European Commission

# Long Term Technical Assistance for the implementation of the Voluntary Partnership Agreement (VPA) in Liberia

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# Assessment of Long-Term Sustainability of Commercial Timber Harvesting

**Mission Report**

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**About Liberia VPA Technical Assistance**

This Technical Assistance takes place in the context of the implementation of the Voluntary Partnership Agreement (VPA) between the Government of Liberia and the European Union, within the framework of Forest Law Enforcement, Governance and Trade (FLEGT) programme. The objective of this short-term consultancy under the "Long Term Technical Assistance for the Implementation of the Voluntary Partnership Agreement in Liberia" (VPA-SU2), a project funded by the European Union, is to provide the elements required to meet the contractual requirement stated in Result Area 1, Output 1.6 "Forest management plans and elements for long-term sustainability of forest operations".

**Disclaimer**



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# Assessment of Long-Term Sustainability of Commercial Timber Harvesting

# Mission Report

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|---|---|
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**Table of Contents**

## LIST OF FIGURES



## LIST OF TABLES

## LIST OF ABBREVIATIONS/ACRONYMS

| | |
|---|---|
| AOP | Annual Operational Plans |
| CFMA | Community Forest Management Agreement |
| DBH | Diameter at Breast Height |
| DCL | DBH Cutting Limit |
| DGR | Diameter Growth Rate (cm/year) |
| EU | European Union |
| FCPF | Forest Carbon Partnership Facility |
| FDA | Forestry Development Authority |
| FLEGT | Forest Law Enforcement, Governance and Trade |
| FMC | Forest Management Contract |
| GFMP | Guidelines for Forest Management Planning |
| GSV | Gross standing volume |
| ha | Hectare |
| HCV | High Conservation Value |
| LCFM | Land Cover and Forest Map of Liberia |
| m | Meter |
| MFD | Minimum Fertility Diameter |
| MMA | Minimum Mapping Area |
| MMU | Minimum Mapping Unit |
| NFI | National Forest Inventory |
| NTFP | Non-Timber Forest Product |
| PA | Protected Area |
| PCPF | Potential Commercial Production Forest |
| PSU | Primary Sampling Unit |
| Re% | Recovery rate of a species |
| RePop% | Recovery rate of a harvestable group of species |
| REDD+ | Reducing Emissions from Deforestation and Forest Degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries |
| RIL | Reduced Impact Logging |
| SFM (P) | Sustainable Forest Management (Plan) |
| TPF | Timber Production Forest (sub-division of a concession area managed with the objective of sustainable timber production) |
| VPA | Voluntary Partnership Agreement |
| VPA-SU2 | Long-Term Technical Assistance for the Implementation of the Voluntary Partnership Agreement in Liberia |

## EXECUTIVE SUMMARY

This study attempts to analyse the sustainability of the existing forest management rules and to project their likely impact on the current Liberian forest stocks and future timber yields, for forests identified in an earlier study at country level as Potential Commercial Production Forests (PCPF).

PCPF were defined as "natural and semi-natural forests" according to the Land Cover and Forest Map of Liberia (LCFM) produced in 2018, less (i) mangrove forests, (ii) declared and proposed Protected Areas (PAs), (iii) areas with a slope > 40%, (iv) 50 m buffer around declared and proposed PAs, and (v) 30 m buffer around major water courses and water bodies. The net productive area potentially available for commercial logging activities in PCPF with contiguous areas ≥ 100ha was estimated to amount to approximately 2.4 Mio ha with a canopy cover from 80% to 100% and to approximately 690,000 ha with a canopy cover from 30% to 80%.

The initial stand and stock data for the projection over one cutting cycle of 25 years of the development of these PCPF were provided by the REDD+ Project based on the data of the National Forest Inventory (NFI) carried out from 2018 to 2019 with the technical assistance from FAO and funded by the Forest Carbon Partnership Facility (FCPF).

The tree species were classified into 4 groups according to their commercial interest, based on the LiberTrace export volume data from 2010 - 2018: Group 1 (priority species) composed of 10 species making up 84% of the total exported volume, Group 2 (secondary species) composed of another 10 species representing 9% of the total exported volume, Group 3 (lesser used species) composed of 69 species making up 7% of the total exported volume, and Group 4 (non-commercial species) composed of the 283 remaining species that have not been exported according to the LiberTrace records. A fifth group (Group Ab) was considered apart, composed of the 20 most abundant species regardless to their commercial interest, accounting for 70% of the potential harvestable volume.

The "Business as Usual (BAU)" projections were made according to the management and harvesting prescriptions of the 2009 Guidelines for Forest Management Planning (GFMP), using the Diameter Cutting Limits (DCL) from the 2007 Code of Forest Harvesting Practices.

The main findings of the analysis of the initial stand and stock data and of the BAU projection over one 25-years cutting cycle are as follows:

- Densities: According to the GFMP, the logging of species whose densities are lower than 0,04 stems/ha at national level for DBH ≥ 10 cm is prohibited. Based on the NFI results, this is the case for *Entandrophragma utile* (Sipo), *Tieghemella heckelii* (Makore), *Chrysophyllum giganteum*, *Chrysophyllum splendens*, *Mansonia altissima* and *Strombosia glaucescens*, which should therefore be banned from any kind of timber harvesting and exportation at national scale.
- Recovery rates: The Recovery Rates (Re%) of the commercial species show poor results in comparison with the national requirements: 7 out of the 10 priority species and 6 out of 10 secondary species have Re% lower than the minimum 50% required. These species account for respectively 87% and 65% of the current available harvestable volume (≥ DCL) of those groups. This indicates that the commercial logging based on them will not yield similar harvesting volumes beyond one cutting cycle, and that a substantial drop of their commercial volumes will occur after the first cutting cycle. Even at group level, these figures are far below the legal requirement of 75% for the group recovery rate (RePop%) mentioned in the GFMP: RePop% of the priority and secondary species group are, respectively, 31.6% and 41.2%, for a cutting cycle of 25 years.

- Regeneration potential: The analysis of the diametric distribution of the priority and secondary species shows that respectively three and two out of the 10 species of each group show an unfavourable regeneration potential, indicating that their long-term existence is compromised in the absence of adjustments to the management and harvesting rules.

Appraised together, the results obtained from the analysis of recovery rate, regeneration potential and density of trees with DBH ≥ 10 cm provide the likely threat that commercial logging operations are affecting on them, for the medium to long-term (one 25-years cutting cycle and ahead). Out of the 30 species of Groups 1, 2 and Ab, 14 are rated "High", 7 are rated "Medium" and 9 are rated "Low" regarding their logging threat.

The low number and corresponding commercial volume of trees above DCL after one cutting cycle forebode that the yield of the currently exploited species cannot be sustained. Indeed, a drastic reduction of stand and stock data for all individual species of the priority species group is anticipated, the most affected being *Gilbertiodendron preussii*, *Lophira alata* and *Parinari excelsa*, with respectively only 5%, 6% and 8% of the current volumes being available after one cutting cycle. This is due to their present diametric distribution, featuring a high proportion of large trees. Among the species of the secondary species group, 5 are most affected by harvesting operations (*Canarium schweinfurthii*, *Hallea ciliata*, *Milicia sp*., *Nauclea diderrichii* and *Oldfieldia africana*), with their commercial volumes after one cutting cycle dropping below 10% of the current level.

At group level, the assessment of the changes of the stand and stock data over one cutting cycle according a BAU scenario shows that on average, compared to the current conditions, future densities and volumes above DCL will dramatically drop to 25% and 12% of today's values, respectively, for species of Group 1 lumped together, and to 30% and 20%, respectively, for species of Group 2 lumped together.

Timber production in the Liberian PCPF cannot be sustained without (i) halting the current average rate of tree cover loss of more than 2.2% per year, (ii) adjusting the current GFMP and harvesting rules, and (iii) enforcing those rules. For securing future timber supplies, the suggested adjustments to the management and harvesting rules apply to:

- Cutting cycle length: A 40-year cutting cycle would be more appropriate in the context of Liberia, being more closely attuned to the increment data of local species than the current 25-year cutting cycle.
- Recovery rate thresholds: The current thresholds (≥50% per species *or* ≥75% at group level) implies a systematic reduction of the harvestable stems over time, which is not compatible with sustainable timber management. Management rules aiming at Re% of 65% per species *and* 100% at group level would be more supportive to sustainable timber exploitation than the current ones. To achieve such rates, major adjustments need to be made with regards to the spectrum of marketable species, DCL and cutting cycle.
- Minimum felling diameter: The DCL per species according to the 2007 version of the Code of Harvesting Practices should be enforced (instead of considering all trees ≥ 60 cm DBH harvestable); then the impact of different DCL on Re% at concession level should be analyzed, based on statistical inventory data in order to adapt the DCL when necessary and when possible.

- Spectrum of marketed species: Due to the detrimental impact of logging on their recovery rates and regeneration processes, it is likely that the species currently being harvested at a high rate will become very scarce on the long term. This is what already happened with the timber species most traditionally exploited in Liberia during the last century (*Entandrophragma*, *Khaya* and *Tieghemella*), which have become very scarce. Consequently, to safeguard sustainable timber production in Liberia, it is important to reduce the harvesting pressure on vulnerable species, notably through the widening of the spectrum of the marketable species, to enhance the stock recovery and the regeneration.
- Yield and harvestable rate: The GFMP states that the harvested volume must not exceed 30 $m^3$/ha at the scale of 100 ha blocks. This limit should be kept and systematically enforced at the scale of single 100 ha blocks.

Further crucial considerations directly affecting sustainable timber management in Liberia are:

- The adoption of a selective timber management system based on yield regulation, substituting the actual creaming practices.
- The strict enforcement of existing regulations and their update
- The control of forest encroachment and all forms of degradation occurring apart from commercial timber harvesting. Without halting deforestation in forest concessions (FMCs and CFMAs), timber production will not be sustainable in Timber Production Forests.
- The implementation of sylvicultural treatments aiming at shortening the time required for forest to recover from logging disturbance, by enhancing regeneration and mitigating the low recovery rates of most exploited species.
- The promotion of alternative commercial species in the timber market, for those species showing good potential for sustainable logging.
- The review of the Community Forest Management Agreements (CFMAs) in order to halt the accelerated creaming occurring in them and target practices stewarding good community land management.

The report concludes with recommendations relevant with the conclusions of this study; they target the Forest Development Authority (FDA), the forest concessionaires and the international community supporting the Liberian forest sector.

# 1 SCOPE OF DOCUMENT AND DEFINITION OF SUSTAINABLE TIMBER MANAGEMENT

This study aims at making a simulation exercise to analyse the sustainability of the existing natural forests harvested under a 25-year cycle management regime and to predict their impact on the current Liberian forest stocks. This simulation is based on the NFI results made available by the REDD+ Project assisted by FAO, for the forests with a canopy cover between 80% to 100%, at national level.

More specifically, this study aims at reducing the gap of knowledge of logging impacts on the timber stocks, species and recovery rates changes after logging over one cutting cycle, based on harvesting practices using the Guidelines for Forest Management Planning in Liberia (GFMP) (FDA, 2009).

**Forest management** is the process of planning and implementing practices for the stewardship and use of forests and other wooded land targeted at specific environmental, economic, social and cultural objectives. Forest management planning is a fundamental component of sustainable forest management (SFM) and is based on information on the terrain (e.g. in maps showing contour lines and watercourses) and on the growing stock, such as species, number of stems, basal area and volume per hectare. SFM is translated into sustainable forest management plans (SFMP) to describe management practices to stakeholders to be implemented in the field.

**Sustainable timber management** is part of SFM and implies taking steps to ensure that permanent forest lands continue to produce timber in the longer term, maintain their renewal capacity as well as the full range of environmental services and non-timber products of the forest.

**Selective harvesting** is a polycyclic system[1] type of timber management using a minimum diameter for harvesting. An extreme form of selective logging is **creaming** of the forest, in which only the best grade timber trees of a few species are taken out. This form of selective logging is the one that has so far prevailed in Liberia since the 1950's (Parren, 1995), and has little to do with a **silvicultural selection system** which focuses its attention on the remaining/future stock of trees.

[1] Polycyclic systems involve the harvesting of trees in a continual series of felling cycles. These systems rely on the existing stock of seedlings, saplings and poles in the forest to produce the next harvestable crop.

# 2 MATERIAL AND METHOD

## 2.1 Material

### 2.1.1 Potential commercial production forests

#### *2.1.1.1 Potential commercial production forests (PCPF)*

The extent of Potential Commercial Production Forests (PCPF) was estimated and delineated in a separate study (DAI/DFS, 2020). PCPF were defined as "natural and semi-natural forests" according to the Land Cover and Forest Map of Liberia (LCFM) (without mangrove forests), less declared and proposed Protected Areas (PAs), less areas with a slope > 40%, less 50 m buffer around declared and proposed PAs, less 30 m buffer around major water courses and water bodies (DAI/DFS, 2020).

PCPF with 30% - 80% canopy cover were deemed not to be available for commercial harvesting in the next 25 years, since most areas have been subject to logging activities several times. Scattered forest patches of less than 500 ha were assumed not to be commercially viable. Hence, the net commercially viable PCPF area (with 80% to 100% canopy cover and contiguous areas ≥ 500 ha, including gaps < 100 ha[2]) was estimated to amount to some 2.3 million ha (see Figure 1) (DAI/DFS, 2020).

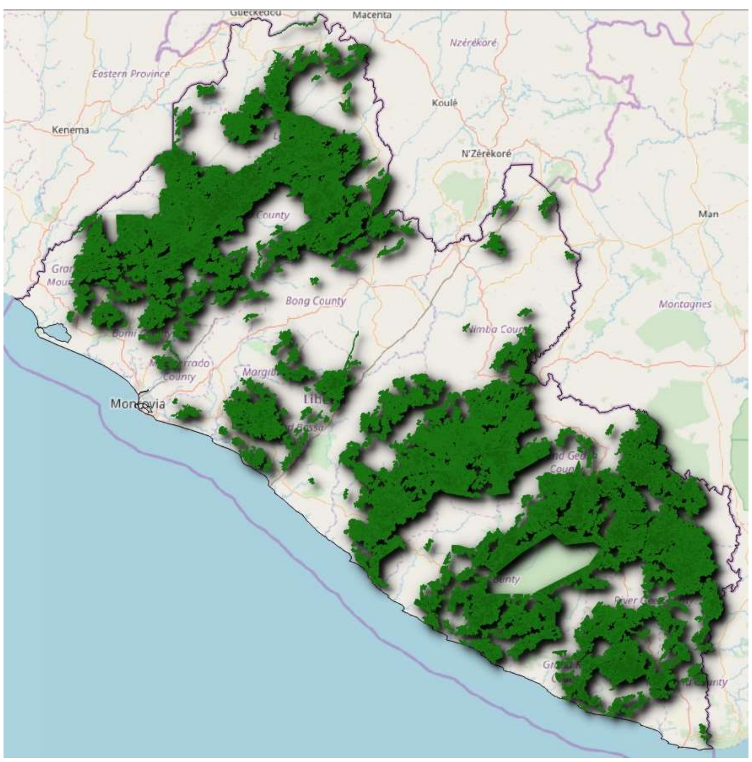


*Figure 1: PCPF with presently 80% - 100% canopy cover and contiguous areas of ≥ 500 ha and assimilated gaps < 100 ha.*

[2] This assumption is based on the consideration that smaller gaps of < 100 ha surrounded by PCPF can be restored in the medium to long term. Consequently, they can be considered part of the PCPF area.

### 2.1.1.2 Timber Production Forests under Forest Management Contracts (FMC)

The total land area presently under Forest Management Contracts (FMC) amounts to roughly 1 Mio ha. Timber Production Forests (TPF) with presently 80% - 100% canopy cover and contiguous areas ≥ 100 ha make up 65% thereof (DAI/DFS, 2020). The remainder of the FMC area are forests with 30% - 60% canopy cover (about 2% of the total FMC area) and non-forest areas as per forest definition (approximately 23% of the total FMC area). Figure 2 provides an overview of the FMC areas in Liberia.


*Figure 2: Location of the areas under Forest Management Contracts.*

### 2.1.1.3 Timber Production Forests under Community Forest Management Agreements (CFMA)

The total area presently under Community Forest Management Agreements (CFMA) amounts to roughly 0.8 Mio ha. The areas of the 40 FDA's awarded CFMAs are shown in Figure 3.

According to DAI/DFS (2020), TPF with presently 80% - 100% canopy cover and contiguous areas ≥ 100 ha cover 0% to 93% of the CFMA areas. In total, just over half (56%) of the area currently under CFMA qualifies as TPF (DAI/DFS, 2020).


*Figure 3: Location of the areas under Community Forest Management Agreements.*

### 2.1.2 Forest stock data

For this study the stand and stock tables based on the National Forest Inventory (NFI) data processed and provided by the REDD+ Project have been used. The NFI was carried out from 2018 to 2019 with technical assistance from FAO and was funded by the Forest Carbon Partnership Facility (FCPF) for advancing Liberia's REDD+ readiness.

The NFI Primary Sampling Units (PSUs) used for this study are those whose cluster point centers are located within the commercially viable PCPF (with presently 80% - 100% canopy cover and contiguous areas of ≥ 500 ha and assimilated gaps < 100 ha).

The NFI stand and stock tables list all recorded species by diameter classes in terms of densities (N/ha), basal area (G/ha, in m²/ha) and commercial volumes (V/ha, in m³/ha) of live trees.

Table 1 gives a brief statistical review of the NFI PSUs used in this study.

*Table 1: Statistical summary of NFI Primary Sampling Units used*

| | |
|---|---|
| Sampling unit distribution (at national level, all NFI PSUs): | Systematic, N-S / W-E oriented hexagonal 19.8 km grid, with random origin |
| Sampling unit design: | L-shaped cluster of 5 nested (concentric) circular plots 60 m apart:<br>• 2 m radius circle to sample regeneration with DBH ≤ 9.9 cm and height ≥ 130 cm<br>• 7 m radius circle to sample trees with 10 cm ≤ DBH < 40 cm<br>• 18 m radius circle to sample trees with DBH ≥ 40 cm |
| Number of PSUs used for this study: | 81 (94 - 13 not accessed) |
| Areal sampling frame for this study: | 2,963,239 ha = Total area for contiguous PCPF in Liberia in with 80% - 100% canopy cover >=500 ha (DAI/DFS, 2020) |
| Total means (and standard deviation) of PSUs used for this study of trees with DBH ≥ 10 cm[3]: | N/ha: 530.3 (370.1) /ha<br>G/ha: 44.5 (59.0) m²/ha<br>V/Ha: 352.3 (518.4) m³/ha |
| Coefficients of variation (s%) of PSUs used for this study of trees with DBH ≥ 10 cm: | N/ha: 69.8%<br>G/ha: 132.6%<br>V/Ha: 147.2% |
| Margins of error (E%) at 90% confidence level of PSUs used for this study of trees with DBH ≥ 10 cm: | N/ha: 12.9%<br>G/ha: 24.5%<br>V/Ha: 27.2% |
| Margins of error (E%) at 95% confidence level of PSUs used for this study of trees with DBH ≥ 10 cm: | N/ha: 15.4%<br>G/ha: 29.3%<br>V/Ha: 32.5% |

[3] These figures differ from the original NFI data as in the latter, some species have been discarded for the purpose of this study (see §2.1.3)

### 2.1.3 Species and species groups

#### *2.1.3.1 Notes on some commercial species names*

The NFI identified 382 tree species in the 80% - 100% canopy cover forests. Not all of these species are currently of commercial interest. In order to work on important forest species (species with available stock and/or potentially marketable), we did an arrangement of some of the species encountered during the NFI. This was done as follows:

First, we filtered the species list and removed the clearly non-timber/natural forests species (i.e. *Coffea liberica, Funtumia sp., Elaeis guineensis, Eucalyptus utilis, Theobroma cacao*).

Then we grouped together some species having the same commercial name (whilst these are different botanical species, they belong to the same genus and their wood properties are equivalent, making them prospected, harvested, processed and sold under the same commercial name). Consequently:

- *Erythrophleum ivorense* and *E. suaveolens* were merged into "*Erythrophleum sp*." (Tali);
- *Hallea ciliata* (referred to as *Fleroya ledermannii* in the NFI species list) and *Mitragyna ledermannii* were merged into "*Hallea ciliata*" (Abura/Bahia);
- *Milicia excelsa* and *Milicia regia* were merged into "*Milicia sp.*" (Iroko);
- *Celtis adolfi-friderici* and *Celtis mildbraedii* were merged into "*Celtis sp.*".

Lastly, in Liberia, some species are more commonly referred to using botanical synonyms; these synonyms were used for:

- *Guarea cedrata* instead of *Leplaea cedrata* used in the NFI;
- *Pycnanthus angolensis* instead of *P. africanus* used by FDA.

The final species list is shown in Annex 6.1. The commercial names originate from the GFMP.

#### *2.1.3.2 Diameter Cutting Limits*

The 2007 version of the Code of Harvesting Practices prescribes DBH Cutting Limits (DCL) for the main commercial tree species. These DCL range from 60 cm to 100 cm according to the species. The revised Code of Harvesting Practice, approved in 2017, does not prescribe DCL.

Beside of this, all FMCs stipulate (article B.6.22) that "holder shall not cut or fell for commercial use any growing tree smaller than 60 cm Diameter at Breast Height" (DBH).

