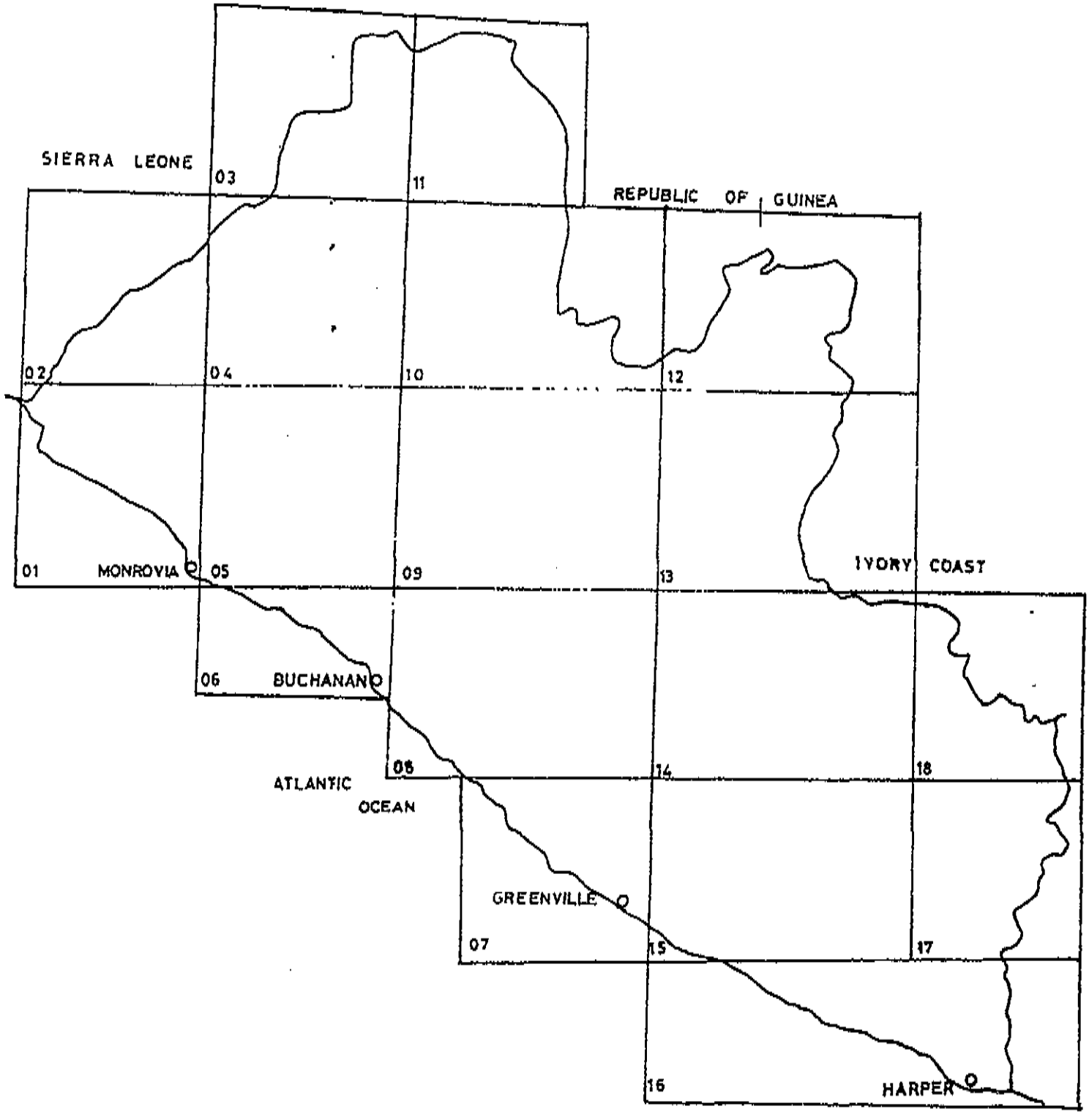


ATTACHMENT 2

DEFINITIONS - VEGETATION TYPES

High Forest -	Forests of a primary or old secondary nature occuring on dryer sites with a closed or almost closed canopy exceeding 30 meters in height.
Mixed Crown Sizes -	High forest containing variable crown sizes with or without emergent trees.
Small Crown Sizes -	High forest containing even, uniformly textured small compact crowns without any emergent trees.
Dominant Species -	Is classified as one that contributes greater than 50% of the crown cover recognizable on the photo image. The area to be demarcated must contain at least 50% by area of these dominant species patches.
Swamp Forest -	High forests but located on swampy or periodically inundated sites.
Mangrove Forest -	Includes all areas covered by mangrove irrespective of canopy or tree height.
Farmland and Regrowth -	Presently farmed lands for subsistance cropping and regrowth resulting from such previously farmed areas. In addition it includes regrowth arising from transitional changes to grassland and low palm/tree cover of coastal formations.
Swamp -	All lands permanently or seasonally inundated with water other than those supporting swamp forest or mangrove.
Savannah -	Mixed tree/grassland formation with a continuous dense grass layer.
Grassland -	Natural grass areas that contain less that 10% woody vegetation cover.
Others -	Include urban areas, bare ground, non wooded coastal dunes, mining areas etc.