Hence, it may be that there is no longer a legal basis to prevent harvesting of trees with DBH > 60cm (World Bank, 2019). The only official document reinstating the DCL of the old Code of Harvesting Practices is a letter addressed to the former Forest Project Manager of SGS Liberia and signed by the FDA Managing Director on December 12, 2018.

**For this study, the DCL from the 2007 Code of Harvesting Practices were used.** They are shown in the Annex 6.1: List of tree species and their main attributes.

#### *2.1.3.3 Classification of commercial species*

For the purpose of this study, the species encountered during the NFI were classified into 4 groups. The classes 1 to 4 are reflecting the commercial interest of the species, according to LiberTrace export volume data from 2010 - 2018. A fifth class was added, named "class Ab", which is composed of the most abundant species according to the stand and stock tables of the NFI, regardless to their commercial interest. The species groups distinguished are hence the following:

1. Priority species (Group 1)

Those are represented by 10 species, making up 84% of the total exported volume between 2010 - 2018. They are, namely: *Anopyxis klaineana, Brachystegia leonensis, Cynometra ananta, Didelotia idae, Gilbertiodendron preussii, Lophira alata, Parinari excelsa, Piptadeniastrum africanum, Tarrietia utilis* and *Tetraberlinia tubmaniana.*

2. Secondary species (Group 2)

Those are represented by 10 species, making up 9% of the total exported volume between 2010 - 2018. They are, namely: *Anthonotha fragrans, Aphanocalyx microphyllus, Canarium schweinfurthii, Erythrophleum sp. (Erythrophleum ivorense* and *Erythrophleum suaveolens), Hallea ciliate (Fleroya ledermannii* and *Mitragyna ledermannii), Klainedoxa gabonensis, Lovoa trichilioides, Milicia sp. (Milicia excelsa* and *Milicia regia), Nauclea diderrichii* and *Oldfieldia africana*.

3. Lesser used species (Group 3)

Those are represented by 69 species, making up 7% of the total exported volume between 2010 - 2018. They can be found in Annex 6.1: List of tree species and their main attributes (see group 3 in column "Group 1-4").

4. Non-commercial species (Group 4)

Those are represented by the 283 remaining species and have not been recorded by LiberTrace as having been exported during the 2010 - 2018 period.

5. Most abundant species (Group Ab)

Those are represented by 20 species accounting for 70% of the potential harvestable volume (≥ DCL). They are, namely: *Anthonotha fragrans, Calpocalyx aubrevillei, Cynometra Ananta, Dialium aubrevillei, Didelotia idea, Erythrophleum sp., Gilbertiodendron preussii, Lophira alata, Maranthes glabra, Parinari excelsa, Parkia bicolor, Pentadesma butyracea, Piptadeniastrum africanum, Pycnanthus angolensis, Quassia undulata, Sacoglottis gabonensis, Stachyothyrsus stapfiana, Tarrietia utilis, Tetraberlinia tubmaniana* and *Uapaca guineensis*.

Of those 20 species, eight species also pertain to Group 1, two to Group 2, eight to Group 3 and two to Group 4.

#### 2.1.3.4 IUCN classification of species of Groups 1, 2 and Ab

According to the IUCN Red List (2020), the assessments of the species of group 1, 2 and Ab are displayed in Table 2[4]. Four species of Group 1 are classified as Vulnerable, as well as two species of Group 2. The two species classified as Vulnerable in Group Ab also pertain to Groups 1 or 2. None of the species analysed pertain to Endangered or Critically Endangered.

[4] CR= Critically Endangered; EN= Endangered; VU= Vulnerable; LR/cd= Lower Risk: Conservation Dependent; NT or LR/nt= Near Threatened; LC or LR/lc= Least Concern; DD= Data Deficient; - = not assessed on the red list

*Table 2: IUCN classification of species of Groups 1, 2 and Ab*

| Scientific name | Group | IUCN assessment |
|---|---|---|
| ***Anopyxis klaineana*** | **1** | **VU** |
| ***Brachystegia leonensis*** | **1** | **VU** |
| *Cynometra ananta* | 1 | LC |
| *Didelotia idae* | 1 | NT |
| *Gilbertiodendron preussii* | 1 | LC |
| ***Lophira alata*** | **1** | **VU** |
| *Parinari excelsa* | 1 | LC |
| *Piptadeniastrum africanum* | 1 | LC |
| *Tarrietia utilis* | 1 | LC |
| ***Tetraberlinia tubmaniana*** | **1** | **VU** |
| *Anthonotha fragrans* | 2 | LC |
| *Aphanocalyx microphyllus* | 2 | LC |
| *Canarium schweinfurthii* | 2 | - |
| *Erythrophleum sp.* | 2 | LC |
| *Hallea ciliata* | 2 | - |
| *Klainedoxa gabonensis* | 2 | LC |
| *Lovoa trichilioides* | 2 | LC |
| ***Milicia sp.*** | **2** | **VU** |
| ***Nauclea diderrichii*** | **2** | **VU** |
| *Oldfieldia africana* | 2 | - |
| *Anthonotha fragrans* | Ab | LC |
| *Calpocalyx aubrevillei* | Ab | - |
| *Cynometra ananta* | Ab | LC |
| *Dialium aubrevillei* | Ab | - |
| *Didelotia idae* | Ab | NT |
| *Erythrophleum sp.* | Ab | LC |
| *Gilbertiodendron preussii* | Ab | LC |
| ***Lophira alata*** | **Ab** | **VU** |
| *Maranthes glabra* | Ab | LC |
| *Parinari excelsa* | Ab | LC |
| *Parkia bicolor* | Ab | LC |
| *Pentadesma butyracea* | Ab | LC |
| *Piptadeniastrum africanum* | Ab | LC |
| *Pycnanthus angolensis* | Ab | - |
| *Quassia undulata* | Ab | - |
| *Sacoglottis gabonensis* | Ab | LC |
| *Stachyothyrsus stapfiana* | Ab | - |
| *Tarrietia utilis* | Ab | LC |
| ***Tetraberlinia tubmaniana*** | **Ab** | **VU** |
| *Uapaca guineensis* | Ab | LC |

### 2.1.4 Present stock

The NFI sampled only living trees and provided data per species on densities, basal area and commercial volumes. This section aims at describing the method used for calculating the present stock in terms of average density (N/ha), basal area (G/ha) and commercial volume (V/ha) estimates, based on NFI results.

#### *2.1.4.1 Density*

The NFI tables give the density (N/ha) for trees by 10 cm diameter classes: class <1 refers to trees higher than 1.30 m and below 10.0 cm DBH; class 1 refers to trees 10.0 cm ≤ DBH < 20.0 cm; class 2 refers to trees 20.0 cm ≤ DBH < 30.0 cm, and so on. Class 10+ refers to trees with DBH ≥100.0 cm.

#### *2.1.4.2 Basal area*

The NFI tables give the basal area (G/ha, in $m^2$/ha) for trees by 10 cm diameter classes (as for N/ha). The basal area was calculated by adding up individual basal areas of trees.

#### *2.1.4.3 Commercial volume*

The NFI tables give the commercial volume (V/ha, in $m^3$/ha) for trees by 10 cm diameter classes (as for N/ha and G/ha). Commercial volume calculation is based on the commercial tree height and the DBH. Thus, the volumes are to be considered as gross bole volumes, and not as the net standing volumes (volume of the entire trunk of a harvestable tree).

During the NFI campaign, one out of every three trees did not have any height measured. For trees without height measurements, the total tree height was estimated by FAO using a height / DBH model derived from the trees with height (and DBH) measurements. Among several models, the algorithm chosen was the one with smaller Root Mean Square Error, which ended up being ($\log(H) = a + b * \log(D)$) with a=0.8393545, and b=0.4844105.

In addition, total height/commercial height ratios were calculated using the data from the trees where both heights were measured. This ratio was then applied to the calculated commercial height to estimate the commercial height.

For the **commercial volume estimates**, the form factor / commercial height model of the Technical Report of the German Forestry Mission to Liberia (1968) was used. Beyond 22 m, it was assumed that the form factor remained constant (0.6701699); the same below 5 m. (0.8588171). The commercial volume was calculated multiplying the individual basal area per the commercial height.

### 2.1.5 Diameter growth

#### *2.1.5.1 Preliminary note on the diameter growth rates*

Stock recovery (see § 2.2.1) is tightly related to the diameter growth rate (DGR). If a species has a DGR of 0.5 cm/year, its DBH increases by 12.5 cm over a felling cycle of 25 years.

However, growth rates are unknown for many species or only known for species in non-Liberian forests (e.g. Ivory Coast, Cameroon, Gabon). This lack of data constrained sometimes the stock recovery estimates.

Some limitations of the available DGRs are as follows:

- they do not necessarily reflect Liberian forest specific conditions;

- often, DGR studies cover only a short time period in relation to the age of a tree in natural forests. In the observed period either poor or good growth conditions may be present as a result of varying climate, unidentified or dynamic reasons that may influence the growth considerably (Worbes & Al., 2002);
- young and thin immature trees have a diameter growth pattern that may differ greatly from the diameter growth pattern of aged and large trees of the same species;
- the same goes for overstorey and understorey trees, as the overstorey trees grow faster than understorey trees, due to decreasing light saturation from the top to the ground of the forest;
- growth rate measurements of tropical forest trees are carried out by repeating diameter measurements, generally lumping together extreme values resulting from the highly variable conditions in the forest;
- differences in site conditions such as those along the soil gradient on slopes have a large influence on potential productivity.

##### *2.1.5.2 Diameter growth rates*

Based on current knowledge, the mean DGR values used for a conservative estimate of the recovery rates are presented in Annex 6.1. They originate from a variety of sources[5]. When no data could be obtained for a particular species, the growth rate applied was 0.5 cm/year[6]. This growth rate seems compatible with the diameter classes situated directly under most DCL, i.e. DBH classes 30-40 cm, 40-50 cm, 50-60 cm and 60-70 cm (Parren, 1995).

## 2.2 Method

### 2.2.1 Stock recovery rate

##### *2.2.1.1 Preliminary note on the stock recovery rate formula*

Sustainable exploitation of commercial species can be assessed using the stock recovery rate (Re%), which is defined in the GFMP (FDA, 2009) as the ratio of the exploitable timber stock at the end of a felling cycle over the exploitable timber stock at the beginning of this cycle. The term “recovery rate” is commonly used and is actually synonymous with the terms "growth index", "reconstitution index" and "reconstitution rate" used in the GFMP. Computing this rate requires forecasting the temporal development of each species during a cutting cycle (Doucet & Al., 2007).

The stock recovery rate has become the standard index to assess timber yield sustainability. The formula used, which is the legal expression of the stock recovery rate, however, does not have all desirable properties (Karsenty & Al., 2006). In particular, it is based on tree numbers and not on the corresponding volumes, it accounts for only a limited knowledge of vital rates, and it does not necessarily increase with higher DCL.

[5] FDA (2009), Doucet (2003), Doucet & Al. (2007), Durrieu de Madron & Al. (2000), Durrieu de Madron (2003), Fétéké & Al. (2015), Biwolé & Al. (2019), Parren (1995).

[6] According to a Liberian forest study mentioned in Parren (1995), the annual diameter increments for Potential Crop Trees range from 0.3 to 0.7 cm (av. 0.5 cm) for logged silvicultural untreated plots.

Growth is not the only unreliable demographic parameter in the formula. More often than not, harvesting damage rates and natural mortality rates are not well known. In general, managers adopt a natural mortality rate of 1%/year and a harvesting damage rate to the remaining stand of 7-10%, in accordance with the country's forest management standards. A biased value of one of these parameters has an opposite effect on the reconstruction (for example, the underestimation of mortality will lead to an overestimation of the recovery rate). For this study, the natural mortality rate applied was 1% and the damage rate 10% as per GFMP.

#### 2.2.1.2 Individual species recovery rate (Re%) formula

The recovery rate (Re%) is assessing the regrowth of the timber resource between 2 cutting cycles (ratio of the exploitable timber stock at the end of a felling cycle over the initial pre-felling stock).

$$Re\% = [N_0.(1\text{-}\Delta)].(1\text{-}\alpha)^{T/}N_P.100$$

*With*: $N_0$=number of stems that will become harvestable after a rotation of T years

$\Delta$=rate of harvesting damage (10%)

$\alpha$=natural mortality rate (1%)

T=rotation length (25 years)

$N_P$=total number of the initial harvestable stems (≥ DCL)

The calculation of $N_0$ requires to estimate the lower DBH ($D_L$) of the smallest tree that will reach the DCL within one cutting cycle. This is calculated as follows:

$$D_L = DCL - (T.DGR)$$

*With*: DCL=DBH cutting limit

DGR=Average Diameter Growth rate (cm/year)

T=cutting cycle (25 years)

Then, $N_0$ is obtained by adding (i) the number of trees ranging from $D_L$ to the first superior diameter class (=$D_{L\ SUP}$) and (ii) the number of trees with diameter classes ranging from $D_{L\ SUP}$ to DCL. For the calculation of the number of trees ranging from $D_L$ to the next higher diameter class (=$D_{L\ SUP}$), it is assumed that the trees of $D_L$ class are distributed following a linear distribution.

#### 2.2.1.3 Species group recovery rate (RePop%) formula

A recovery rate can be calculated by species group, by weighting the Re% of the species constituting the group:

$$REpop\% = \Sigma_i\ [\%R_iN_{Pi}]\ /\ \Sigma_i\ [N_{Pi}]$$

*With*: REpop%= Recovery rate of a group of species

$\%Re_i$= Recovery rate of species *i*

$N_{Pi}$= total number of the initial (T=0) harvestable stems of species *i*

#### 2.2.1.4 *Interpretation of the stock recovery formula and it's use as national directive*

Species with a low recovery rate (Figure 4-a) are those for which a potentially significant reduction in the number of exploitable trees will be observed after the first cutting cycle, which could translate in the long-term by a scarcity of mother trees and less regeneration. Conversely, good values of the recovery rate can sometimes hide the insufficient nature of the regeneration of a species (Figure 4-b).

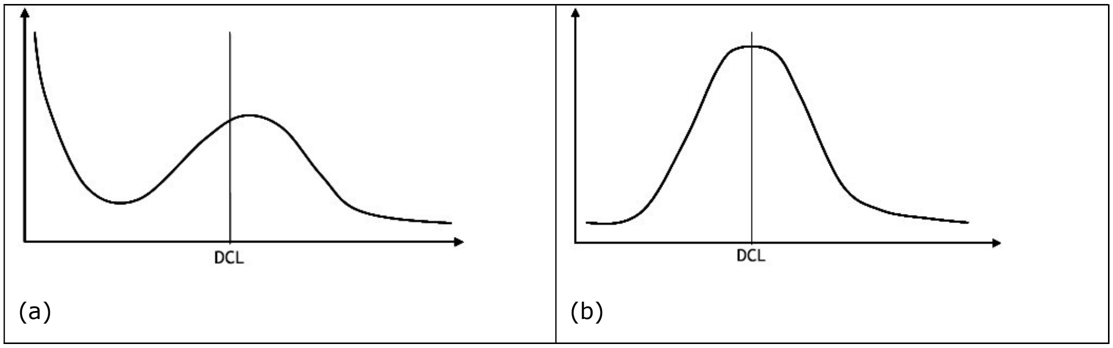


*Figure 4: Examples of diametric structures explaining unexpected figures of recovery rates (Re%).*

As said above (§ 2.2.1.1), Re% is calculated based on the numbers of trees, not on volumes, while timber yield sustainability is likely to be better assessed by ensuring a constant harvestable volume than a constant number of harvestable trees. When a species population shows a high percentage of its harvestable stems at high diameters (above 100 cm DBH), the recovery rate hides a drastic reduction of the future harvestable volumes of this species.

Therefore, the stock recovery rate alone gives a partial understanding of yield sustainability and its interpretation must take other parameters into account, such as the diameter distribution structure and the ecological profile of the species.

### 2.2.2 Regeneration potential

The species regeneration potential was analysed based on the stand structure (distribution particularly of N/ha over diameter classes).

The analysis of the diametric distribution of trees serves to predict the risks of the species' medium or long-term extinction in the absence of any intervention aimed at reversing this process. Poorly regenerating species (for which young individuals are rare) are directly threatened by logging and may disappear after two or three cutting cycles. This type of analysis is particularly interesting for commercial species. Studying the diametric curves therefore gives a better idea of the long-term regeneration potential of the species than examining the recovery rates alone.

Three main categories of species regeneration potential can be distinguished[7]:

1. Species whose existence over the long-term is guaranteed (whose population structure shows an exponential or linear decrease, or even an exponential decrease with little irregularities in the intermediate classes) -*Figure 5*;

[7] The diagrams accompanying the text show on the abscissa the classes of diameters increasing and, on the ordinate the percentages of individuals in the population

*Figure 5: Diametric structures of species whose existence over the long-term is guaranteed*

2. Species with a likely slowdown in regeneration (whose population structure presents a bell truncated to the left or waves) -*Figure 6* ;

*Figure 6: Diametric structures of species with a likely slowdown in regeneration*

3. Species with low regeneration whose long-term existence is compromised (very irregular structures characterized by the rarity of individuals in small diameter classes) –*Figure 7*

*Figure 7: Diametric structures of species with low regeneration whose long-term existence is compromised*

In this study, each of the species for which the diametrical distribution was studied was assigned one of the following ratings regarding their regeneration potential: "Favourable" (first category of regeneration potential), "Average" (second category of regeneration potential) and "Unfavourable" (third category of regeneration potential), according to the shape of its diameter structure curve.

### 2.2.3 Logging threat on timber species

The results obtained from the above analysis are appraised together in order to provide the likely threat that commercial logging operations will have on them, for the medium to long-term (one 25-years cutting cycle and ahead).

The thresholds used for this ranking are presented in Table 3 and are a combination of recovery rate, regeneration potential and density of trees with DBH ≥ 10 cm.

*Table 3: Thresholds used to estimate the logging threat to species of Groups 1, 2 and Ab*

| **N/ha ≥ 10cm** [/ha] | **Re%** [%] | **Regeneration potential** | **Threat** |
|---|---|---|---|
| unspecified | <50% | Unfavourable | **High** |
| unspecified | <30% | unspecified | **High** |
| <0,50 | whatever | Unfavourable | **High** |
| <0,10 | >50% | Favourable or Average | **High** |
| unspecified | >30% and <50% | Favourable or Average | Medium |
| >0,50 | unspecified | Unfavourable | Medium |
| >0,10 | >50% and <100% | Favourable or Average | Medium |
| >0,10 | ≥100% | Favourable or Average | Low |

# 3 ANALYSIS OF SUSTAINABILITY OF COMMERCIAL TIMBER HARVESTING

## 3.1 Commercial potential of present stock

### 3.1.1 Density, basal area and commercial volume of trees above DCL

The detailed densities per diameter class can be found in Annex 6.2, for all species of Groups 1 to 3. In this section, the analysis focuses on the densities, basal areas and commercial volumes of trees above DCL of the species of Groups 1, 2 and Ab.

#### 3.1.1.1 Priority species (Group 1)

Densities, basal areas and commercial volumes of trees above DCL of the 10 priority species are shown in Table 4. Out of those 10 species, 6 yield a commercial volume above 10 m³/ha (in bold). These are, namely: *Gilbertiodendron preussii*, *Lophira alata*, *Parinari excelsa*, *Piptadeniastrum africanum*, *Tarrietia utilis* and *Tetraberlinia tubmaniana*. The volumes of the other 4 species are substantially lower ranging from less than 1 to 5 m³/ha.

This group thus presents considerable volume for this cutting cycle and, as shown by the table, except for *Anopexis klaineana*, all species feature a high percentage of their timber stocks above the DCL (from 76 to 91%), which will be cross-checked in § 3.2 when studying the recovery rates based on the number of stems.

*Table 4: Density, basal area and commercial volume of trees above DCL of the 10 priority species (Group 1)*

| Scientific name | FDA Class | DCL [cm] | N/ha ≥ DCL [/ha] | G/ha ≥ DCL [m²/ha] | V/ha ≥ DCL [m³/ha] | % V/ha ≥ DCL [%] |
|---|---|---|---|---|---|---|
| *Anopyxis klaineana* | B | 60 | 0.12 | 0.05 | 0.79 | 35% |
| *Brachystegia leonensis* | A | 90 | 0.08 | 0.07 | 0.57 | 63% |
| *Cynometra ananta* | B | 60 | 0.55 | 0.60 | 5.03 | 84% |
| *Didelotia idae* | B | 60 | 0.44 | 0.35 | 3.47 | 84% |
| ***Gilbertiodendron preussii*** | A | 60 | 1.14 | 1.65 | **17.72** | 84% |
| ***Lophira alata*** | A | 80 | 0.64 | 0.99 | **10.27** | 90% |
| ***Parinari excelsa*** | C | 60 | 1.02 | 1.38 | **11.93** | 85% |
| ***Piptadeniastrum africanum*** | A | 80 | 1.35 | 1.65 | **18.36** | 91% |
| ***Tarrietia utilis*** | A | 60 | 1.00 | 1.03 | **10.11** | 76% |
| ***Tetraberlinia tubmaniana*** | A | 60 | 1.39 | 1.39 | **13.60** | 84% |

*Figure 8* shows the commercial volumes, accordingly.