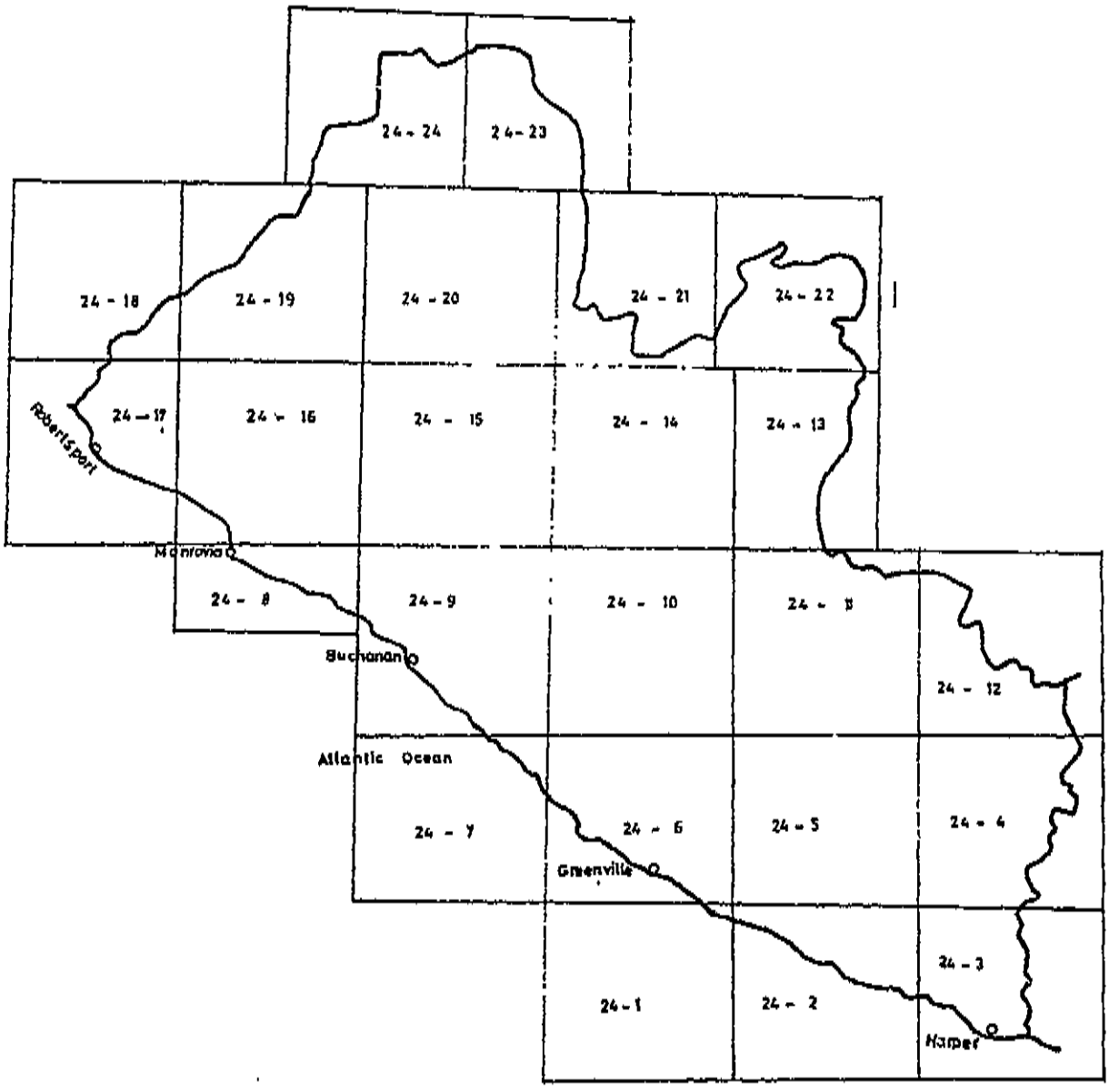
ATTACHMENT 3 (a)



LIBERIA 1 : 2,500 000

ATTACHMENT 3 (b)

LOCATION DIAGRAM (STABLE BASE)



LIBERIA 1 2,500,000

ATTACHMENT 4

FOREST TYPES OF LIBERIA — AREA SUMMARY IN ACRES

Sheet No.	11a	11b	11c	12a	12b	12c	13a	13b	13c	21	22	31	321	322	323	41	42	43	44	45	TOTAL	46	TOTAL
1	70,345	697	4,210				24,985	324			7,323	5,555	29,394	5,655	498	636,625	496	25,832	6,576	14 896	832,513	44,564	878,077
2	220,827	83,972	93,861				14,946	2,043	6,302	5,331			149			304,575			144	6,128	738,278	9,042	747,320
3	240,132	157,880	240,082	124		897				6,105				13 925		353,771	1,519	2,291	2 790	9,092	1,028,609	3,818	1,032 419
4	696136	328,537	171,007	5,017	6,526	5,804	3,488	2591		7,149			75		1,569	457 197	5,331			4,484	1,699, 0r1	7,249	1 706,260
5	96,326	44,216	36 169				6,900	9 217	7,797	125	3,537	1,420	253,730			1,163,472	772	24,885	12,231	22,967	1,684,167	15,469	1 699,636
6	16,308	7,201	817					15,257	13,973		10,859		3,853		701	233,921		26,335	12,748	195	348,468	5,391	353,859
7	306,213										13,302	548	274	8,544		223,343				1,146	553,376	4,708	558,084
8	877,801	126,294	120,241	423	1 744	1,644							1,618	4,235		968,676			4,758		2,107,636	14,423	2,122,059
9	379,775	107,063	76,100					3,361		3 886			13,178			1,586,757	1,046			1,221	2,272,393	9,765	2,282,158
10	818,441	93,286	115,732	299	199	622				2,342			5,438		4,384	907,919	5,331		1 893	2,590	1,758,470	12,953	1,771,423
11	254,207	111,995	396,094	1,644		847							249	50	149	426,732	399	125	4,459	4,384	1,201,334	3,188	1,204,522
12	84,643	68,904	39,010										8,444			738,183	249	648		15,767	936,048	1,221	937,269
13	407,901	45,930	68,204	3,737						14,248		374	474		249	884,804	1,644			997	1,429,262	6,800	1 436,062
14	1,620,446	126,094	65,836	8,693	2,566					9740		6,701		697		438,542			872	4,708	3,284,895	3,361	2 288,258
15	1,190,623	193,874	29,991		947					1,270	2,516		6,203		1,918	704,629	1,395				2,133, 366	5,804	2 139,170
16	98,693	1,519	996								9,490		25,483			530,683		6,850		548	674,262	8,420	682,682
17	416,796	68,976	7,921									3,662				439,514				100	1,136,569	15,693	1 152,262
18	631,593	106,541	26,330	6,501	3,039					5,232		3,587				322,508	1,170			224	906,725	31,434	938,159
TOTAL	8,427,818	1,693,981	1,492,601	30,438	15,021	9,814	50,319	32,795	28,072	55,428	46,327	21,847	348,457	33,106	9,568	11,221,451	19,354	88,966	55,571	89,447	23,766,381	187,298	23, 953,679

11a	High Forest (Mixed crown sizes)	Slope	0 - 15%
11b	" " " " "	"	15 - 30%
11c	" " " " "	"	30%+
12a	" " (Small crown ")	"	0 - 15%
12b	" " " "	"	15 - 30%
12c	" " " "	"	30%+
13a	" " (Parinari Dominated)	"	0 - 15%
13b	" " " "	"	15 - 30%
13c	" " " "	"	30%+
21	" " (Freshwater swamp)		

22	Mangrove Swamp
31	Forest Plantation (Gross)
321	Rubber " "
322	Oil Palm " "
323	Other " "
41	Farmland and regrowth
42	Non-forested swamp
43	Savannah
44	Grassland
45	Other lands N.E.I
46	Inland lakes and waterways

ATTACHMENT 5

RATE OF DEFORESTATION STUDY

Study Area	Total Area	In Hectares HF 1953	HF 1969	HF 1979/82	Annual Rate Deforestation 1953/69	69/79*/82	53/79*/82
Bopolu (a)	167,546	135,276	126,738	106,700*	.39%	1.58%*	.81%*
Nimba	198,645	179,231	169,566	158,782*	.34%	.64%*	.44%*
Sinoe	202,410	151,862	137,654	131,448	.58%	.35%	.46%
TOTALS	568,601	466,369	433,958	396,930	.43%	.78%	.55%

Notes (a) Bopolu area had considerable logging activities in the 1970's followed by clear felling for farmland along roads.