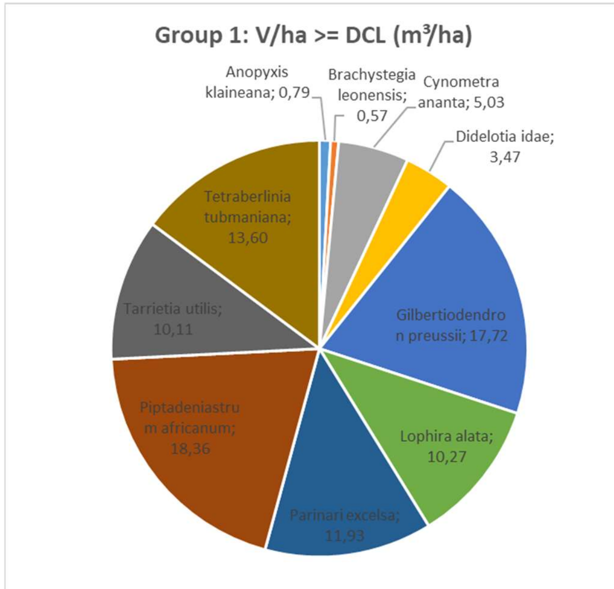


*Figure 8: Commercial volume/ha of trees above DCL of the 10 priority species (Group 1)*

#### 3.1.1.2 Secondary species (Group 2)

Densities, basal areas and commercial volumes of trees above DCL of the 10 secondary species are shown in Table 5. Out of those 10 species, none yields commercial volumes as high as the species of Group 1. The volumes actually range from less than 0.5 m³/ha to almost 2.5 m³/ha.

*Table 5: Density, basal area and commercial volume of trees above DCL of the 10 secondary species (Group 2)*

| Scientific name | FDA Class | DCL [cm] | N/ha ≥ DCL [/ha] | G/ha ≥ DCL [m²/ha] | V/ha ≥ DCL [m³/ha] | % V/ha ≥ DCL [%] |
|---|---|---|---|---|---|---|
| *Anthonotha fragrans* | C | 60 | 0.52 | 0.24 | 2.23 | 57% |
| *Aphanocalyx microphyllus* | C | 60 | 0.08 | 0.04 | 0.42 | 61% |
| *Canarium schweinfurthii* | A | 80 | 0.13 | 0.12 | 1.32 | 70% |
| *Erythrophleum sp.* | B | 80 | 0.22 | 0.20 | 2.36 | 64% |
| *Hallea ciliata* | A | 60 | 0.24 | 0.13 | 1.28 | 81% |
| *Klainedoxa gabonensis* | C | 60 | 0.25 | 0.19 | 1.72 | 83% |
| *Lovoa trichilioides* | A | 70 | 0.10 | 0.07 | 1.14 | 70% |
| *Milicia sp.* | A | 80 | 0.08 | 0.06 | 0.63 | 64% |
| *Nauclea diderrichii* | A | 80 | 0.05 | 0.04 | 0.65 | 51% |
| *Oldfieldia africana* | B | 60 | 0.05 | 0.13 | 1.34 | 86% |

*Figure 9* below shows the commercial volumes, accordingly.

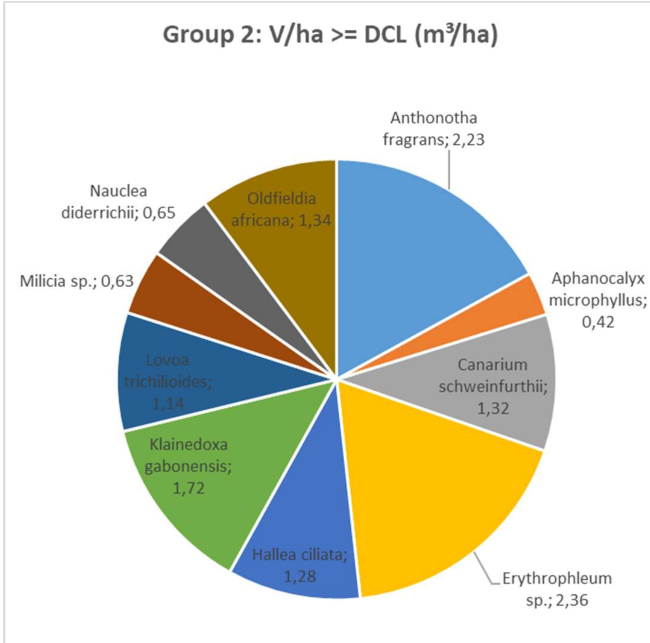


*Figure 9: Commercial volume of trees above DCL of the 10 secondary species (Group 2)*

#### 3.1.1.3 Most abundant species (Group Ab)

Densities, basal areas and commercial volumes of trees above DCL of the 20 most abundant species are shown in Table 6. Out of those 20 species, the 6 species belonging to Group 1 (marked in bold) yield the highest stocks. Beside of these, four species of Group 3 (with their V/ha underlined) feature a commercial volume above 5 m³/ha, showing some potential for commercial harvesting, should the market show some interest. These are, namely, *Calpocalyx aubrevillei*, *Dialium aubrevillei*, *Parkia bicolor* and *Sacoglottis gabonensis*.

*Table 6: Density, basal area and commercial volume of trees above DCL of the 20 most abundant species (Group Ab)*

| Scientific name | FDA Class | Group | DCL [cm] | N/ha ≥ DCL [/ha] | G/ha ≥ DCL [m²/ha] | V/ha ≥ DCL [m³/ha] | % V/ha ≥ DCL [%] |
|---|---|---|---|---|---|---|---|
| *Anthonotha fragrans* | C | 2 | 60 | 0.52 | 0.24 | 2.23 | 57% |
| *Calpocalyx aubrevillei* | C | 3 | 60 | 0.80 | 0.62 | 7.68 | 67% |
| *Cynometra ananta* | B | 1 | 60 | 0.55 | 0.60 | 5.03 | 84% |
| *Dialium aubrevillei* | C | 3 | 60 | 0.64 | 0.57 | 5.89 | 69% |
| *Didelotia idae* | B | 1 | 60 | 0.44 | 0.35 | 3.47 | 84% |
| *Erythrophleum sp.* | B | 2 | 80 | 0.22 | 0.20 | 2.36 | 64% |
| ***Gilbertiodendron preussii*** | A | 1 | 60 | 1.14 | 1.65 | **17.72** | 84% |
| ***Lophira alata*** | A | 1 | 80 | 0.64 | 0.99 | **10.27** | 90% |
| *Maranthes glabra* | C | 4 | 60 | 0.39 | 0.44 | 3.36 | 60% |
| ***Parinari excelsa*** | C | 1 | 60 | 1.02 | 1.38 | **11.93** | 85% |
| *Parkia bicolor* | C | 3 | 60 | 0.84 | 0.62 | 6.55 | 79% |
| *Pentadesma butyracea* | C | 3 | 60 | 0.10 | 0.18 | 2.77 | 71% |
| ***Piptadeniastrum africanum*** | A | 1 | 80 | 1.35 | 1.65 | **18.36** | 91% |

| Scientific name | FDA Class | Group | DCL [cm] | N/ha ≥ DCL [/ha] | G/ha ≥ DCL [m²/ha] | V/ha ≥ DCL [m³/ha] | % V/ha ≥ DCL [%] |
|---|---|---|---|---|---|---|---|
| *Pycnanthus angolensis* | B | 3 | 70 | 0.22 | 0.41 | 4.92 | 84% |
| *Quassia undulata* | C | 3 | 60 | 0.15 | 0.22 | 2.35 | 88% |
| *Sacoglottis gabonensis* | B | 3 | 70 | 0.79 | 1.05 | 9.08 | 87% |
| *Stachyothyrsus stapfiana* | C | 4 | 60 | 0.45 | 0.35 | 3.38 | 77% |
| ***Tarrietia utilis*** | A | 1 | 60 | 1.00 | 1.03 | **10.11** | 76% |
| ***Tetraberlinia tubmaniana*** | A | 1 | 60 | 1.39 | 1.39 | **13.60** | 84% |
| *Uapaca guineensis* | C | 3 | 60 | 0.73 | 0.32 | 2.70 | 44% |

*Figure 10* shows the commercial volumes, accordingly.

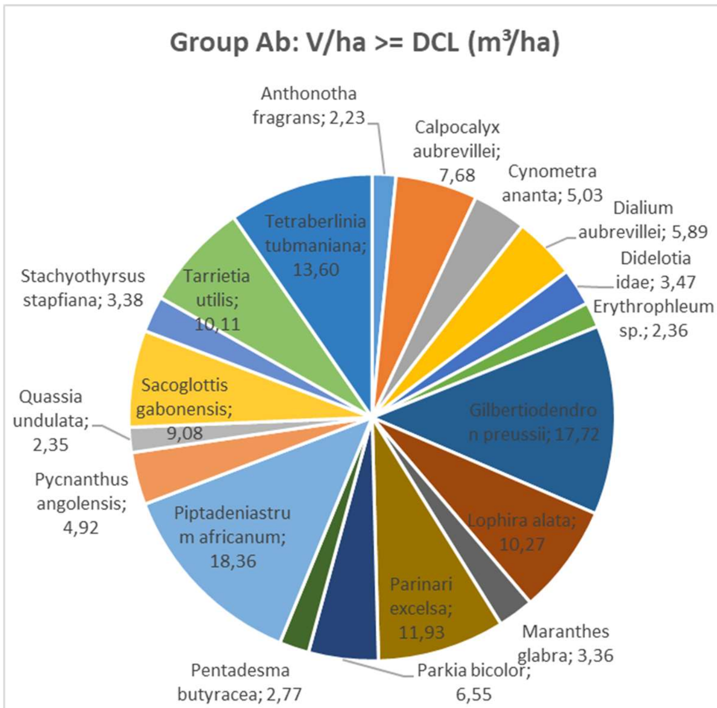


*Figure 10: Commercial volume/ha of trees above DCL of the 20 most abundant species (Group Ab)*

#### *3.1.1.4 Lesser used species and Non-commercial species (Groups 3 and 4)*

The species of Group 3 and 4 showing a potential for commercial harvesting thanks to their commercial volume stock of more than 5 m³/ha each have been identified in § 3.1.1.3, with four species of Group 3 -and none of Group 4. For more details, the species of Group 3 and 4 may be found in Annex 6.1, under the column "Group", with the respective attribute (3 or 4).

### 3.1.2 Species densities of trees with DBH ≥ 10 cm

#### *3.1.2.1 Species with low densities of trees with DBH ≥ 10 cm*

Densities of trees with DBH ≥ 10 cm are shown in Annex 6.2, for all species of Groups 1 to 3.

Species with densities of trees with DBH ≥ 10 cm of less than 0.10/ha are shown in Table 7, for Groups 1, 2 and 3. They actually all are from the species Group 3, none of those species being part of Group 1 or 2. Four of them feature a density of less than 0.04/ha (marked in red), which is the limit at national level for a species to be potentially harvested according the GFMP.

*Table 7: Species with densities of trees with DBH ≥ 10 cm ≤ 0,10/ha (Groups 1, 2 and 3)*

| Scientific name | FDA Class | Group | DCL [cm] | N/ha ≥ 10cm [/ha] |
|---|---|---|---|---|
| *Aningeria robusta* | A | 3 | 80 | 0.05 |
| *Bombax buonopozense* | B | 3 | 70 | 0.09 |
| *Chrysophyllum giganteum* | B | 3 | 60 | **0.02** |
| *Chrysophyllum splendens* | B | 3 | 60 | **0.02** |
| *Distemonanthus benthamianus* | A | 3 | 80 | 0.10 |
| *Entandrophragma angolense* | A | 3 | 90 | 0.07 |
| *Erythroxylum mannii* | C | 3 | 60 | 0.07 |
| *Guarea cedrata* | A | 3 | 80 | 0.05 |
| *Mansonia altissima* | B | 3 | 60 | **0.00** |
| *Nesogordonia papaverifera* | B | 3 | 60 | 0.05 |
| *Strombosia glaucescens* | C | 3 | 60 | **0.00** |

#### *3.1.2.2 Species going extinct at national level*

At least two species are not appearing in the PCPF stand and stock tables, while they are part of the NFI species list (FDA & Al., 2018, Annex 6: Trees Species List). These are *Entandrophragma utile* (Sipo) and *Tieghemella heckelii* (Makore), two species of the highest former commercial importance.

Their density is probably so low that the NFI did not sample them in any diameter class. Since even no young trees or regeneration was found, it can be assumed that their densities (above 10 cm DBH) are close to 0.00 stems/ha within the PCPF.

**According to the GFMP, the logging of species with such low densities is prohibited at national level. *Entandrophragma utile* (Sipo) and *Tieghemella heckelii* (Makore) should therefore be banned from any kind of timber harvesting and exportation. Furthermore, most probably their regeneration may not be sufficient to maintain them on the long-term. To avoid their extinction, some measures should be taken (see § 4.3.4).**

## 3.2 Stock recovery rate

### 3.2.1 Application of a harvesting rate based on stem exclusion at micro level

Beside exclusion zones at macro level, the Revised Code of Harvesting Practices stipulates requirements for timber extraction, i.e. standards for road construction, frequencies of log landings, and riparian strip protection along minor watercourses and swamps (FDA, 2017).

The areas required for forest development represent 13% of the gross PCPF area (DAI/DFS, 2020). This percentage results from a combination of 4.5% for forest road access, 1% for the required log landing sites and 7.5% for riparian buffer around minor watercourses and inaccessible terrain (swamps, heavily dissected terrain and otherwise inaccessible spots where machine movement is restricted).

As the 7.5% reduction applies to PCPF, this figure was used to determine the harvesting rate of the commercial species of the average present stock (ratio that converts numbers of standing trees - or gross standing volume - into number of harvestable trees or commercial volumes that can be harvested and marketed). Consequently, **in the calculation of the Re% and RePop%, it was assumed that the number of trees above the DCL would be felled at a ratio of 92.5%** (100% - 7.5%).

### 3.2.2 Stock recovery rates of the priority species (Group 1)

The recovery rates (Re%) of the 10 priority species are shown in the Table 8, for a cutting cycle of 25 years. The table indicates that for seven species, Re% show deficiencies as the minimum Re% of 50% is not reached (scores marked in red). Within those, species with a Re% between 30% and 50% are highlighted in purple, while species with a Re% of less than 30% are highlighted in orange. Such low Re% are observed for *Didelotia idae* (Bondu), *Gilbertiodendron preussii* (Limbali), *Piptadeniastrum africanum* (Dabeme) and *Lophira alala* (Ekki), the last three species being part of the currently most exploited species. For these three species, the Re% of 15%, 10% and 12%, respectively, clearly indicate that the commercial logging based on them will not yield similar harvestable volumes beyond one cutting cycle. This is also the case for all other species of Group 1, except for *Anopyxis klaineana* which shows a Re% > 100%, though at a lower scale.

*Table 8: Recovery Rates of the 10 priority species (cutting cycle of 25 years)*

| Scientific name | FDA Class | DCL [cm] | DGR [cm/year] | Re% [%] |
|---|---|---|---|---|
| *Anopyxis klaineana* | B | 60 | 0.5 | **110.1%** |
| *Brachystegia leonensis* | A | 90 | 0.5 | **80.7%** |
| *Cynometra ananta* | B | 60 | 0.5 | **47.8%** |
| *Didelotia idae* | B | 60 | 0.5 | **28.0%** |
| *Gilbertiodendron preussii* | A | 60 | 0.1 | **15.4%** |
| *Lophira alata* | A | 80 | 0.45 | **11.9%** |
| *Parinari excelsa* | C | 60 | 0.5 | **36.7%** |
| *Piptadeniastrum africanum* | A | 80 | 0.4 | **10.4%** |
| *Tarrietia utilis* | A | 60 | 0.6 | **62.5%** |
| *Tetraberlinia tubmaniana* | A | 60 | 0.5 | **33.7%** |

At group level, the recovery rate (RePop%) of Group 1 is 31.6%, for a cutting cycle of 25 years. This figure is far below the legal requirement of 75% for RePop% mentioned in the GFMP.

### 3.2.3 Stock recovery rates of the secondary species (Group 2)

The recovery rates (Re%) of the 10 secondary species are shown in the Table 9, for a cutting cycle of 25 years. Six of those species have a Re% of less than 50% (marked in red), of which two range between 30% and 50% (*Erythrophleum sp*. and *Klainedoxa gabonensis*, highlighted in purple) and four of them fall below 30%: *Canarium schweinfurthii* (Aiele), *Hallea ciliata* (Abura/Bahia) *Milicia sp*. (Iroko) and *Oldfieldia africana* (Oldfieldia/Dantoue).

*Table 9: Recovery Rates of the 10 secondary species (cutting cycle of 25 years)*

| Scientific name | FDA Class | DCL [cm] | DGR [cm/year] | Re% [%] |
|---|---|---|---|---|
| *Anthonotha fragrans* | C | 60 | 0.5 | **63.8%** |
| *Aphanocalyx microphyllus* | C | 60 | 0.5 | **56.3%** |
| *Canarium schweinfurthii* | A | 80 | 0.5 | **9.3%** |
| *Erythrophleum sp.* | B | 80 | 0.45 | **44.4%** |
| *Hallea ciliata* | A | 60 | 0.5 | **5.7%** |
| *Klainedoxa gabonensis* | C | 60 | 0.5 | **39.6%** |
| *Lovoa trichilioides* | A | 70 | 0.45 | **62.1%** |
| *Milicia sp.* | A | 80 | 0.55 | **5.7%** |
| *Nauclea diderrichii* | A | 80 | 0.45 | **57.6%** |
| *Oldfieldia africana* | B | 60 | 0.5 | **26.3%** |

At group level, the recovery rate (RePop%) of Group 2 amounts to 41.2%, for a cutting cycle of 25 years. As for Group 1, this figure for Group 2 is also far below the legal requirement of 75% for RePop% mentioned in the GFMP.

### 3.2.4 Stock recovery rates of the most abundant species (Group Ab)

The recovery rates (Re%) of the 20 most abundant species are shown in the Table 10, for a cutting cycle of 25 years. The species of this group showing a good Re% (≥50%) can be divided into two sub-groups: species with a current economic interest (*Anthonotha fragrans* and *Tarrietia utilis*), and species of so far low commercial interest (*Calpocalyx aubrevillei*, *Maranthes glabra*, *Pentadesma butyracea* and *Uapaca guineensis*). For the latter sub-group, it would be interesting to develop new market possibilities (See § 4.3.5).

In § 3.1.1.3, it was mentioned that 5 species of Group 3 show promising commercial volumes above 5 m³/ha (*Calpocalyx aubrevillei*, *Dialium aubrevillei*, *Parkia bicolor*, *Pycnanthus angolensis* and *Sacoglottis gabonensis*). Of these 5 species, only one features a Re% above 50% (namely *Calpocalyx aubrevillei).*

According to the above, the three most promising species of this group are: *Anthonotha fragrans*, *Calpocalyx aubrevillei* and *Tarrietia utilis* (highlighted in light green).

*Table 10: Recovery Rates of the 20 most abundant species (cutting cycle of 25 years)*

| Scientific name | FDA Class | Group | DCL [cm] | DGR [cm/year] | Re% [%] |
|---|---|---|---|---|---|
| *Anthonotha fragrans* | C | 2 | 60 | 0.5 | **63.8%** |
| *Calpocalyx aubrevillei* | C | 3 | 60 | 0.5 | **68.4%** |
| *Cynometra ananta* | B | 1 | 60 | 0.5 | **47.8%** |
| *Dialium aubrevillei* | C | 3 | 60 | 0.5 | **35.0%** |
| *Didelotia idae* | B | 1 | 60 | 0.5 | **28.0%** |
| *Erythrophleum sp.* | B | 2 | 80 | 0.45 | **44.4%** |
| *Gilbertiodendron preussii* | A | 1 | 60 | 0.1 | **15.4%** |
| *Lophira alata* | A | 1 | 80 | 0.45 | **11.9%** |
| *Maranthes glabra* | C | 4 | 60 | 0.5 | **53.7%** |
| *Parinari excelsa* | C | 1 | 60 | 0.5 | **36.7%** |
| *Parkia bicolor* | C | 3 | 60 | 0.5 | **49.4%** |
| *Pentadesma butyracea* | C | 3 | 60 | 0.5 | **159.8%** |

| Scientific name | FDA Class | Group | DCL [cm] | DGR [cm/year] | Re% [%] |
|---|---|---|---|---|---|
| *Piptadeniastrum africanum* | A | 1 | 80 | 0.4 | **10.4%** |
| *Pycnanthus angolensis* | B | 3 | 70 | 0.35 | **12.9%** |
| *Quassia undulata* | C | 3 | 60 | 0.5 | **37.4%** |
| *Sacoglottis gabonensis* | B | 3 | 70 | 0.5 | **17.3%** |
| *Stachyothyrsus stapfiana* | C | 4 | 60 | 0.5 | **38.1%** |
| *Tarrietia utilis* | A | 1 | 60 | 0.6 | **62.5%** |
| *Tetraberlinia tubmaniana* | A | 1 | 60 | 0.5 | **33.7%** |
| *Uapaca guineensis* | C | 3 | 60 | 0.5 | **67.6%** |

At group level, the recovery rate (RePop%) of Group Ab amounts to 53.2%, for a cutting cycle of 25 years. This figure is below the legal requirement of 75% for RePop% mentioned in the GFMP.