ATTACHMENT 5

RATE OF DEFORESTATION STUDY

Study Area	Total Area	In Hectares HF 1953	HF 1969	HF 1979/82	Annual Rate Deforestation 1953/69	69/79*/82	53/79*/82
Bopolu (a)	167,546	135,276	126,738	106,700*	.39%	1.58%*	.81%*
Nimba	198,645	179,231	169,566	158,782*	.34%	.64%*	.44%*
Sinoe	202,410	151,862	137,654	131,448	.58%	.35%	.46%
TOTALS	568,601	466,369	433,958	396,930	.43%	.78%	.55%

Notes (a) Bopolu area had considerable logging activities in the 1970's followed by clear felling for farmland along roads.

ATTACHMENT 6

RESERVED FOREST AREAS OF LIBERIA

		PROCLAIMATION - AREAS IN ACRES				FOREST RESOURCES MAP - AREAS IN ACRES			
	0	1	2	3	4	5	6	7	8
No.	National Forest Area	Original Proclaimed Area	Resumption Within Original Area	Additions To Original Area	Present Reserved Forest Area	Present Reserved Forest Area From Resources Map (1979 cf Col.4)	Farmland & Regrowth	Actual High Forest Area as at 1979	% High Forest Remaining as at 1979
1	Gio	81,370	-	-	81,370	78,964	12,542	66,422	84
2	North Gio	10,976	-	-	10,976	10,985	4,932	6,053	55
3	West Nimba	32,400	15,693	5,455	22,162	21,697	947	20,750	96
4	East Nimba	71,000	44,639	2,591	28,952	24,636	6,793	17,843	72
5	Gola	511,485	12,240	-	499,245	500,725	15,743	484,982	97
6	Lorma	107,500	9,291	-	98,209	95,854	5,530	90,324	94
7	North Lorma	247,100	21,251	-	225,849	224,837	13,526	211,311	94
8	Gbi	150,656	-	-	150,656	151,104	3,064	148,040	98
9	Grebo	643,266	-	-	643,266	648,731	40,140	608,591	94
10	Kpelle	432,000	4,320	-	427,680	426,318	28,621	397,697	93
11	Krahn-Bassa	1,270,000	-	-	1,270,000	1,258,021	92,989	1,165,032	93
NATIONAL FOREST Sub-total		3,557,753	107,434	8,046	3,458,365	3,441,872	224,827	3,217,045	93.5
Sapo National		323,075	-	-	323,075	323,075	3,737	319,338	99%
GRAND TOTAL(Acres)		3,880,828	107,434	8,046	3,781,440	3,764,947	228,564	3,536,383	94%
GRAND TOTAL (Hectares)		1,570,571	43,479	3,257	1,530,349	1,523,674	92,500	1,431,174	94%

ATTACHMENT 7

AREA SUMMARY - VEGETATION TYPES

Area in Thousand of Acres/Hectares

High Forest - Mixed Crown Sizes - Slope	0-15%	8428 Ac.	3411 Ha.
" " - Small " " - "	0-15%	30	12
" " - Parinari excelsa Dominated	0-15%	50	20
Sub-total High Forest - Slope 15-30%		8508	3443
High Forest - Mixed Crown Sizes - Slope	15-30%	1694	686
" " - Small " " - "	15-30%	15	6
" " - Parinari excelsa Dominated	15-30%	33	13
Sub-total High Forest - Slope	15-30%	1742	705
High Forest - Mixed Crown Sizes - Slope	30%+	1493	604
- Small " " - "	30%+	10	4
- Parinari excelsa Dominated	30%+	28	12
Sub-total High Forest - Slope	30%+	1531	620
High Forest - Fresh Water Swamp		55	22
Total - All High Forest Areas		11836	4790
Mangrove Swamp		46	19
Savannah Forest		89	36
*Plantations - Forest		22	9
- Rubber		348	141
- Oil Palm		33	13
- Other Agricultural		10	4
Farm Land and Regrowth		11221	4541
Non Forested Swamp		19	8
Grasslands		52	21
Other lands N.E.I. e.g. towns mining area etc		89	36
TOTAL ALL TYPES (LAND AREA)		23765	9618

*Plantation areas are gross areas including roads, fire breaks, contained small swampy and unplanted areas as well as failed or unproductive areas Thus, stated areas are not to be quoted as actual plantation acreages.
All areas calculated from 1 in 125,000 mapping sheets.

Slope Categories - Three categories viz 0-15%, 15-30% and 30%+ have been set. Such areas will be estimated on the photos using reference slope percentages as a guide. Such categories refer to major relief and apply to high forest areas only.

LIST OF REFERENCES

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