#### 3.2.5 Main conclusions on the current stock recovery rates

The recovery rates of the commercial species show poor results in comparison with the national requirements: 7 out of the 10 priority species and 6 out of 10 secondary species have Re% lower than 50%. These species account for respectively 87% and 65% of the current available harvestable volume (≥ DCL) of those groups. **This indicates that the commercial logging based on them will not yield similar harvesting volumes beyond one cutting cycle, and that a substantial drop of their commercial volumes will occur after the first cutting cycle.**

However, some species among the most abundant ones (Group Ab) show good recovery rates, like *Tarrietia utilis* (Group 1), *Anthonotha fragrans* (Group 2), and *Calpocalyx aubrevillei* (Group 3).

### 3.3 Regeneration potential

#### 3.3.1 Regeneration potential of the priority species (Group 1)

The regeneration potential based on the analysis of the diametric distribution of the priority species is presented in Table 11. **It shows that three out of the 10 species show an unfavourable regeneration potential, indicating that their long-term existence is compromised in the absence of adjustments to the management and harvesting rules**. These are, namely: *Brachystegia leonensis*, *Cynometra ananta* and *Piptadeniastrum africanum*.

*Table 11: Regeneration potential of the 10 priority species*

| Scientific name | FDA Class | DCL [cm] | Regeneration potential |
|---|---|---|---|
| *Anopyxis klaineana* | B | 60 | Average |
| *Brachystegia leonensis* | A | 90 | **Unfavourable** |
| *Cynometra ananta* | B | 60 | **Unfavourable** |
| *Didelotia idae* | B | 60 | Average |
| *Gilbertiodendron preussii* | A | 60 | Average |
| *Lophira alata* | A | 80 | Favourable |
| *Parinari excelsa* | C | 60 | Favourable |
| *Piptadeniastrum africanum* | A | 80 | **Unfavourable** |
| *Tarrietia utilis* | A | 60 | Average |
| *Tetraberlinia tubmaniana* | A | 60 | Favourable |

### 3.3.2 Regeneration potential of the secondary species (Group 2)

In Group 2, the diametric distribution analysis (see Table 12) reveals that **two out of the 10 species present unfavourable regeneration potential, indicating that their long-term existence is compromised in the absence of adjustments to the management and harvesting rules.** These are, namely: *Erythrophleum sp*. and *Lovoa trichilioides*.

*Table 12: Regeneration potential of the 10 secondary species*

| Scientific name | FDA Class | DCL [cm] | Regeneration potential |
|---|---|---|---|
| *Anthonotha fragrans* | C | 60 | Average |
| *Aphanocalyx microphyllus* | C | 60 | Favourable |
| *Canarium schweinfurthii* | A | 80 | Favourable |
| *Erythrophleum sp.* | B | 80 | **Unfavourable** |
| *Hallea ciliata* | A | 60 | Average |
| *Klainedoxa gabonensis* | C | 60 | Average |
| *Lovoa trichilioides* | A | 70 | **Unfavourable** |
| *Milicia sp.* | A | 80 | Favourable |
| *Nauclea diderrichii* | A | 80 | Average |
| *Oldfieldia africana* | B | 60 | Favourable |

### 3.3.3 Regeneration potential of the most abundant species (Group Ab)

In the group of the most abundant species, five species out of 20 show an unfavourable regeneration potential, as shown in Table 13. Three of those species having unfavourable regeneration potential belong to the Groups 1 and 2 (see § 3.3.1 and 3.3.2), and two of them to Group 3, namely: *Quassia undulata* and *Sacoglottis gabonensis*.

*Table 13: Regeneration potential of the 20 most abundant species*

| Scientific name | FDA Class | Group | DCL [cm] | Regeneration potential |
|---|---|---|---|---|
| *Anthonotha fragrans* | C | 2 | 60 | Average |
| *Calpocalyx aubrevillei* | C | 3 | 60 | Favourable |
| *Cynometra ananta* | B | 1 | 60 | **Unfavourable** |
| *Dialium aubrevillei* | C | 3 | 60 | Favourable |
| *Didelotia idae* | B | 1 | 60 | Average |
| *Erythrophleum sp.* | B | 2 | 80 | **Unfavourable** |
| *Gilbertiodendron preussii* | A | 1 | 60 | Average |
| *Lophira alata* | A | 1 | 80 | Favourable |
| *Maranthes glabra* | C | 4 | 60 | Favourable |
| *Parinari excelsa* | C | 1 | 60 | Favourable |
| *Parkia bicolor* | C | 3 | 60 | Favourable |
| *Pentadesma butyracea* | C | 3 | 60 | Favourable |
| *Piptadeniastrum africanum* | A | 1 | 80 | **Unfavourable** |
| *Pycnanthus angolensis* | B | 3 | 70 | Favourable |
| *Quassia undulata* | C | 3 | 60 | **Unfavourable** |
| *Sacoglottis gabonensis* | B | 3 | 70 | **Unfavourable** |
| *Stachyothyrsus stapfiana* | C | 4 | 60 | Favourable |
| *Tarrietia utilis* | A | 1 | 60 | Average |
| *Tetraberlinia tubmaniana* | A | 1 | 60 | Favourable |

| Scientific name | FDA Class | Group | DCL [cm] | Regeneration potential |
|---|---|---|---|---|
| *Uapaca guineensis* | C | 3 | 60 | Favourable |

### 3.3.4 Regeneration potential of grouped species (Groups 1 & 2)

Once compiled together, the species of Groups 1, 2 and Ab all show a favourable diametric structure, which could indicate that the deficiencies in one species are compensated by some other species with different diametric structures.

## 3.4 Synthesis on the logging threat of species

Table 14 indicates the logging threat of species of Groups 1, 2 and Ab, according to the thresholds defined in § 2.2.3. For the sake of readability of the table, species appearing in Groups 1 and 2 do not appear again in Group Ab when they are also part of this group. The table consequently displays the results for 30 species.

*Table 14: Logging threat to species of Groups 1, 2 and Ab*

| Group | Scientific name | FDA Class | DCL [cm] | N/ha ≥ 10cm [/ha] | Re% [%] | Regeneration potential | Logging threat |
|---|---|---|---|---|---|---|---|
| 1 | *Anopyxis klaineana* | B | 60 | 2.73 | 110.10% | Average | Low |
| 1 | *Brachystegia leonensis* | A | 90 | 0.17 | 80.70% | Unfavourable | **High** |
| 1 | *Cynometra ananta* | B | 60 | 1.44 | 47.80% | Unfavourable | **High** |
| 1 | *Didelotia idae* | B | 60 | 2.22 | 28.00% | Average | **High** |
| 1 | *Gilbertiodendron preussii* | A | 60 | 10.83 | 15.40% | Average | **High** |
| 1 | *Lophira alata* | A | 80 | 3.03 | 11.90% | Favourable | **High** |
| 1 | *Parinari excelsa* | C | 60 | 6.75 | 36.70% | Favourable | Medium |
| 1 | *Piptadeniastrum africanum* | A | 80 | 3.49 | 10.40% | Unfavourable | **High** |
| 1 | *Tarrietia utilis* | A | 60 | 7.23 | 62.50% | Average | Low |
| 1 | *Tetraberlinia tubmaniana* | A | 60 | 9.40 | 33.70% | Favourable | Medium |
| 2 | *Anthonotha fragrans* | C | 60 | 5.86 | 63.80% | Average | Low |
| 2 | *Aphanocalyx microphyllus* | C | 60 | 0.74 | 56.30% | Favourable | Low |
| 2 | *Canarium schweinfurthii* | A | 80 | 1.45 | 9.30% | Favourable | **High** |
| 2 | *Erythrophleum sp.* | B | 80 | 2.48 | 44.40% | Unfavourable | **High** |
| 2 | *Hallea ciliata* | A | 60 | 1.70 | 5.70% | Average | **High** |
| 2 | *Klainedoxa gabonensis* | C | 60 | 0.97 | 39.60% | Average | Medium |
| 2 | *Lovoa trichilioides* | A | 70 | 0.55 | 62.10% | Unfavourable | Medium |
| 2 | *Milicia sp.* | A | 80 | 1.53 | 5.70% | Favourable | **High** |
| 2 | *Nauclea diderrichii* | A | 80 | 1.27 | 57.60% | Average | Low |
| 2 | *Oldfieldia africana* | B | 60 | 0.75 | 26.30% | Favourable | **High** |
| 3 | *Calpocalyx aubrevillei* | C | 60 | 13.42 | 68.40% | Favourable | Low |
| 3 | *Dialium aubrevillei* | C | 60 | 7.04 | 35.00% | Favourable | Medium |
| 4 | *Maranthes glabra* | C | 60 | 7.48 | 53.70% | Favourable | Low |
| 3 | *Parkia bicolor* | C | 60 | 4.09 | 49.40% | Favourable | Medium |
| 3 | *Pentadesma butyracea* | C | 60 | 3.37 | 159.80% | Favourable | Low |
| 3 | *Pycnanthus angolensis* | B | 70 | 1.85 | 12.90% | Favourable | **High** |

| Group | Scientific name | FDA Class | DCL [cm] | N/ha ≥ 10cm [/ha] | Re% [%] | Regeneration potential | Logging threat |
|---|---|---|---|---|---|---|---|
| 3 | *Quassia undulata* | C | 60 | 2.81 | 37.40% | Unfavourable | **High** |
| 3 | *Sacoglottis gabonensis* | B | 70 | 2.57 | 17.30% | Unfavourable | **High** |
| 4 | *Stachyothyrsus stapfiana* | C | 60 | 4.18 | 38.10% | Favourable | Medium |
| 3 | *Uapaca guineensis* | C | 60 | 9.80 | 67.60% | Favourable | Low |

**Out of those 30 species, 14 are rated "High", 7 are rated "Medium" and 9 are rated "Low", regarding their logging threat.**

## 3.5 Limitations

The main limitations of this study are as follows:

1. This study present average stand and stock data observed during the recent NFI according to a logging scenario that would comply with the FDA GFMP and the Code of Forest Harvesting Practices, while the policies and regulations framing the forest management sector enforcement by the FDA is very weak. According to the World Bank (2019), so far, no concession has ever prepared a 25-year Strategic Forest Management Plan. Practically, they are operating based on 5-year Forest Management and Annual Operational Plans (AOPs).
2. The stand and stock data used are representative of the national PCPF, not necessarily of the TFP within concessions (FMC/CFMA). Significant variations may be found at concession scale, according to site conditions, previous logging, etc.

# 4 DISCUSSION

## 4.1 Assessment of the changes of the TPF over one cutting cycle according a harvesting scenario based on the GFMP

### 4.1.1 Residual growing stock levels

#### *4.1.1.1 Changes in the stand structure for the priority species*

Table 15 shows the densities and volumes per diameter class at present (T=0) and the projection after one cutting cycle (T=25) for all 10 species of Group 1 lumped together. The figures shown for N/ha and V/ha are based on the above-mentioned (§ 2.1.5 and § 2.2.1) DGR, natural mortality rate and harvesting damage, and for a cutting cycle of 25 years. Note that projections for diameter classes < 10.0 cm and 10.0 – 19.9 cm cannot be calculated per se. **On average, this table indicates that, compared to the current stand and stock data, future densities and volumes above DCL will dramatically drop to 25% and 12% of today's values, respectively.**

*Table 15: Density and commercial volume per diameter class at present and after a cutting cycle for species of Group 1 lumped together*

| | T=0 | | T= 25 | |
|---|---|---|---|---|
| **Diameter class** | **N/ha** [/ha] | **V/ha*** [m³/ha] | **N/ha** [/ha] | **V/ha*** [m³/ha] |
| < 10.0 cm | 110.88 | 1.05 | - | - |
| 10.0 – 19.9 cm | 18.58 | 1.39 | - | - |
| 20.0 – 29.9 cm | 8.10 | 2.40 | 14.63 | 4.33 |
| 30.0 – 39.9 cm | 7.59 | 5.00 | 9.65 | 6.36 |
| 40.0 – 49.9 cm | 2.37 | 2.51 | 6.95 | 7.34 |
| 50.0 – 59.9 cm | 2.54 | 4.90 | 3.31 | 6.38 |
| 60.0 – 69.9 cm | 1.62 | 4.11 | 2.25 | 5.72 |
| 70.0 – 79.9 cm | 0.87 | 3.25 | 0.68 | 2.54 |
| 80.0 – 89.9 cm | 0.62 | 2.72 | 0.10 | 0.44 |
| 90.0 – 99.9 cm | 0.79 | 4.85 | 0.10 | 0.58 |
| ≥100 cm | 4.21 | 78.15 | 0.28 | 5.28 |
| *≥10.0 cm* | *47.30* | *109.28* | *56.53* | *40.36* |
| **≥DCL** | **7.73** | **93.08** | **1.97** | **10.92** |

* based on the commercial tree height

Table 16 shows the density, basal area and commercial volume of trees above DCL for each species of Group 1. **This shows a drastic reduction of stand and stock data for all species of the group, the most affected being *Gilbertiodendron preussii*, *Lophira alata* and *Parinari excelsa*, with respectively 5%, 6% and 8% of the current volumes being available after one cutting cycle**. This is due to their present diametric distribution, featuring a high proportion of large trees.

*Table 16: Densities, basal areas and volumes at present and after a cutting cycle for species of Group 1*

| | | | | T = 0 | | | T = 25 | | |
|---|---|---|---|---|---|---|---|---|---|
| **Scientific name** | **FDA Class** | **DCL** [cm] | **DGR** [cm/ year] | **N/ha ≥DCL** [/ha] | **V/ha ≥DCL** [m³/ha] | **G/ha ≥DCL** [m²/ha] | **N/ha ≥DCL** [/ha] | **V/ha ≥DCL** [m³/ha] | **G/ha ≥DCL** [m²/ha] |
| *Anopyxis klaineana* | B | 60 | 0.5 | 0.12 | 0.79 | 0.05 | 0.10 | 0.47 | 0.03 |
| *Brachystegia leonensis* | A | 90 | 0.5 | 0.08 | 0.57 | 0.07 | 0.04 | 0.22 | 0.03 |
| *Cynometra ananta* | B | 60 | 0.5 | 0.55 | 5.03 | 0.60 | 0.19 | 0.79 | 0.08 |
| *Didelotia idae* | B | 60 | 0.5 | 0.44 | 3.47 | 0.35 | 0.09 | 0.38 | 0.04 |
| *Gilbertiodendron preussii* | A | 60 | 0.1 | 1.14 | 17.72 | 1.65 | 0.13 | 0.90 | 0.10 |
| *Lophira alata* | A | 80 | 0.45 | 0.64 | 10.27 | 0.99 | 0.05 | 0.58 | 0.06 |
| *Parinari excelsa* | C | 60 | 0.5 | 1.02 | 11.93 | 1.38 | 0.27 | 0.94 | 0.14 |
| *Piptadeniastrum africanum* | A | 80 | 0.4 | 1.35 | 18.36 | 1.65 | 0.31 | 3.58 | 0.33 |
| *Tarrietia utilis* | A | 60 | 0.6 | 1.00 | 10.11 | 1.03 | 0.45 | 1.66 | 0.19 |
| *Tetraberlinia tubmaniana* | A | 60 | 0.5 | 1.39 | 13.60 | 1.39 | 0.34 | 1.39 | 0.16 |

#### *4.1.1.2 Changes in the stand structure for the secondary species*

Table 17 shows the density and commercial volume per diameter class at present (T=0) and projected after a cutting cycle (T=25) for all 10 species of Group 2 lumped together. **On average, this table reveals that compared to current stand and stock data, future densities and volumes of trees above DCL will drop to 30% and 20% of today's level, respectively.**

*Table 17: Density and commercial volume per diameter class at present and after a cutting cycle for species of Group 2 gathered*

| | T=0 | | T= 25 | |
|---|---|---|---|---|
| **Diameter class** | **N/ha** [/ha] | **V/ha*** [m³/ha] | **N/ha** [/ha] | **V/ha*** [m³/ha] |
| < 10.0 cm | 58.26 | 0.36 | - | - |
| 10.0 – 19.9 cm | 6.98 | 0.49 | - | - |
| 20.0 – 29.9 cm | 4.46 | 1.14 | 5.50 | 1.40 |
| 30.0 – 39.9 cm | 2.16 | 0.83 | 4.58 | 1.77 |
| 40.0 – 49.9 cm | 0.79 | 0.88 | 2.46 | 2.77 |
| 50.0 – 59.9 cm | 0.78 | 1.51 | 1.02 | 1.95 |
| 60.0 – 69.9 cm | 0.61 | 2.08 | 0.71 | 2.40 |
| 70.0 – 79.9 cm | 0.43 | 1.97 | 0.22 | 1.00 |
| 80.0 – 89.9 cm | 0.48 | 2.54 | 0.06 | 0.33 |
| 90.0 – 99.9 cm | 0.21 | 1.84 | 0.05 | 0.40 |
| ≥100 cm | 0.40 | 5.98 | 0.03 | 0.40 |
| *≥10.0 cm* | *17.29* | *19.26* | *21.59* | *12.91* |
| **≥DCL** | **1.71** | **13.10** | **0.51** | **2.60** |

* based on the commercial tree height

Table 18 shows the density, basal area and commercial volume of trees above DCL for each species of Group 2. Among those species, 5 are most affected by harvesting operations (*Canarium schweinfurthii*, *Hallea ciliata*, *Milicia sp.*, *Nauclea diderrichii* and *Oldfieldia africana*), with their commercial volumes after one cutting cycle dropping below 10% of the current level.

*Table 18: Density, basal area and commercial volumes at present and after a cutting cycle for species of Group 2*

| | | | | T = 0 | | | T = 25 | | |
|---|---|---|---|---|---|---|---|---|---|
| **Scientific name** | **FDA Class** | **DCL** [cm] | **DGR** [cm/ year] | **N/ha ≥DCL** [/ha] | **V/ha ≥DCL** [m³/ha] | **G/ha ≥DCL** [m²/ha] | **N/ha ≥DCL** [/ha] | **V/ha ≥DCL** [m³/ha] | **G/ha ≥DCL** [m²/ha] |
| *Anthonotha fragrans* | C | 60 | 0.5 | 0.52 | 2.23 | 0.24 | 0.24 | 0.97 | 0.09 |
| *Aphanocalyx microphyllus* | C | 60 | 0.5 | 0.08 | 0.42 | 0.04 | 0.03 | 0.19 | 0.01 |
| *Canarium schweinfurthii* | A | 80 | 0.5 | 0.13 | 1.32 | 0.12 | 0.01 | 0.06 | 0.01 |
| *Erythrophleum sp.* | B | 80 | 0.45 | 0.22 | 2.36 | 0.20 | 0.07 | 0.44 | 0.04 |
| *Hallea ciliata* | A | 60 | 0.5 | 0.24 | 1.28 | 0.13 | 0.01 | 0.07 | 0.01 |
| *Klainedoxa gabonensis* | C | 60 | 0.5 | 0.25 | 1.72 | 0.19 | 0.07 | 0.32 | 0.03 |
| *Lovoa trichilioides* | A | 70 | 0.45 | 0.10 | 1.14 | 0.07 | 0.05 | 0.43 | 0.02 |
| *Milicia sp.* | A | 80 | 0.55 | 0.08 | 0.63 | 0.06 | 0.00 | 0.02 | 0.00 |
| *Nauclea diderrichii* | A | 80 | 0.45 | 0.05 | 0.65 | 0.04 | 0.02 | 0.03 | 0.00 |
| *Oldfieldia africana* | B | 60 | 0.5 | 0.05 | 1.34 | 0.13 | 0.01 | 0.05 | 0.01 |

#### 4.1.2 Changes in the species composition

By repeatedly removing mature trees of a limited list of highly demanded species, a gradual shift in the composition of the forest in favour of non-desired species takes place in the course of time. The forest composition will alter in favour of non-commercial species if such selective logging takes place over several felling cycles. A genetic erosion may also occur (Parren, 1995) because exploitation consistently removes the best phenotypes and genotypes.

**In Liberia, the timber species most traditionally exploited in the last century (*Entandrophragma*, *Khaya* and *Tieghemella*) have become very scarce. This is likely to happen to the species currently being harvested at a high rate as well, as harvest rates are well above the recovery rates and regeneration potential of most species.**

#### 4.1.3 Highlights of major changes occurring in Timber Production Forests under logging

Logging practices (intensity and frequency of cutting, tree selection, skidding and road construction) change the structure and species composition over time (Asamoah & Al.). In Liberia, most of the commercial forests were logged repeatedly within brief periods of time, resulting in short cutting cycles. It is difficult to predict how these short cutting cycles affect the future stand structure and composition. Too frequent cuttings, however, cause relatively high levels of damage to the residual stand. These damages contribute to a reduction of the stock recovery rate (Asamoah & Al.).

As analysed in the two above paragraphs (§ 4.1.1.1 and 4.1.1.2), the low number (and corresponding commercial volume) of trees above DCL at T=25, forebode that the yield of the currently exploited species cannot be sustained.

Moreover, some commercial species are becoming very scarce (§ 4.1.2) due to the detrimental impact of logging on their recovery rates and regeneration processes.

**To safeguard sustainable timber production in Liberia, it is important to reduce the harvesting pressure on vulnerable species, notably through the widening of the spectrum of the marketable species, to enhance the stock recovery and the regeneration.**

## 4.2 Examination of potential impacts of management and harvesting rule adjustments on the long-term timber production sustainability

### 4.2.1 Adjustment to the cutting cycle

#### *4.2.1.1 A cutting cycle based on increment data*

Cutting cycle lengths vary from country to country across the tropics. For example, it is 30 years in Brazil, 40-50 years in Nigeria, and 30-45 years in the Philippines (In Asamoah & Al., 2006). **In Ghana in 1990, a 40-years felling cycle was introduced based on the average time of passage estimated for most of the high value species to grow from the next lower diameter class to the exploitable class (In Asamoah & Al., 2006).**

The GFMP stipulates a cutting cycle of 25 years, as does the Code of Harvesting Practices. **The decision of such short cutting cycle seems to have been justified by short-term economic profitability, without paying attention to a strategy for securing future timber supplies in the second and following felling cycles based on sustained forest management.**

The length of a felling cycle is typically about half the time required for a particular species to reach marketable size (FAO, 2020, website). The felling cycle of 25 years applied in Liberia, however, is not based on increment data. A rough estimate based on an average DGR of 0.5 cm/year and on an average DCL of 60 cm indicates that the cutting cycle should rather be 60 cm / 0.5 cm/year / 2 = 60 years! The cutting cycle should also be chosen to transform the diameter distribution into a balanced structure at the end of the cutting cycle.

For species Groups 1 and 2, the impact of various cutting cycles on the stock recovery rates is shown in Table 19. For Group 1, the figures indicate that a cutting cycles below 50 years won't allow the timber harvesting to comply with the legal requirement of 75% for RePop% at group level if exploitation occurs with no changes on other parameters. For Group 2 a cutting cycle of 50 years seems to be compliant with the legal requirement of 75% for RePop% at group level, if exploitation occurs with no changes on other parameters.

*Table 19: Recovery Rates of species of Groups 1 and 2 according to different cutting cycles*

| Group | Cutting cycle [years] | | | | | | |
|---|---|---|---|---|---|---|---|
| | 20 | 25 | 30 | 35 | 40 | 45 | 50 |
| Group 1 | 27.2% | 31.6% | 35.6% | 39.8% | 44.6% | 51.5% | 57.8% |
| Group 2 | 35.5 | 41.2 | 46.3 | 50.8 | 54.9 | 68.4 | 80.7 |

Though theoretically not optimal, a **40-year cutting cycle would be more appropriate in the context of Liberia**. However, one would probably need several cutting cycles of consistent application of this regulation before seeing its impacts.

#### *4.2.1.2 Logging threat ranking changes under a cutting cycle of 40 years*

In Table 20, a comparison of the effect of a cutting cycle of 40 years is made, according to the changes induced on Re% for the species with high or medium logging threats (§ 3.4). The new ranking is based on changes of the Re% only, the other parameters being unchanged (regeneration potential and density above 10cm DBH). According to the diametric structure of the species population, Re% evolves differently from species to species.

As a result, passing from a cutting cycle of 25 years to one of 40 years would change the logging threat as follows:

- 2 species previously rated 'High' have shifted to 'Medium' (*Cynometra ananta* and *Erythrophleum sp.*);
- 1 species previously rated 'High' has shifted to 'Low' (*Oldfieldia africana*);
- 4 species previously rated 'Medium' have shifted to 'Low' rank (*Parinari excelsa*, *Klainedoxa gabonensis*, *Dialium aubrevillei* and *Parkia bicolor*).

**In total, the increase of the cutting cycle from 25 to 40 years yields positive results for 7 species out of the 21 selected.**

*Table 20: Comparison of the Logging threat of species rated Medium or High due to their low Re%, under a cutting cycle of 25 and 40 years*

| Group | Scientific name | Re% (25 years) [%] | Re% (40 years) [%] | Logging threat (25 years) | Logging threat (40 years) |
|---|---|---|---|---|---|
| 1 | *Brachystegia leonensis* | 80.7% | 69.4% | High | High |
| 1 | *Cynometra ananta* | 47.8% | 51.9% | High | Medium |
| 1 | *Didelotia idae* | 28.0% | 26.8% | High | High |
| 1 | *Gilbertiodendron preussii* | 15.4% | 18.2% | High | High |
| 1 | *Lophira alata* | 11.9% | 12.3% | High | High |
| 1 | *Parinari excelsa* | 36.7% | 52.9% | Medium | Low |
| 1 | *Piptadeniastrum africanum* | 10.4% | 13.2% | High | High |
| 1 | *Tetraberlinia tubmaniana* | 33.7% | 49.9% | Medium | Medium |
| 2 | *Canarium schweinfurthii* | 9.3% | 17.2% | High | High |
| 2 | *Erythrophleum sp.* | 44.4% | 62.8% | High | Medium |
| 2 | *Hallea ciliata* | 5.7% | 4.9% | High | High |
| 2 | *Klainedoxa gabonensis* | 39.6% | 63.2% | Medium | Low |
| 2 | *Lovoa trichilioides* | 62.1% | 63.9% | Medium | Medium |
| 2 | *Milicia sp.* | 5.7% | 9.2% | High | High |
| 2 | *Oldfieldia africana* | 26.3% | 75.8% | High | Low |
| 3 | *Dialium aubrevillei* | 35.0% | 67.5% | Medium | Low |
| 3 | *Parkia bicolor* | 49.4% | 73.4% | Medium | Low |
| 3 | *Pycnanthus angolensis* | 12.9% | 23.8% | High | High |
| 3 | *Quassia undulata* | 37.4% | 48.4% | High | High |
| 3 | *Sacoglottis gabonensis* | 17.3% | 19.4% | High | High |

| Group | Scientific name | Re% (25 years) [%] | Re% (40 years) [%] | Logging threat (25 years) | Logging threat (40 years) |
|---|---|---|---|---|---|
| 4 | *Stachyothyrsus stapfiana* | 38,1% | 40,6% | Medium | Medium |

### 4.2.2 Adjustment to the Recovery rate thresholds

FDA recommends managing species so that the Re% is equal or above 50% per species, or 75% at group level. While these thresholds may be acceptable in forests with largely untouched timber stocks, this is not the case in Liberia, where creaming has heavily occurred since the 1950s, with no attention to the reconstitution of timber stocks.

This interpretation of the stock recovery formula implies a systematic reduction of the harvestable stems over time, which is not compatible with sustainable timber management. The thresholds should be adjusted to allow a better reconstitution of the timber stocks over one cutting cycle.

**Management rules aiming at Re% of 65% per species and 100% at group level would be more supportive to sustainable timber exploitation than the current ones.**

This seems not to be feasible with the species currently harvested and marketed. To achieve such rates, major adjustments need to be made with regards to the spectrum of marketable species, DCL and cutting cycle.

### 4.2.3 Adjustment to the DCL

Minimum felling diameters are still an important aspect of the regulation mechanisms in Liberia, but the rationale appears still to be influenced more by the ease of application than by ecological or silvicultural aspects.

The impacts of logging on the recovery of timber stocks are still largely unknown in West and Central Africa, due to the lack of data on the dynamics of the tree populations concerned.

Unreasonably low DCLs result in premature removals of fast-growing trees with high value increment. In order to avoid harvesting trees at a time of their life cycle where they are most productive, the DCL should be compared with DGR by diameter class.

A DCL lower than the Minimum Fertility Diameter (MFD) would impede the species to regenerate and make it disappear at local scale. To improve forest management, it would be necessary to fully understand the seed production pattern (flowering, fruiting, seed dispersal, etc.) and the seedling ecology (seed germination, nutrient and micro-climate requirement for seedling growth and establishment, etc.) of the species. While seedling ecology may require medium to long-term research and/or experimentation, simple forest exploratory surveys may provide basic data on seedling recruitment and MFD around potential mother trees.

Annex 6.3 provides estimates of the Recovery rates (Re%) for various DCL and cutting cycles for the 10 species with ‘High’ residual logging threats (see 4.2.1.2). The Re% do not always raise to a significant level with the increase of the DCL and/or the cutting cycle due to each specific species’ diametric distribution. For most species some (drastic) adjustments to the cutting cycle and/or the DCL may lift their Re% above (or at least close to) 50%. However, this seems to never be the case with *Gilbertiodendron preussii*, *Lophira alata*, and *Piptadeniastrum africanum*.

**It is recommended (i) to enforce the DCL per species according to the 2007 version of the Code of Harvesting Practices (instead of considering all trees ≥ 60 DBH harvestable), and (ii) to analyse the impact of different DCL on Re% at concession level based on statistical inventory data in order to adapt the DCL when necessary and when possible.**

### 4.2.4 Adjustment to the spectrum of marketed species

The analysis undertaken in the previous sections leads to some general as well as to some specific recommendations. General recommendations are as follows:

- Low threatened species do not require adjustments of management parameters at national level. However, they may require adjustments at operational (concession) level based on management inventory results.
- Medium threatened species require systematic adjustments of their management parameters at operational level, in an effort to shift them to the Low threatened species at this scale.
- High threatened species require major adjustments of their management parameters at national level in an effort to shift them to the Medium or Low threatened species at national level. They must then be carefully studied at operational level and their management parameters must again be adjusted in an effort to shift them to the Medium or Low threatened species at this level.

**Special and urgent attention should be paid to those species currently under heavy logging pressure as they may disappear from the harvestable potential after one cutting cycle if management parameters are not adjusted. These species are: *Gilbertiodendron preussii*, *Lophira alata*, and *Piptadeniastrum africanum* (Group 1) and *Canarium schweinfurthii*, *Hallea ciliata*, *Milicia sp*. (Group 2).**

**At national level, measures should be undertaken to enhance the regeneration of species whose regeneration potential is unfavourable.**

**Two species with a low logging threat and currently of economic interest appear to be promising in terms of long-term timber supply. These are: *Anthonotha fragrans* (Group 2) and *Tarrietia utilis* (Group 1).**

The marketing potential of the following species with Re%>65% that are currently of low commercial interest shall be explored:

- With commercial volumes above 5 m³/ha: *Calpocalyx aubrevillei*
- With commercial volumes below 5 m³/ha*: Pentadesma butyracea* and *Uapaca guineensis*.

**According to the GFMP, the logging of species whose densities are lower than 0,04 stems/ha at national level for DBH ≥ 10 cm is prohibited. Based on the NFI results, this is the case for *Entandrophragma utile* (Sipo), *Tieghemella heckelii* (Makore), *Chrysophyllum giganteum*, *Chrysophyllum splendens*, *Mansonia altissima* and *Strombosia glaucescens*, which should therefore be banned from any kind of timber harvesting and exportation at national scale.**

### 4.2.5 Adjustment to the yield and the harvestable rate

The yield, which is the total volume to be harvested by a logging operation at one time, should remain restricted to what the forest can support, taking into account the loss of mother trees and harvesting damage. According to Parren (1995), in Liberia, this would probably be not more than some 30-40 m³/ha in each felling over a period of 20 to 40 years.

**The GFMP states that the harvested volume must not exceed 30 m³/ha at the scale of 100 ha blocks.** If applied, this is a kind of yield regulation that can prevent excessive detrimental impact on the residual stand. It also allows to maintain some mature trees, available to shed seeds and ensure regeneration during the recovery period after logging has occurred.

**This limit should be kept and systematically be enforced at the scale of single 100 ha blocks**. Note that for the calculation of harvested volume per ha, logging companies should not make this calculation on several blocks at one time (e.g. 30 m³/ha based on three 100 ha blocks, one being inaccessible), otherwise this measure would literally have no sense.

## 4.3 Further considerations affecting sustainable timber management

### 4.3.1 The need of shifting from creaming to a selective timber management system

Sustainability of timber exploitation will not be reached in Liberia if the same wasteful creaming practices continue to be applied. Instead, **a selective timber management system should be implemented, based on yield regulation**.

The effectiveness of yield regulation in maintaining a well-stocked residual forest depends on the ability to determine sustainable levels of harvest intensity and frequency, the appropriate diameter and species composition of the harvest as well as the composition of the retained trees (Asamoah & Al.).

Beside management implementation, a critical factor for maintaining healthy residual forests is to minimize soil and stand disturbance during logging operations. Therefore, **Reduced Impact Logging (RIL) should be systematically implemented** in accordance with the Code of Forest Harvesting Practices (FDA, 2017).

The transition towards sustainable timber management requires a cyclical process of goal setting, planning and capacity building, field management, monitoring, information assessment and goal-revision.

### 4.3.2 The need of policy enforcement and update

In Liberia, the policies and regulations framing the forest management sector are not enforced (World Bank, 2019). As of today, no company completed the 25-year, 5-year and annual planning processes according to the official requirements (Ibid.). However, the FDA generally accepts the plans and most times issues a harvesting certificate, which indicates that governance of the planning processes is very weak (World Bank, 2019).

Again, without the strict enforcement of existing regulations and their update as recommended in the previous sections, timber exploitation will remain unsustainable.

### 4.3.3 The need of protecting Timber Production Forests against encroachment

Beside the described changes in stand structure and composition of the TPF over a cutting cycle, pressures from deforestation and informal logging jeopardize the long-term integrity of the TPF. Therefore, the management effort to be made must be complemented by their protection.

**The current average rate of tree cover loss in Liberia is >2.2% (DAI/DFS, 2020). Without reversing this trend and ultimately halting deforestation in forest concessions (FMCs and CFMAs), timber production will not be sustainable in TPF.**

Thus, **controlling forest encroachment and all forms of degradation occurring apart from commercial timber harvesting under management practices is essential to ensure timber production sustainability**. For their own sake, timber concessions need to prevent forest clearings, illegal timber harvesting and mining (by small holders or companies operating with or without authorized permits).

### 4.3.4 The need of sylvicultural treatments aiming at enhancing both regeneration and the recovery rates

In forests managed for timber production, sylvicultural interventions are necessary to address the relative depletion of commercial tree species caused by past logging interventions, to increase the growth of commercial species, and to optimize the commercial value of the forest (Parren, 1995).

**As pointed out in this study, a major problem of the Liberian PCPF are the low recovery rates of most exploited species, even if we would consider a 40-years cutting cycle. The time required for forest to recover from logging disturbance probably will be longer if selective logging is not followed by any sylvicultural treatment** (Asamoah & Al.).

The decline of species with partially or completely heliophilus or light-demanding temperaments can be mitigated by dynamic silviculture. Such silviculture could rely on two pillars: thinning and stimulation of regeneration. Thinning can accelerate the growth and survival of future harvestable trees and would most probably have a positive impact after two cutting cycles. Support for regeneration could be based on the recruitment of pre-existing or established seedlings during exploitation or by enrichment planting (Biwolé & Al., 2019).

Enrichment planting generally consists of transplanting nursery-grown seedlings or wildlings into natural forest openings, gaps created by tree felling, or lines or strips opened specifically for this purpose. Enrichment planting may be appropriate in areas where the natural regeneration of desired species is deficient or irregularly distributed, or to favour particular (usually high-value) species that do not regenerate easily (Doucet & Al., 2007, Biwolé & Al., 2019).

### 4.3.5 The need of including alternative commercial species in the timber market

A major problem of sustainably managing most tropical African commercial forest areas is the low number of marketable species and the difficulty in attracting market interest in alternative species.

Two factors, among others, seem to be the driving forces behind the creaming of natural forests (Asamoah & Al.). First, consumer confidence in timber species takes a very long time to develop, and most consumers will only accept species that they are familiar with and or sure of a consistent supply. Second, timber companies must compete on an international market. Hence, they focus on species and products that have competitive prices and are consistently of high quality.

As shown above, alternative species with good potential for sustainable logging are available. Commercial efforts should be undertaken in order to widen the spectrum of species used in commercial logging and thus to reduce pressure on the species under logging threat.

To **compel loggers to take more of the lesser used and fewer of the depleted species, a log pricing or stumpage policy based on scarcity of species and local production cost could be applied**. The idea here is that paying the true market value of trees will have significant effects on real profits and compel loggers and local consumers to switch to lesser used but more abundant species.

Log export bans could also be applied to the most threatened species to encourage species diversification and value addition.

#### 4.3.6 Comment on unsustainable forestry practices occurring in CFMAs

**Accelerated creaming is occurring in CFMAs, with virtually no actions targeting timber sustainability.** Timber harvesting is conducted by forest logging companies under "authorizations" issued by FDA on the basis of 15-year agreements signed with local communities. Forest exploitation is occurring at a much faster rate (generally 5 to 10 years) than the legal 25 years prescribed.

**We recommend a review of this type of agreement in order to prevent CFMAs areas to become conversion forests. Practices to steward good community land management should also be implemented and target long-term community welfare (land use planning according to land suitability, support to agroforestry and sustainable agriculture practices, definition of protection areas, etc.).**

# 5 RECOMMENDATIONS TOWARDS THE LONG-TERM SUSTAINABILITY OF FOREST OPERATIONS IN TIMBER PRODUCTION FORESTS

## 5.1 Recommendations to FDA

About FDA mission:

- Develop the capacity within FDA to effectively implement a management system based on support, monitoring and supervision;
- Apply the existing harvesting and management regulations in the planning process and in the allocation of licences in the forest sector (e.g. Strategic Forest Management Plans, Annual Operational Plans, etc.) and do not emit any authorisation that is not compliant with those documents;
- Improve governance and transparency on those topics;
- Revise the FDA organisational chart and make the management and law enforcement bodies visible and effective.
- Enhance the field control rates to ensure the respect management and harvesting parameters.

About TPF yield and management plans:

- Increase the cutting cycle from 25 to 40 years or above;
- Ensure forest protection on FMC against illegal operations (pitsaw milling and forest clearing) and promote alternative sources of income of the adjacent populations;
- Enforce control of logging operations wherever logging occurs (application of management rules and RIL), including periodic audits of forest management in concessions (FMCs, CFMAs);
- Base yield regulations on data obtained on forest ecological processes and by inventories both of a temporary and of a more permanent character. (i.e. NFI permanent plots and FMC inventories);
- Require the implementation of quality management plans on TPF.

About species management and harvesting parameters:

- Enforce applicable DCLs in order to make DCLs applied according to the 2007 version of the Code of Harvesting Practices instead of considering all trees ≥ 60 DBH harvestable;
- Analyse the need of revising each species DCL according to the GFMP within every FMC to ensure the long-term reconstitution of the forest;
- Revise the recovery rates thresholds (Re% and RePop%) to more sustainable figures;
- Fiscally promote the harvesting of species of currently low commercial interest and presenting good recovery rates;
- Ban the logging, exploitation and exportation of species with low densities such as *Entandrophragma utile* (Sipo) and *Tieghemella heckelii* (Makore) at national level;
- Implement log export ban or increase the stumpage fees of the most threatened species to prevent excessive exploitation of those species (*Gilbertiodendron preussii*, *Lophira alata*, *Piptadeniastrum africanum*, *Canarium schweinfurthii*, *Hallea ciliate* and *Milicia sp*.);
- Test and encourage active silvicultural systems supporting commercial species with unfavourable regeneration and low recovery rates;

- Study the phenology parameters to ensure each species' DCL is above its minimum fertility diameter (MFD).

## 5.2 Recommendations to the forest concessionaires

- Develop and implement strategic management plans for all forest concessions;
- Comply with all legal FDA management and harvesting rules, both on FMCs and CFMAs;
- Evolve from today's wasteful timber exploitation methods (creaming system) to an efficient but careful working, with care for the forest residual stand (management system);
- Protect the forest matrix through the implementation of reduced impact logging practices;
- Install silvicultural operations to promote regeneration and recovery processes for species under logging threat.

## 5.3 Recommendations to the international community supporting the Liberian forest sector

- Appraise the probability of achieving both legality compliance and long-term sustainability on FMCs/CFMAs, given the actual stakeholders' behaviour and capacity in (i) sustainably managing the FMCs/CFMAs, and (ii) maintaining the forest cover;
- If the above-mentioned behaviour and capacity may change in the near future, analyse the feasibility of implementing a project aiming at assisting Liberia (FDA and concessionaries) to develop all FMC management plans (including statistical forest inventories, data processing, sociological studies, High Conservation Value (HCV) forests identification and writing of the document) and the subsequent first operational 5-years plans, and to assist in their field implementation;
- Given the very weak legality compliance on CFMAs and the obviously unsustainable timber harvesting occurring in these CFMAs, do not fund their industrial / export-oriented timber exploitation and concentrate rather on alternative sustainable uses of those, by and for the communities to reduce local pressure on timber resources;
- Support the forestry sector (public and private) in implementing ecological studies on the commercial species, aiming at providing local reliable data to analyse the timber logging sustainability and the commercial species regeneration (diameter growth rate, phenological aspects);
- Increase knowledge of forests importance in both public opinion and among decision-makers.

# 6 ANNEXES

## 6.1 List of tree species and their main attributes

| Scientific name | Commercial name | FDA Class | Group | DCL [cm] | DGR [cm/year] |
|---|---|---|---|---|---|
| *Adenanthera pavonina* | | C | 4 | 60 | 0.5 |
| *Aeglopsis chevalieri* | | C | 4 | 60 | 0.5 |
| *Afrolicania elaeosperma* | | C | 4 | 60 | 0.5 |
| *Afzelia bella* | Doussie / Apa | A | 3 | 70 | 0.25 |
| *Afzelia parviflora* | Doussie / Apa | A | 3 | 70 | 0.5 |
| *Albizia adianthifolia* | | C | 4 | 60 | 0.5 |
| *Albizia ferruginea* | | C | 4 | 60 | 0.5 |
| *Albizia glaberrima* | | C | 4 | 60 | 0.5 |
| *Albizia zygia* | | C | 3 | 60 | 0.5 |
| *Alchornea cordifolia* | | C | 4 | 60 | 0.5 |
| *Allanblackia floribunda* | | C | 4 | 60 | 0.5 |
| *Allanblackia parviflora* | | C | 4 | 60 | 0.5 |
| *Alstonia boonei* | Emien | C | 3 | 70 | 0.5 |
| *Amanoa bracteosa* | | C | 4 | 60 | 0.5 |
| *Amphimas pterocarpoides* | Lati / Bokanga | C | 3 | 60 | 0.5 |
| *Androsiphonia adenostegia* | | C | 4 | 60 | 0.5 |
| *Aningeria robusta* | Aningre | A | 3 | 80 | 0.4 |
| *Anisophyllea laurina* | | C | 4 | 60 | 0.5 |
| *Anisophyllea meniaudii* | | C | 4 | 60 | 0.5 |
| *Annickia chlorantha* | | C | 4 | 60 | 0.5 |
| *Annickia polycarpa* | | C | 4 | 60 | 0.5 |
| *Annona glabra* | | C | 4 | 60 | 0.5 |
| *Anopyxis klaineana* | Kokoti | B | 1 | 60 | 0.5 |
| *Anthocleista nobilis* | | C | 3 | 60 | 0.5 |
| *Anthocleista vogelii* | | C | 4 | 60 | 0.5 |
| *Anthonotha crassifolia* | | C | 4 | 60 | 0.5 |
| *Anthonotha fragrans* | Anthonota / Kibokoko | C | 2 | 60 | 0.5 |
| *Anthonotha macrophylla* | | C | 4 | 60 | 0.5 |
| *Anthonotha sassandraensis* | | C | 4 | 60 | 0.5 |
| *Anthonotha vignei* | | C | 4 | 60 | 0.5 |
| *Anthostema senegalense* | | C | 4 | 60 | 0.5 |
| *Antiaris toxicaria* | Ako | B | 3 | 60 | 0.5 |
| *Antidesma laciniatum* | | C | 4 | 60 | 0.5 |
| *Antidesma oblongum* | | C | 4 | 60 | 0.5 |
| *Antidesma rufescens* | | C | 4 | 60 | 0.5 |
| *Antrocaryon micraster* | | C | 4 | 60 | 0.5 |
| *Aphanocalyx microphyllus* | | C | 2 | 60 | 0.5 |
| *Aphanocalyx pteridophyllus* | | C | 4 | 60 | 0.5 |
| *Aubrevillea platycarpa* | | C | 3 | 60 | 0.5 |
| *Aulacocalyx jasminiflora* | | C | 4 | 60 | 0.5 |
| *Baphia nitida* | | C | 4 | 60 | 0.5 |
| *Baphia obanensis* | | C | 4 | 60 | 0.5 |
| *Baphia pubescens* | | C | 4 | 60 | 0.5 |

| Scientific name | Commercial name | FDA Class | Group | DCL [cm] | DGR [cm/year] |
|---|---|---|---|---|---|
| *Baphia spathacea* | | C | 4 | 60 | 0.5 |
| *Beilschmiedia chevalieri* | | C | 4 | 60 | 0.5 |
| *Beilschmiedia mannii* | Kanda | C | 3 | 60 | 0.5 |
| *Berlinia bracteosa* | | C | 4 | 60 | 0.5 |
| *Berlinia confusa* | Pocouli / Ebiara | C | 3 | 60 | 0.5 |
| *Berlinia tomentella* | | C | 4 | 60 | 0.5 |
| *Bertiera retrofracta* | | C | 4 | 60 | 0.5 |
| *Bertiera spicata* | | C | 4 | 60 | 0.5 |
| *Blighia sapida* | | C | 4 | 60 | 0.5 |
| *Bombax brevicuspe* | | C | 4 | 70 | 0.5 |
| *Bombax buonopozense* | | B | 3 | 70 | 0.5 |
| *Brachystegia leonensis* | Naga | A | 1 | 90 | 0.5 |
| *Brenandendron frondosum* | | C | 4 | 60 | 0.5 |
| *Breynia disticha* | | C | 4 | 60 | 0.5 |
| *Bridelia grandis* | | C | 3 | 60 | 0.5 |
| *Bridelia micrantha* | | C | 4 | 60 | 0.5 |
| *Bussea occidentalis* | | C | 3 | 60 | 0.5 |
| *Caloncoba brevipes* | | C | 4 | 60 | 0.5 |
| *Caloncoba echinata* | | C | 4 | 60 | 0.5 |
| *Calpocalyx aubrevillei* | | C | 3 | 60 | 0.5 |
| *Calpocalyx brevibracteatus* | | C | 4 | 60 | 0.5 |
| *Campylospermum amplectens* | | C | 4 | 60 | 0.5 |
| *Campylospermum duparquetianum* | | C | 4 | 60 | 0.5 |
| *Campylospermum flavum* | | C | 4 | 60 | 0.5 |
| *Canarium schweinfurthii* | Aiele | A | 2 | 80 | 0.5 |
| *Carapa procera* | | C | 4 | 60 | 0.5 |
| *Carpolobia alba* | | C | 4 | 60 | 0.5 |
| *Carpolobia lutea* | | C | 4 | 60 | 0.5 |
| *Cassia fikifiki* | | C | 4 | 60 | 0.5 |
| *Cassipourea gummiflua* | | C | 4 | 60 | 0.5 |
| *Cathormion altissimum* | | C | 4 | 60 | 0.5 |
| *Ceiba pentandra* | Ceiba / Fromager | A | 3 | 90 | 1.5 |
| *Celtis adolfi-friderici* | Celtis / Lokenfi | C | 3 | 60 | 0.5 |
| *Chidlowia sanguinea* | | C | 3 | 60 | 0.5 |
| *Chrysophyllum africanum* | Akatio / Longhi | B | 3 | 60 | 0.5 |
| *Chrysophyllum albidum* | Akatio / Longhi | B | 3 | 60 | 0.5 |
| *Chrysophyllum giganteum* | Akatio / Longhi | B | 3 | 60 | 0.5 |
| *Chrysophyllum perpulchrum* | Akatio / Longhi | B | 3 | 60 | 0.5 |
| *Chrysophyllum splendens* | Akatio / Longhi | B | 3 | 60 | 0.5 |
| *Chrysophyllum subnudum* | Akatio / Longhi | B | 3 | 60 | 0.5 |
| *Citropsis gabunensis* | | C | 4 | 60 | 0.5 |
| *Cleistopholis patens* | | C | 4 | 60 | 0.5 |
| *Coelocaryon oxycarpum* | | C | 4 | 60 | 0.5 |
| *Cola acuminata* | | C | 4 | 60 | 0.5 |
| *Cola angustifolia* | | C | 4 | 60 | 0.5 |
| *Cola buntingii* | | C | 4 | 60 | 0.5 |

| Scientific name | Commercial name | FDA Class | Group | DCL [cm] | DGR [cm/year] |
|---|---|---|---|---|---|
| *Cola caricifolia* | | C | 4 | 60 | 0.5 |
| *Cola chlamydantha* | | C | 4 | 60 | 0.5 |
| *Cola digitata* | | C | 4 | 60 | 0.5 |
| *Cola gabonensis* | | C | 4 | 60 | 0.5 |
| *Cola gigantea* | | C | 4 | 60 | 0.5 |
| *Cola heterophylla* | | C | 4 | 60 | 0.5 |
| *Cola hispida* | | C | 4 | 60 | 0.5 |
| *Cola lateritia* | | C | 4 | 60 | 0.5 |
| *Cola lorougnonis* | | C | 4 | 60 | 0.5 |
| *Cola nitida* | | C | 4 | 60 | 0.5 |
| *Cola umbratilis* | | C | 4 | 60 | 0.5 |
| *Corynanthe lane-poolei* | | C | 4 | 60 | 0.5 |
| *Corynanthe pachyceras* | | C | 4 | 60 | 0.5 |
| *Coula edulis* | | C | 3 | 60 | 0.5 |
| *Craterispermum caudatum* | | C | 4 | 60 | 0.5 |
| *Crudia gabonensis* | | C | 4 | 60 | 0.5 |
| *Crudia senegalensis* | | C | 4 | 60 | 0.5 |
| *Cryptosepalum tetraphyllum* | | C | 3 | 60 | 0.5 |
| *Cussonia bancoensis* | | C | 4 | 60 | 0.5 |
| *Cylicodiscus gabunensis* | | C | 4 | 60 | 0.5 |
| *Cynometra ananta* | Apome | B | 1 | 60 | 0.5 |
| *Cynometra leonensis* | | C | 4 | 60 | 0.5 |
| *Dacryodes edulis* | | C | 4 | 60 | 0.5 |
| *Dacryodes klaineana* | | C | 3 | 60 | 0.65 |
| *Daniellia ogea* | | C | 4 | 60 | 0.5 |
| *Daniellia thurifera* | Faro | B | 3 | 70 | 0.5 |
| *Deinbollia cuneifolia* | | C | 4 | 60 | 0.5 |
| *Deinbollia grandifolia* | | C | 4 | 60 | 0.5 |
| *Desplatsia subericarpa* | | C | 4 | 60 | 0.5 |
| *Detarium senegalense* | | C | 4 | 60 | 0.5 |
| *Dialium aubrevillei* | | C | 3 | 60 | 0.5 |
| *Dialium dinklagei* | | C | 4 | 60 | 0.5 |
| *Dialium guianense* | | C | 4 | 60 | 0.5 |
| *Dialium guineense* | | C | 4 | 60 | 0.5 |
| *Dichapetalum heudelotii* | | C | 4 | 60 | 0.5 |
| *Dichapetalum madagascariense* | | C | 4 | 60 | 0.5 |
| *Didelotia afzelii* | | C | 4 | 60 | 0.5 |
| *Didelotia idae* | Bondu | B | 1 | 60 | 0.5 |
| *Didelotia unifoliolata* | | C | 4 | 60 | 0.5 |
| *Diospyros barteri* | | C | 4 | 60 | 0.5 |
| *Diospyros canaliculata* | | C | 4 | 60 | 0.5 |
| *Diospyros chevalieri* | | C | 4 | 60 | 0.5 |
| *Diospyros cooperi* | | C | 4 | 60 | 0.5 |
| *Diospyros dichrophylla* | | C | 4 | 60 | 0.5 |
| *Diospyros elliotii* | | C | 4 | 60 | 0.5 |
| *Diospyros feliciana* | | C | 4 | 60 | 0.5 |

| Scientific name | Commercial name | FDA Class | Group | DCL [cm] | DGR [cm/year] |
|---|---|---|---|---|---|
| *Diospyros gabunensis* | | C | 4 | 60 | 0.5 |
| *Diospyros heudelotii* | | C | 4 | 60 | 0.5 |
| *Diospyros kamerunensis* | | C | 4 | 60 | 0.5 |
| *Diospyros liberiensis* | | C | 4 | 60 | 0.5 |
| *Diospyros mannii* | | C | 4 | 60 | 0.5 |
| *Diospyros piscatoria* | | C | 4 | 60 | 0.5 |
| *Diospyros sanza-minika* | | C | 3 | 60 | 0.5 |
| *Diospyros thomasii* | | C | 4 | 60 | 0.5 |
| *Diospyros vignei* | | C | 4 | 60 | 0.5 |
| *Discoclaoxylon hexandrum* | | C | 4 | 60 | 0.5 |
| *Discoglypremna caloneura* | | C | 4 | 60 | 0.5 |
| *Distemonanthus benthamianus* | Movingui | A | 3 | 80 | 0.45 |
| *Donella ubangiensis* | | C | 4 | 60 | 0.5 |
| *Drypetes aframensis* | | C | 4 | 60 | 0.5 |
| *Drypetes afzelii* | | C | 4 | 60 | 0.5 |
| *Drypetes aubrevillei* | | C | 4 | 60 | 0.5 |
| *Drypetes aylmeri* | | C | 4 | 60 | 0.5 |
| *Drypetes chevalieri* | | C | 4 | 60 | 0.5 |
| *Drypetes floribunda* | | C | 4 | 60 | 0.5 |
| *Drypetes inaequalis* | | C | 4 | 60 | 0.5 |
| *Drypetes ivorensis* | | C | 4 | 60 | 0.5 |
| *Drypetes klainei* | | C | 4 | 60 | 0.5 |
| *Drypetes leonensis* | | C | 4 | 60 | 0.5 |
| *Duguetia staudtii* | | C | 4 | 60 | 0.5 |
| *Englerophytum laurentii* | | C | 4 | 90 | 0.5 |
| *Entandrophragma angolense* | Tiama / Edinam | A | 3 | 90 | 0.35 |
| *Entandrophragma cylindricum* | Sapele | A | 3 | 90 | 0.4 |
| *Erythrophleum sp.* | Tali | B | 2 | 80 | 0.45 |
| *Erythroxylum mannii* | | C | 3 | 60 | 0.5 |
| *Eugenia whytei* | | C | 4 | 60 | 0.5 |
| *Ficus kamerunensis* | | C | 4 | 60 | 0.5 |
| *Ficus mucuso* | | C | 4 | 60 | 0.5 |
| *Ficus sur* | | C | 4 | 60 | 0.5 |
| *Ficus vogeliana* | | C | 4 | 60 | 0.5 |
| *Garcinia afzelii* | | C | 4 | 60 | 0.5 |
| *Garcinia elliotii* | | C | 4 | 60 | 0.5 |
| *Garcinia epunctata* | | C | 4 | 60 | 0.5 |
| *Garcinia gnetoides* | | C | 4 | 60 | 0.5 |
| *Garcinia kola* | | C | 4 | 60 | 0.5 |
| *Garcinia mannii* | | C | 4 | 60 | 0.5 |
| *Garcinia ovalifolia* | | C | 4 | 60 | 0.5 |
| *Garcinia smeathmannii* | | C | 4 | 60 | 0.5 |
| *Gilbertiodendron bilineatum* | | C | 4 | 60 | 0.5 |
| *Gilbertiodendron ivorense* | | C | 4 | 60 | 0.5 |
| *Gilbertiodendron limba* | | C | 4 | 60 | 0.5 |
| *Gilbertiodendron preussii* | Limbali | A | 1 | 60 | 0.1 |

| Scientific name | Commercial name | FDA Class | Group | DCL [cm] | DGR [cm/year] |
|---|---|---|---|---|---|
| *Gilbertiodendron splendidum* | | C | 4 | 60 | 0.5 |
| *Glenniea adamii* | | C | 4 | 60 | 0.5 |
| *Gluema ivorensis* | | C | 3 | 60 | 0.5 |
| *Greenwayodendron oliveri* | | C | 4 | 60 | 0.5 |
| *Grewia praecox* | | C | 4 | 60 | 0.5 |
| *Guarea cedrata* | Bosse | A | 3 | 80 | 0.4 |
| *Guibourtia dinklagei* | | C | 4 | 60 | 0.5 |
| *Guibourtia ehie* | Amazakoue / Bubinga | A | 3 | 60 | 0.35 |
| *Hallea ciliata* | Abura / Bahia | A | 2 | 60 | 0.5 |
| *Haplormosia monophylla* | Black gum / Idewa | B | 3 | 60 | 0.5 |
| *Harrisonia abyssinica* | | C | 4 | 60 | 0.5 |
| *Harungana madagascariensis* | | C | 4 | 60 | 0.5 |
| *Heisteria parvifolia* | | C | 4 | 60 | 0.5 |
| *Heritiera densiflora* | | C | 4 | 60 | 0.5 |
| *Homalium africanum* | | C | 4 | 60 | 0.5 |
| *Homalium le-testui* | | C | 4 | 60 | 0.5 |
| *Homalium longistylum* | | C | 4 | 60 | 0.5 |
| *Homalium smythei* | | C | 4 | 60 | 0.5 |
| *Homalium stipulaceum* | | C | 4 | 60 | 0.5 |
| *Hugonia rufipilis* | | C | 4 | 60 | 0.5 |
| *Hymenostegia afzelii* | | C | 4 | 60 | 0.5 |
| *Hymenostegia gracilipes* | | C | 4 | 60 | 0.5 |
| *Irvingia gabonensis* | | C | 3 | 60 | 0.5 |
| *Khaya ivorensis* | Khaya | A | 3 | 70 | 0.4 |
| *Kigelia africana* | | C | 4 | 60 | 0.5 |
| *Klainedoxa gabonensis* | Klainedoxa / Eveuss | C | 2 | 60 | 0.5 |
| *Lecaniodiscus cupanioides* | | C | 4 | 60 | 0.5 |
| *Leptonychia occidentalis* | | C | 4 | 60 | 0.5 |
| *Loesenera kalantha* | | C | 4 | 60 | 0.5 |
| *Lophira alata* | Ekki / Azobe | A | 1 | 80 | 0.45 |
| *Lovoa trichilioides* | Lovoa / Dibetou | A | 2 | 70 | 0.45 |
| *Macaranga barteri* | | C | 4 | 60 | 0.5 |
| *Macaranga heterophylla* | | C | 4 | 60 | 0.5 |
| *Macaranga heudelotii* | | C | 4 | 60 | 0.5 |
| *Macaranga hurifolia* | | C | 4 | 60 | 0.5 |
| *Maesobotrya barteri* | | C | 4 | 60 | 0.5 |
| *Mammea africana* | Mammea / Oboto | B | 3 | 60 | 0.5 |
| *Manilkara obovata* | | C | 3 | 60 | 0.5 |
| *Mansonia altissima* | Mansonia / Bete | B | 3 | 60 | 0.55 |
| *Maranthes aubrevillei* | | C | 4 | 60 | 0.5 |
| *Maranthes chrysophylla* | | C | 4 | 60 | 0.5 |
| *Maranthes glabra* | | C | 4 | 60 | 0.5 |
| *Mareya micrantha* | | C | 4 | 60 | 0.5 |
| *Margaritaria discoidea* | | C | 4 | 60 | 0.5 |
| *Markhamia tomentosa* | | C | 4 | 60 | 0.5 |

| Scientific name | Commercial name | FDA Class | Group | DCL [cm] | DGR [cm/year] |
|---|---|---|---|---|---|
| *Massularia acuminata* | | C | 4 | 60 | 0.5 |
| *Melia azedarach* | | C | 4 | 60 | 0.5 |
| *Memecylon lateriflorum* | | C | 4 | 60 | 0.5 |
| *Memecylon polyanthemos* | | C | 4 | 60 | 0.5 |
| *Microdesmis keayana* | | C | 4 | 60 | 0.5 |
| *Microdesmis puberula* | | C | 4 | 60 | 0.5 |
| *Milicia sp.* | Iroko | A | 2 | 80 | 0.55 |
| *Millettia chrysophylla* | | C | 4 | 60 | 0.5 |
| *Millettia lane-poolei* | | C | 4 | 60 | 0.5 |
| *Millettia leonensis* | | C | 4 | 60 | 0.5 |
| *Millettia liberica* | | C | 4 | 60 | 0.5 |
| *Millettia warneckei* | | C | 4 | 60 | 0.5 |
| *Monodora crispata* | | C | 4 | 60 | 0.5 |
| *Monodora myristica* | | C | 4 | 60 | 0.5 |
| *Morinda lucida* | | C | 4 | 60 | 0.5 |
| *Musanga cecropioides* | | C | 4 | 60 | 0.5 |
| *Myrianthus arboreus* | | C | 4 | 60 | 0.5 |
| *Myrianthus libericus* | | C | 4 | 60 | 0.5 |
| *Napoleonaea alata* | | C | 4 | 60 | 0.5 |
| *Napoleonaea heudelotii* | | C | 4 | 60 | 0.5 |
| *Napoleonaea sapoensis* | | C | 4 | 60 | 0.5 |
| *Napoleonaea talbotii* | | C | 4 | 60 | 0.5 |
| *Napoleonaea vogelii* | | C | 4 | 60 | 0.5 |
| *Nauclea diderrichii* | Kusia / Bilinga / Opepe | A | 2 | 80 | 0.45 |
| *Nauclea latifolia* | | C | 4 | 60 | 0.5 |
| *Nauclea pobeguinii* | | C | 4 | 60 | 0.5 |
| *Necepsia afzelii* | | C | 4 | 60 | 0.5 |
| *Neostenanthera gabonensis* | | C | 4 | 60 | 0.5 |
| *Neostenanthera hamata* | | C | 4 | 60 | 0.5 |
| *Nesogordonia papaverifera* | Danta / Kotibe | B | 3 | 60 | 0.45 |
| *Newbouldia laevis* | | C | 4 | 60 | 0.5 |
| *Newtonia aubrevillei* | | C | 3 | 60 | 0.5 |
| *Newtonia duparquetiana* | | C | 4 | 60 | 0.5 |
| *Nothospondias staudtii* | | C | 4 | 60 | 0.5 |
| *Ochna afzelii* | | C | 4 | 60 | 0.5 |
| *Octoknema borealis* | | C | 4 | 60 | 0.5 |
| *Okoubaka aubrevillei* | | C | 4 | 60 | 0.5 |
| *Oldfieldia africana* | Oldfieldia / Dantoue | B | 2 | 60 | 0.5 |
| *Omphalocarpum ahia* | | C | 4 | 60 | 0.5 |
| *Ongokea gore* | Angueuk / Kuwi | C | 3 | 60 | 0.5 |
| *Ophiobotrys zenkeri* | | C | 4 | 60 | 0.5 |
| *Panda oleosa* | | C | 4 | 60 | 0.5 |
| *Paramacrolobium coeruleum* | | C | 4 | 60 | 0.5 |
| *Parinari congensis* | | C | 4 | 60 | 0.5 |
| *Parinari excelsa* | Parinari / Songue | C | 1 | 60 | 0.5 |

| Scientific name | Commercial name | FDA Class | Group | DCL [cm] | DGR [cm/year] |
|---|---|---|---|---|---|
| *Parkia bicolor* | Parkia | C | 3 | 60 | 0.5 |
| *Pentaclethra macrophylla* | | C | 3 | 60 | 0.5 |
| *Pentadesma butyracea* | | C | 3 | 60 | 0.5 |
| *Pericopsis elata* | Afromorsia | B | 3 | 60 | 0.5 |
| *Petersianthus macrocarpus* | | C | 4 | 60 | 0.5 |
| *Piptadeniastrum africanum* | Dabeme | A | 1 | 80 | 0.4 |
| *Plagiosiphon emarginatus* | | C | 4 | 60 | 0.5 |
| *Polyceratocarpus parviflorus* | | C | 4 | 60 | 0.5 |
| *Polystemonanthus dinklagei* | | C | 4 | 60 | 0.5 |
| *Pouteria alnifolia* | | C | 4 | 60 | 0.5 |
| *Pouteria altissima* | | C | 4 | 60 | 0.5 |
| *Pouteria cuspidata* | | C | 4 | 60 | 0.5 |
| *Protomegabaria stapfiana* | | C | 4 | 60 | 0.5 |
| *Pseudospondias microcarpa* | | C | 4 | 60 | 0.5 |
| *Psychotria limba* | | C | 4 | 60 | 0.5 |
| *Psydrax arnoldiana* | | C | 4 | 60 | 0.5 |
| *Pterygota bequaertii* | | C | 4 | 60 | 0.5 |
| *Pterygota macrocarpa* | Koto / Ake | B | 3 | 60 | 0.5 |
| *Pycnanthus angolensis* | Ilomba | B | 3 | 70 | 0.35 |
| *Quassia silvestris* | | C | 4 | 60 | 0.5 |
| *Quassia undulata* | Hannoa / Effeu | C | 3 | 60 | 0.5 |
| *Rauvolfia vomitoria* | | C | 4 | 60 | 0.5 |
| *Ricinodendron heudelotii* | | C | 3 | 60 | 0.5 |
| *Rinorea aylmeri* | | C | 4 | 60 | 0.5 |
| *Rinorea brachypetala* | | C | 4 | 60 | 0.5 |
| *Rinorea ilicifolia* | | C | 4 | 60 | 0.5 |
| *Rinorea preussii* | | C | 4 | 60 | 0.5 |
| *Rothmannia hispida* | | C | 4 | 60 | 0.5 |
| *Rothmannia whitfieldii* | | C | 4 | 60 | 0.5 |
| *Sacoglottis gabonensis* | Ozouga | B | 3 | 70 | 0.5 |
| *Salacia lehmbachii* | | C | 4 | 60 | 0.5 |
| *Salacia mannii* | | C | 4 | 60 | 0.5 |
| *Salacia miegei* | | C | 4 | 60 | 0.5 |
| *Samanea dinklagei* | | C | 3 | 60 | 0.5 |
| *Santiria trimera* | | C | 4 | 60 | 0.5 |
| *Scottellia coriacea* | | C | 4 | 60 | 0.5 |
| *Scytopetalum tieghemii* | | C | 4 | 60 | 0.5 |
| *Senna alata* | | C | 4 | 60 | 0.5 |
| *Senna siamea* | | C | 4 | 60 | 0.5 |
| *Shirakiopsis aubrevillei* | | C | 4 | 60 | 0.5 |
| *Smeathmannia pubescens* | | C | 4 | 60 | 0.5 |
| *Spondianthus preussii* | | C | 4 | 60 | 0.5 |
| *Spondias dulcis* | | C | 4 | 60 | 0.5 |
| *Spondias mombin* | | C | 4 | 60 | 0.5 |
| *Stachyothyrsus stapfiana* | | C | 4 | 60 | 0.5 |
| *Stemonocoleus micranthus* | | C | 4 | 60 | 0.5 |

| Scientific name | Commercial name | FDA Class | Group | DCL [cm] | DGR [cm/year] |
|---|---|---|---|---|---|
| *Sterculia oblonga* | | C | 4 | 60 | 0.5 |
| *Sterculia tragacantha* | | C | 4 | 60 | 0.5 |
| *Strephonema pseudocola* | | C | 4 | 60 | 0.5 |
| *Strombosia glaucescens* | | C | 3 | 60 | 0.5 |
| *Strombosia pustulata* | | C | 4 | 60 | 0.5 |
| *Strombosiopsis nana* | | C | 4 | 60 | 0.5 |
| *Symphonia globulifera* | | C | 3 | 60 | 0.5 |
| *Synsepalum afzelii* | | C | 3 | 60 | 0.5 |
| *Synsepalum brevipes* | | C | 3 | 60 | 0.5 |
| *Syzygium guineense* | | C | 4 | 60 | 0.5 |
| *Tabernaemontana africana* | | C | 4 | 60 | 0.5 |
| *Tarrietia utilis* | Niangon | A | 1 | 60 | 0.6 |
| *Terminalia ivorensis* | Framire /Baji / Emire | A | 3 | 70 | 0.75 |
| *Terminalia superba* | Frake / Limba / Afara | A | 3 | 70 | 0.75 |
| *Tetraberlinia tubmaniana* | Tetra / Sikon | A | 1 | 60 | 0.5 |
| *Tetrapleura tetraptera* | | C | 4 | 60 | 0.5 |
| *Tetrorchidium didymostemon* | | C | 4 | 60 | 0.5 |
| *Tetrorchidium oppositifolium* | | C | 4 | 60 | 0.5 |
| *Treculia africana* | | C | 4 | 60 | 0.5 |
| *Trichilia monadelpha* | | C | 4 | 60 | 0.5 |
| *Trichilia ornithothera* | | C | 4 | 60 | 0.5 |
| *Trichilia tessmannii* | | C | 4 | 60 | 0.5 |
| *Trichoscypha arborea* | | C | 4 | 60 | 0.5 |
| *Trichoscypha baldwinii* | | C | 4 | 60 | 0.5 |
| *Trichoscypha barbata* | | C | 4 | 60 | 0.5 |
| *Trichoscypha bijuga* | | C | 4 | 60 | 0.5 |
| *Trichoscypha cavalliensis* | | C | 4 | 60 | 0.5 |
| *Trichoscypha longifolia* | | C | 4 | 60 | 0.5 |
| *Triplochiton scleroxylon* | Obeche / Samba / Wawa | A | 3 | 90 | 1.1 |
| *Turraea leonensis* | | C | 4 | 60 | 0.5 |
| *Turraeanthus africanus* | Avodire | B | 3 | 80 | 0.5 |
| *Uapaca corbisieri* | | C | 4 | 60 | 0.5 |
| *Uapaca guineensis* | Uapaca / Rikio | C | 3 | 60 | 0.5 |
| *Uapaca heudelotii* | | C | 4 | 60 | 0.5 |
| *Uapaca paludosa* | | C | 4 | 60 | 0.5 |
| *Uapaca pynaertii* | | C | 4 | 60 | 0.5 |
| *Unknown sp.* | | C | 4 | 60 | 0.5 |
| *Unlisted sp.* | | C | 4 | 60 | 0.5 |
| *Vepris tabouensis* | | C | 3 | 60 | 0.5 |
| *Vitex doniana* | | C | 4 | 60 | 0.5 |
| *Vitex grandifolia* | | C | 4 | 60 | 0.5 |
| *Vitex micrantha* | | C | 4 | 60 | 0.5 |
| *Vitex rivularis* | | C | 4 | 60 | 0.5 |
| *Warneckea fascicularis* | | C | 4 | 60 | 0.5 |
| *Xylia evansii* | | C | 3 | 60 | 0.5 |

| Scientific name | Commercial name | FDA Class | Group | DCL [cm] | DGR [cm/year] |
|---|---|---|---|---|---|
| *Xylopia acutiflora* | | C | 4 | 60 | 0.5 |
| *Xylopia aethiopica* | | C | 3 | 60 | 0.5 |
| *Xylopia le-testui* | | C | 4 | 60 | 0.5 |
| *Xylopia parviflora* | | C | 4 | 60 | 0.5 |
| *Xylopia quintasii* | | C | 4 | 60 | 0.5 |
| *Xylopia rubescens* | | C | 4 | 60 | 0.5 |
| *Xylopia staudtii* | | C | 4 | 60 | 0.5 |
| *Xylopia villosa* | | C | 4 | 60 | 0.5 |
| *Zanthoxylum atchoum* | | C | 4 | 60 | 0.5 |
| *Zanthoxylum gilletii* | | C | 3 | 60 | 0.5 |

## 6.2 Initial diameter distribution for species of Groups 1, 2 and 3

| Species parameters | | | | Initial harvest stocks: N/ha according NFI selection | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scientific name | FDA Class | Group | DCL [cm] | < 10.0 cm | 10-19.9 cm | 20-29.9 cm | 30-39.9 cm | 40-49.9 cm | 50-59.9 cm | 60-69.9 cm | 70-79.9 cm | 80-89.9 cm | 90-99.9 cm | ≥ 100.0 cm | **N/ha ≥ 10.0 cm** [/ha] | **N/ha ≥ DCL** [/ha] |
| *Afzelia bella* | A | 3 | 70 | 6.30 | 0.34 | 0.16 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 | 0.00 | | 0.05 |
| *Afzelia parviflora* | A | 3 | 70 | 0.00 | 0.00 | 0.00 | 0.33 | 0.08 | 0.08 | 0.03 | 0.00 | 0.05 | 0.02 | 0.00 | 0.59 | 0.07 |
| *Albizia zygia* | C | 3 | 60 | 0.00 | 0.33 | 0.00 | 0.16 | 0.05 | 0.08 | 0.05 | 0.02 | 0.00 | 0.00 | 0.02 | 0.72 | 0.10 |
| *Alstonia boonei* | C | 3 | 70 | 0.00 | 0.16 | 0.17 | 0.00 | 0.00 | 0.00 | 0.03 | 0.02 | 0.00 | 0.02 | 0.00 | 0.41 | 0.05 |
| *Amphimas pterocarpoides* | C | 3 | 60 | 10.23 | 0.33 | 1.18 | 0.49 | 0.05 | 0.07 | 0.08 | 0.08 | 0.08 | 0.00 | 0.02 | 2.39 | 0.26 |
| *Aningeria robusta* | A | 3 | 80 | 1.97 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 |
| *Anopyxis klaineana* | B | 1 | 60 | 7.11 | 1.00 | 0.99 | 0.34 | 0.15 | 0.13 | 0.07 | 0.02 | 0.00 | 0.00 | 0.02 | 2.73 | 0.12 |
| *Anthocleista nobilis* | C | 3 | 60 | 1.97 | 3.91 | 1.53 | 0.16 | 0.08 | 0.02 | 0.12 | 0.00 | 0.03 | 0.00 | 0.02 | 5.87 | 0.17 |
| *Anthonotha fragrans* | C | 2 | 60 | 32.35 | 2.99 | 0.50 | 1.35 | 0.15 | 0.36 | 0.17 | 0.16 | 0.15 | 0.04 | 0.00 | 5.86 | 0.52 |
| *Antiaris toxicaria* | B | 3 | 60 | 4.34 | 0.66 | 0.64 | 0.00 | 0.02 | 0.02 | 0.05 | 0.03 | 0.05 | 0.00 | 0.00 | 1.48 | 0.12 |
| *Aphanocalyx microphyllus* | C | 2 | 60 | 1.97 | 0.33 | 0.20 | 0.00 | 0.11 | 0.03 | 0.02 | 0.00 | 0.05 | 0.00 | 0.00 | 0.74 | 0.08 |
| *Aubrevillea platycarpa* | C | 3 | 60 | 0.00 | 0.40 | 0.16 | 0.19 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.81 | 0.00 |
| *Beilschmiedia mannii* | C | 3 | 60 | 7.91 | 2.42 | 0.68 | 0.00 | 0.20 | 0.05 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 3.42 | 0.08 |
| *Berlinia confusa* | C | 3 | 60 | 8.09 | 1.34 | 0.33 | 0.49 | 0.10 | 0.20 | 0.05 | 0.03 | 0.02 | 0.00 | 0.00 | 2.55 | 0.10 |
| *Bombax buonopozense* | B | 3 | 70 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 | 0.09 | 0.06 |
| *Brachystegia leonensis* | A | 1 | 90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.07 | 0.03 | 0.05 | 0.17 | 0.08 |
| *Bridelia grandis* | C | 3 | 60 | 0.00 | 0.49 | 0.49 | 0.16 | 0.00 | 0.07 | 0.07 | 0.05 | 0.02 | 0.03 | 0.02 | 1.41 | 0.20 |
| *Bussea occidentalis* | C | 3 | 60 | 10.44 | 2.13 | 1.00 | 0.35 | 0.13 | 0.13 | 0.02 | 0.00 | 0.02 | 0.00 | 0.00 | 3.79 | 0.05 |
| *Calpocalyx aubrevillei* | C | 3 | 60 | 26.54 | 6.29 | 4.27 | 0.98 | 0.55 | 0.53 | 0.35 | 0.07 | 0.10 | 0.00 | 0.27 | 13.42 | 0.80 |
| *Canarium schweinfurthii* | A | 2 | 80 | 2.00 | 0.87 | 0.17 | 0.16 | 0.05 | 0.05 | 0.02 | 0.00 | 0.05 | 0.00 | 0.08 | 1.45 | 0.13 |
| *Ceiba pentandra* | A | 3 | 90 | 0.00 | 0.16 | 0.00 | 0.16 | 0.05 | 0.02 | 0.00 | 0.02 | 0.00 | 0.00 | 0.05 | 0.47 | 0.05 |
| *Celtis sp.* | C | 3 | 60 | 3.97 | 0.66 | 0.17 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.85 | 0.00 |

| Species parameters | | | | Initial harvest stocks: N/ha according NFI selection | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scientific name | FDA Class | Group | DCL [cm] | < 10.0 cm | 10-19.9 cm | 20-29.9 cm | 30-39.9 cm | 40-49.9 cm | 50-59.9 cm | 60-69.9 cm | 70-79.9 cm | 80-89.9 cm | 90-99.9 cm | ≥ 100.0 cm | **N/ha ≥ 10.0 cm** [/ha] | **N/ha ≥ DCL** [/ha] |
| *Chidlowia sanguinea* | C | 3 | 60 | 1.97 | 0.51 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.51 | 0.00 |
| *Chrysophyllum africanum* | B | 3 | 60 | 2.00 | 0.84 | 0.16 | 0.00 | 0.02 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.05 | 0.00 |
| *Chrysophyllum albidum* | B | 3 | 60 | 6.18 | 0.81 | 0.65 | 0.33 | 0.15 | 0.12 | 0.05 | 0.00 | 0.00 | 0.02 | 0.02 | 2.17 | 0.10 |
| *Chrysophyllum giganteum* | B | 3 | 60 | 1.98 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.02** | 0.00 |
| *Chrysophyllum perpulchrum* | B | 3 | 60 | 2.25 | 0.82 | 0.36 | 0.33 | 0.13 | 0.07 | 0.03 | 0.08 | 0.00 | 0.05 | 0.11 | 1.98 | 0.27 |
| *Chrysophyllum splendens* | B | 3 | 60 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.02** | 0.00 |
| *Chrysophyllum subnudum* | B | 3 | 60 | 0.00 | 0.17 | 0.18 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.37 | 0.03 |
| *Coula edulis* | C | 3 | 60 | 11.83 | 2.60 | 0.81 | 0.89 | 0.29 | 0.23 | 0.05 | 0.00 | 0.03 | 0.02 | 0.00 | 4.92 | 0.10 |
| *Cryptosepalum tetraphyllum* | C | 3 | 60 | 7.23 | 0.00 | 0.36 | 0.00 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.43 | 0.00 |
| *Cynometra ananta* | B | 1 | 60 | 9.90 | 0.33 | 0.16 | 0.00 | 0.12 | 0.28 | 0.10 | 0.07 | 0.02 | 0.08 | 0.28 | 1.44 | 0.55 |
| *Dacryodes klaineana* | C | 3 | 60 | 23.00 | 3.34 | 0.98 | 0.66 | 0.18 | 0.12 | 0.05 | 0.07 | 0.03 | 0.00 | 0.00 | 5.44 | 0.15 |
| *Daniellia thurifera* | B | 3 | 70 | 3.96 | 0.49 | 0.00 | 0.16 | 0.10 | 0.07 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.87 | 0.00 |
| *Dialium aubrevillei* | C | 3 | 60 | 14.44 | 2.33 | 1.88 | 1.57 | 0.49 | 0.12 | 0.17 | 0.27 | 0.02 | 0.00 | 0.17 | 7.04 | 0.64 |
| *Didelotia idae* | B | 1 | 60 | 7.99 | 0.49 | 0.82 | 0.33 | 0.02 | 0.12 | 0.10 | 0.05 | 0.05 | 0.10 | 0.15 | 2.22 | 0.44 |
| *Diospyros sanza-minika* | C | 3 | 60 | 37.34 | 10.43 | 3.27 | 1.47 | 0.08 | 0.07 | 0.00 | 0.12 | 0.02 | 0.02 | 0.07 | 15.56 | 0.24 |
| *Distemonanthus benthamianus* | A | 3 | 80 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.02 | 0.00 | 0.00 | 0.05 | 0.10 | 0.05 |
| *Entandrophragma angolense* | A | 3 | 90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.03 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.07 | 0.00 |
| *Entandrophragma cylindricum* | A | 3 | 90 | 0.00 | 0.16 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.18 | 0.00 |
| *Erythrophleum sp.* | B | 2 | 80 | 0.00 | 0.81 | 0.81 | 0.16 | 0.10 | 0.15 | 0.12 | 0.10 | 0.07 | 0.02 | 0.12 | 2.48 | 0.22 |
| *Erythroxylum mannii* | C | 3 | 60 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.03 | 0.02 | 0.00 | 0.07 | 0.05 |
| *Gilbertiodendron preussii* | A | 1 | 60 | 18.66 | 4.78 | 1.83 | 2.30 | 0.20 | 0.59 | 0.32 | 0.08 | 0.05 | 0.02 | 0.67 | 10.83 | 1.14 |
| *Gluema ivorensis* | C | 3 | 60 | 4.05 | 0.00 | 0.16 | 0.33 | 0.22 | 0.13 | 0.02 | 0.05 | 0.00 | 0.00 | 0.05 | 0.96 | 0.12 |

| Species parameters | | | | Initial harvest stocks: N/ha according NFI selection | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scientific name | FDA Class | Group | DCL [cm] | < 10.0 cm | 10-19.9 cm | 20-29.9 cm | 30-39.9 cm | 40-49.9 cm | 50-59.9 cm | 60-69.9 cm | 70-79.9 cm | 80-89.9 cm | 90-99.9 cm | ≥ 100.0 cm | **N/ha ≥ 10.0 cm** [/ha] | **N/ha ≥ DCL** [/ha] |
| *Guarea cedrata* | A | 3 | 80 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.02 | 0.05 | 0.02 |
| *Guibourtia ehie* | A | 3 | 60 | 1.98 | 0.32 | 0.49 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.81 | 0.00 |
| *Hallea ciliata* | A | 2 | 60 | 13.97 | 0.32 | 1.13 | 0.00 | 0.00 | 0.00 | 0.10 | 0.05 | 0.02 | 0.05 | 0.03 | 1.70 | 0.24 |
| *Haplormosia monophylla* | B | 3 | 60 | 0.00 | 0.00 | 0.00 | 0.38 | 0.00 | 0.00 | 0.06 | 0.06 | 0.00 | 0.03 | 0.00 | 0.52 | 0.15 |
| *Irvingia gabonensis* | C | 3 | 60 | 0.00 | 0.16 | 0.00 | 0.00 | 0.02 | 0.05 | 0.05 | 0.02 | 0.00 | 0.00 | 0.05 | 0.37 | 0.13 |
| *Khaya ivorensis* | A | 3 | 70 | 0.00 | 0.00 | 0.17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.17 | 0.00 |
| *Klainedoxa gabonensis* | C | 2 | 60 | 2.01 | 0.17 | 0.33 | 0.00 | 0.15 | 0.07 | 0.02 | 0.07 | 0.05 | 0.05 | 0.05 | 0.97 | 0.25 |
| *Lophira alata* | A | 1 | 80 | 1.98 | 1.27 | 0.52 | 0.32 | 0.05 | 0.15 | 0.03 | 0.05 | 0.08 | 0.07 | 0.49 | 3.03 | 0.64 |
| *Lovoa trichilioides* | A | 2 | 70 | 0.00 | 0.16 | 0.00 | 0.16 | 0.03 | 0.02 | 0.07 | 0.03 | 0.02 | 0.03 | 0.02 | 0.55 | 0.10 |
| *Mammea africana* | B | 3 | 60 | 7.96 | 2.21 | 1.16 | 0.16 | 0.11 | 0.14 | 0.02 | 0.00 | 0.00 | 0.02 | 0.08 | 3.91 | 0.13 |
| *Manilkara obovata* | C | 3 | 60 | 6.22 | 0.68 | 0.00 | 0.20 | 0.03 | 0.00 | 0.00 | 0.03 | 0.03 | 0.00 | 0.00 | 0.96 | 0.05 |
| *Mansonia altissima* | B | 3 | 60 | 2.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.00** | 0.00 |
| *Milicia sp.* | A | 2 | 80 | 2.00 | 0.50 | 0.66 | 0.16 | 0.10 | 0.03 | 0.00 | 0.00 | 0.05 | 0.00 | 0.02 | 1.53 | 0.08 |
| *Nauclea diderrichii* | A | 2 | 80 | 1.98 | 0.50 | 0.50 | 0.00 | 0.05 | 0.07 | 0.07 | 0.02 | 0.00 | 0.02 | 0.02 | 1.27 | 0.05 |
| *Nesogordonia papaverifera* | B | 3 | 60 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.05 | 0.02 |
| *Newtonia aubrevillei* | C | 3 | 60 | 6.93 | 0.32 | 0.66 | 0.17 | 0.10 | 0.05 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 1.42 | 0.12 |
| *Oldfieldia africana* | B | 2 | 60 | 1.98 | 0.32 | 0.16 | 0.16 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.75 | 0.05 |
| *Ongokea gore* | C | 3 | 60 | 2.04 | 0.83 | 0.00 | 0.17 | 0.02 | 0.02 | 0.03 | 0.03 | 0.00 | 0.00 | 0.03 | 1.13 | 0.08 |
| *Parinari excelsa* | C | 1 | 60 | 13.86 | 2.81 | 1.16 | 1.00 | 0.45 | 0.31 | 0.23 | 0.11 | 0.07 | 0.10 | 0.51 | 6.75 | 1.02 |
| *Parkia bicolor* | C | 3 | 60 | 4.14 | 1.88 | 0.17 | 0.32 | 0.53 | 0.35 | 0.31 | 0.10 | 0.15 | 0.13 | 0.15 | 4.09 | 0.84 |
| *Pentaclethra macrophylla* | C | 3 | 60 | 8.57 | 1.16 | 0.34 | 0.16 | 0.12 | 0.19 | 0.13 | 0.13 | 0.05 | 0.03 | 0.05 | 2.36 | 0.39 |
| *Pentadesma butyracea* | C | 3 | 60 | 3.94 | 1.31 | 0.66 | 0.87 | 0.31 | 0.12 | 0.00 | 0.00 | 0.03 | 0.00 | 0.07 | 3.37 | 0.10 |
| *Pericopsis elata* | B | 3 | 60 | 0.00 | 0.59 | 0.00 | 0.20 | 0.06 | 0.02 | 0.00 | 0.00 | 0.05 | 0.00 | 0.03 | 0.95 | 0.08 |
| *Piptadeniastrum africanum* | A | 1 | 80 | 4.08 | 0.16 | 0.49 | 0.99 | 0.10 | 0.18 | 0.15 | 0.08 | 0.17 | 0.27 | 0.90 | 3.49 | 1.35 |
| *Pterygota macrocarpa* | B | 3 | 60 | 0.00 | 0.16 | 0.16 | 0.16 | 0.05 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.59 | 0.00 |

| Species parameters | | | | Initial harvest stocks: N/ha according NFI selection | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scientific name | FDA Class | Group | DCL [cm] | < 10.0 cm | 10-19.9 cm | 20-29.9 cm | 30-39.9 cm | 40-49.9 cm | 50-59.9 cm | 60-69.9 cm | 70-79.9 cm | 80-89.9 cm | 90-99.9 cm | ≥ 100.0 cm | **N/ha ≥ 10.0 cm** [/ha] | **N/ha ≥ DCL** [/ha] |
| *Pycnanthus angolensis* | B | 3 | 70 | 6.16 | 0.55 | 0.16 | 0.65 | 0.16 | 0.10 | 0.02 | 0.00 | 0.02 | 0.00 | 0.20 | 1.85 | 0.22 |
| *Quassia undulata* | C | 3 | 60 | 0.00 | 2.02 | 0.54 | 0.00 | 0.05 | 0.05 | 0.00 | 0.00 | 0.02 | 0.02 | 0.10 | 2.81 | 0.15 |
| *Ricinodendron heudelotii* | C | 3 | 60 | 0.00 | 0.16 | 0.16 | 0.25 | 0.06 | 0.05 | 0.07 | 0.00 | 0.00 | 0.00 | 0.02 | 0.79 | 0.10 |
| *Sacoglottis gabonensis* | B | 3 | 70 | 0.00 | 0.33 | 0.32 | 0.81 | 0.15 | 0.07 | 0.10 | 0.07 | 0.20 | 0.07 | 0.44 | 2.57 | 0.79 |
| *Samanea dinklagei* | C | 3 | 60 | 0.00 | 0.16 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.21 | 0.03 |
| *Strombosia glaucescens* | C | 3 | 60 | 8.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.00** | 0.00 |
| *Symphonia globulifera* | C | 3 | 60 | 5.98 | 1.63 | 0.48 | 0.00 | 0.10 | 0.02 | 0.00 | 0.02 | 0.00 | 0.02 | 0.02 | 2.30 | 0.07 |
| *Synsepalum afzelii* | C | 3 | 60 | 10.72 | 0.33 | 0.16 | 0.00 | 0.00 | 0.00 | 0.05 | 0.02 | 0.00 | 0.00 | 0.00 | 0.56 | 0.07 |
| *Synsepalum brevipes* | C | 3 | 60 | 3.94 | 0.34 | 0.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.52 | 0.00 |
| *Tarrietia utilis* | A | 1 | 60 | 14.06 | 2.66 | 1.16 | 1.34 | 0.66 | 0.42 | 0.26 | 0.23 | 0.03 | 0.02 | 0.45 | 7.23 | 1.00 |
| *Terminalia ivorensis* | A | 3 | 70 | 0.00 | 0.16 | 0.32 | 0.00 | 0.07 | 0.07 | 0.05 | 0.02 | 0.05 | 0.05 | 0.05 | 0.86 | 0.17 |
| *Terminalia superba* | A | 3 | 70 | 0.00 | 0.16 | 0.16 | 0.00 | 0.00 | 0.00 | 0.10 | 0.05 | 0.00 | 0.00 | 0.00 | 0.47 | 0.05 |
| *Tetraberlinia tubmaniana* | A | 1 | 60 | 33.23 | 5.09 | 0.97 | 0.99 | 0.60 | 0.37 | 0.36 | 0.17 | 0.07 | 0.10 | 0.69 | 9.40 | 1.39 |
| *Triplochiton scleroxylon* | A | 3 | 90 | 0.00 | 0.00 | 0.00 | 0.16 | 0.00 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.21 | 0.00 |
| *Turraeanthus africanus* | B | 3 | 80 | 9.89 | 0.98 | 0.32 | 0.16 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.49 | 0.00 |
| *Uapaca guineensis* | C | 3 | 60 | 30.32 | 4.26 | 1.62 | 1.94 | 0.88 | 0.38 | 0.40 | 0.12 | 0.08 | 0.05 | 0.08 | 9.80 | 0.73 |
| *Vepris tabouensis* | C | 3 | 60 | 0.00 | 0.32 | 0.16 | 0.33 | 0.00 | 0.03 | 0.02 | 0.02 | 0.00 | 0.06 | 0.00 | 0.95 | 0.11 |
| *Xylia evansii* | C | 3 | 60 | 0.00 | 0.17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.17 | 0.00 |
| *Xylopia aethiopica* | C | 3 | 60 | 9.99 | 7.03 | 2.32 | 0.65 | 0.22 | 0.05 | 0.12 | 0.07 | 0.10 | 0.02 | 0.10 | 10.69 | 0.41 |
| *Zanthoxylum gilletii* | C | 3 | 60 | 6.71 | 1.46 | 0.49 | 0.00 | 0.05 | 0.02 | 0.02 | 0.02 | 0.00 | 0.00 | 0.02 | 2.10 | 0.07 |

## 6.3 Recovery rate (Re%) according to DCL and cutting cycle

***Didelotia idae***

| **DCL** [cm] | **Cutting cycle** [years] | | | | | | |
|---|---|---|---|---|---|---|---|
| | **20** | **25** | **30** | **35** | **40** | **45** | **50** |
| **60** | 28.3% | 28.0% | 27.6% | 27.2% | 26.8% | 37.0% | 46.1% |
| **70** | 28.9% | 34.3% | 39.1% | 43.4% | 47.2% | 46.0% | 44.8% |
| **80** | 19.2% | 24.6% | 29.4% | 33.8% | 37.6% | 42.2% | 46.4% |
| **90** | 21.9% | 24.6% | 27.0% | 29.0% | 30.9% | 35.6% | 39.8% |
| **100** | 6.0% | 62.1% | 65.0% | 67.5% | 69.6% | 71.3% | 72.7% |

***Gilbertiodendron preussii***

| **DCL** [cm] | **Cutting cycle** [years] | | | | | | |
|---|---|---|---|---|---|---|---|
| | **20** | **25** | **30** | **35** | **40** | **45** | **50** |
| **60** | 14.1% | 15.4% | 16.5% | 17.4% | 18.2% | 18.9% | 19.5% |
| **70** | 12.2% | 13.0% | 13.8% | 14.4% | 15.0% | 15.5% | 15.8% |
| **80** | 7.6% | 7.6% | 7.6% | 7.6% | 7.6% | 7.5% | 7.4% |
| **90** | 7.1% | 7.0% | 6.9% | 6.8% | 6.7% | 6.6% | 6.5% |
| **100** | 6.6% | 6.4% | 6.2% | 6.0% | 5.8% | 5.7% | 5.5% |

***Lophira alata***

| **DCL** [cm] | **Cutting cycle** [years] | | | | | | |
|---|---|---|---|---|---|---|---|
| | **20** | **25** | **30** | **35** | **40** | **45** | **50** |
| **60** | 21.4% | 22.7% | 22.8% | 22.9% | 22.8% | 23.3% | 28.1% |
| **70** | 9.0% | 11.0% | 14.1% | 16.9% | 19.4% | 21.3% | 21.3% |
| **80** | 11.5% | 11.9% | 12.1% | 12.2% | 12.3% | 12.6% | 15.2% |
| **90** | 15.7% | 16.7% | 17.3% | 17.8% | 18.2% | 18.5% | 18.3% |
| **100** | 16.7% | 18.5% | 20.1% | 21.5% | 22.7% | 23.7% | 23.9% |

***Piptadeniastrum africanum***

| **DCL** [cm] | **Cutting cycle** [years] | | | | | | |
|---|---|---|---|---|---|---|---|
| | **20** | **25** | **30** | **35** | **40** | **45** | **50** |
| **60** | 13.1% | 14.2% | 14.4% | 14.5% | 14.6% | 14.7% | 14.7% |
| **70** | 12.5% | 13.5% | 14.6% | 15.6% | 16.4% | 17.1% | 17.8% |
| **80** | 9.9% | 10.4% | 11.4% | 12.4% | 13.2% | 13.9% | 14.5% |
| **90** | 15.3% | 16.7% | 16.9% | 17.1% | 17.2% | 17.2% | 17.2% |
| **100** | 25.2% | 28.6% | 29.9% | 31.1% | 32.0% | 32.8% | 33.4% |

***Canarium schweinfurthii***

| **DCL** [cm] | **Cutting cycle** [years] | | | | | | |
|---|---|---|---|---|---|---|---|
| | **20** | **25** | **30** | **35** | **40** | **45** | **50** |
| **60** | 32.0% | 37.2% | 41.8% | 45.8% | 49.3% | 63.4% | 76.0% |
| **70** | 21.1% | 27.4% | 33.1% | 38.1% | 42.6% | 47.1% | 51.0% |
| **80** | 6.0% | 9.3% | 12.2% | 14.9% | 17.2% | 22.4% | 27.1% |
| **90** | 59.2% | 56.3% | 53.5% | 50.9% | 48.4% | 51.0% | 53.1% |
| **100** | 6.0% | 18.3% | 29.5% | 39.5% | 48.4% | 46.1% | 43.8% |

***Hallea ciliata***

| DCL [cm] | Cutting cycle [years] | | | | | | |
|---|---|---|---|---|---|---|---|
| | **20** | **25** | **30** | **35** | **40** | **45** | **50** |
| **60** | 6.0% | 5.7% | 5.4% | 5.1% | 4.9% | 4.6% | 4.4% |
| **70** | 58.6% | 55.7% | 53.0% | 50.4% | 47.9% | 45.5% | 43.3% |
| **80** | 45.7% | 62.2% | 77.0% | 90.1% | 101.8% | 96.8% | 92.1% |
| **90** | 32.4% | 43.3% | 53.2% | 61.9% | 69.7% | 86.7% | 101.9% |
| **100** | 6.0% | 170.6% | 179.7% | 187.6% | 194.2% | 214.9% | 233.0% |

***Milicia sp.***

| DCL [cm] | Cutting cycle [years] | | | | | | |
|---|---|---|---|---|---|---|---|
| | **20** | **25** | **30** | **35** | **40** | **45** | **50** |
| **60** | 43.2% | 68.7% | 91.7% | 112.2% | 141.6% | 171.9% | 198.8% |
| **70** | 8.6% | 15.2% | 21.0% | 26.3% | 44.0% | 64.5% | 82.8% |
| **80** | 6.0% | 5.7% | 5.4% | 5.1% | 9.2% | 14.5% | 19.2% |
| **90** | 170.4% | 162.1% | 154.1% | 146.6% | 139.4% | 132.5% | 126.0% |
| **100** | 22.4% | 64.3% | 102.1% | 135.9% | 139.4% | 132.5% | 126.0% |

***Pycnanthus angolensis***

| DCL [cm] | Cutting cycle [years] | | | | | | |
|---|---|---|---|---|---|---|---|
| | **20** | **25** | **30** | **35** | **40** | **45** | **50** |
| **60** | 28.7% | 32.6% | 37.0% | 42.7% | 47.8% | 52.3% | 56.2% |
| **70** | 12.1% | 12.9% | 14.9% | 19.6% | 23.8% | 27.5% | 30.8% |
| **80** | 6.0% | 5.7% | 5.8% | 6.8% | 7.7% | 8.6% | 9.3% |
| **90** | 13.0% | 14.0% | 14.5% | 13.8% | 13.1% | 12.4% | 11.8% |
| **100** | 6.0% | 5.7% | 5.9% | 7.1% | 8.2% | 9.1% | 10.0% |

***Quassia undulata***

| DCL [cm] | Cutting cycle [years] | | | | | | |
|---|---|---|---|---|---|---|---|
| | **20** | **25** | **30** | **35** | **40** | **45** | **50** |
| **60** | 32.8% | 37.4% | 41.6% | 45.2% | 48.4% | 46.1% | 43.8% |
| **70** | 6.0% | 12.0% | 17.5% | 22.4% | 26.8% | 30.6% | 34.0% |
| **80** | 6.0% | 5.7% | 5.4% | 5.1% | 4.9% | 9.9% | 14.3% |
| **90** | 21.6% | 20.6% | 19.6% | 18.6% | 17.7% | 16.8% | 16.0% |
| **100** | 6.0% | 29.4% | 32.4% | 35.0% | 37.3% | 35.5% | 33.7% |

***Sacoglottis gabonensis***

| DCL [cm] | Cutting cycle [years] | | | | | | |
|---|---|---|---|---|---|---|---|
| | **20** | **25** | **30** | **35** | **40** | **45** | **50** |
| **60** | 12.5% | 15.0% | 17.3% | 19.4% | 21.2% | 34.1% | 45.7% |
| **70** | 16.3% | 17.3% | 18.1% | 18.8% | 19.4% | 21.4% | 23.1% |
| **80** | 14.3% | 16.3% | 18.1% | 19.7% | 21.0% | 21.6% | 22.0% |
| **90** | 36.6% | 37.5% | 38.3% | 38.9% | 39.3% | 40.5% | 41.4% |
| **100** | 6.0% | 27.0% | 33.8% | 39.8% | 45.2% | 45.6% | 45.8% |

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## 6.6 List of people met

**FDA**

Mr Joseph TALLY, Deputy Managing Director for Operations

Mr Jerry G. YONMAH, Technical Director, Commercial Forestry Department

Mr Edward KAMARA, Manager, Forest Products Marketing and Revenue Forecast Division, Commercial Forestry Department

Mr Philipp JOEKOLO, Manager, National Authorizing Division, Commercial Forestry Department

Mr Isaac NYANEYON KANNAH, MRV Consultant for REDD+ Implementation Unit

**Delegation of the European Union to Liberia**

Mr David PALACIOS, Programme Manager Forestry, Environment & Natural Resources

**VPA-SU2**

Mr Abraham GUILLEN, Team Leader

Mr Wolfgang THOMA, Forestry Advisor

Mr Shiv PANSE, FLEGT Licensing and Verification Advisor

## 6.7 Terms of Reference

| | |
|---|---|
| Project | Long Term Technical Assistance for the implementation of the Voluntary Partnership Agreement (VPA) in Liberia - Service Contract FED/2019/405-854 **(VPA-SU2)** |
| Role | **Senior Non-Key Expert (NKE) Assessment of Long-Term Sustainability of Forest Operations in Commercial Forests** |
| Start/ end date | March – April 2020 |
| Inputs | 15 working days |
| Travel | Domestic travel within Liberia may be required. Per Diem while in Liberia and international travel from/to home base of consultant |
| Supervision | Reporting to the Key Expert 2 - Forestry Advisor |
| Location | Primarily Monrovia, Liberia |

# 1. PROGRAM BACKGROUND

In 2013, the Government of Liberia and the EU entered a Forest Law Enforcement, Governance and Trade Voluntary Partnership Agreement (FLEGT-VPA). Liberia committed to strengthen its governance system and ensure that all timber produced is legal. The EU, the UK and other donors supported Liberia to reach this goal, as part of a wider program of support for forest reform.

Since the adoption of the National Forestry Reform Law (NFRL) and the lifting of the United Nations Security Council sanctions on Liberian timber in 2006, commercial forest operations have resumed in logging concessions under Forest Management Contracts (FMC) and, following the adoption in 2009 of the Community Rights Law (CRL) with respect to forest lands, in forests under Community Forest Management Agreements (CFMA) through commercial use contracts entered by Authorized Forest Communities (AFC) with logging companies pre-qualified by FDA.

Recently acquired data on the extent and condition of the forest resources, particularly (i) the 2014 land cover and forest map prepared by Metria and GeoVille and (ii) the National Forest Inventory (NFI) carried out from 2018 to 2019 with technical assistance by FAO, both funded by the Forest Carbon Partnership Facility (FCPF) for advancing Liberia's REDD+ readiness, provide a basis to assess the long-term sustainability of the commercial forest operations as aimed by the 2007 National Forest Management Strategy.

# 2. OBJECTIVE(S), EXPECTED DELIVERABLE(S) AND DEADLINE(S) OF THE ASSIGNMENT

## a. Objective(s) of the assignment

The objective of this short-term consultancy under NKE is to assist the VPA-SU2 in assessing the long-term sustainability of forest operations in "*commercial forests*" (natural forests available for commercial timber production) through the modelling over one cutting cycle of 25 years of the development of the average stand structure and composition under a Business As Usual (BAU) scenario (i.e. following the Guidelines for Forest Management Planning in Liberia of 2009), firstly without deforestation and secondly with deforestation. On one hand, this consultancy builds upon the results of the earlier TAF-S4 NKE short-term consultancy tasked with the delineation of the "*commercial forests*" based on the 2014 land cover and forest map and with the assessment of the deforestation rate / trend. On the other hand, this consultancy relies on the baseline of the "*commercial forests*" conditions, i.e. the stand and stock tables by species and by diameter classes in terms of number of live trees per hectare (N/ha), of basal area of live trees per hectare (G/ha) and of volume of live trees per hectare (V/ha) prevailing in the "*commercial forests*", including estimates of the total means, coefficients of variation (s%) and margins of error (E%) at 95% confidence level, in MS Excel format as illustrated below, based on the National Forest Inventory (NFI) carried out by FDA from 2018 to 2019 with technical assistance by FAO, funded by the Forest Carbon Partnership Facility (FCPF) for advancing Liberia's REDD+ readiness, pledged by FAO. Together, these two consultancies provide the elements needed to meet the contractual requirement stated in Result Area 1, Output 1.6 "Forest management plans and elements for long-term sustainability of forest operations".

Structure of the stand and stock tables pledged by FAO based on the 2018 - 2019 NFI data:

| | Diameter Classes | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Species** | **2 - 9 cm** | **10 - 19 cm** | **.....** | **.....** | **.....** | **140 - 149 cm** | **>= 150 cm** | **Total** |
| *Acridocarpus plagiopterus* | | | | | | | | |
| ..... | | | | | | | | |
| ..... | | | | | | | | |
| ..... | | | | | | | | |
| *Zanthoxylum viride* | | | | | | | | |
| Unknown | | | | | | | | |
| **Total** | | | | | | | | |
| | | | | | | | | |
| Number of PSUs | | | | | | | | |
| Mean | | | | | | | | |
| Coefficient of variation | | | | | | | | |
| Margin of error* | | | | | | | | |
| *95% confidence level | | | | | | | | |

## b. Expected output(s)

Expected outputs are:

a) MS Excel - based model of the development over one cutting cycle of 25 years of the average stand structure and composition of the "*commercial forests*" under a BAU scenario, without and with deforestation.

b) Assessment of the changes of the "*commercial forests*" conditions over one cutting cycle in terms of the stand structure (number of trees per hectare [N/ha], basal area of trees per hectare [G/ha] and volume of trees per hectare [V/ha] by diameter classes) and of the species composition from the perspective of the long-term sustainability of the forest operations.

c) Examination of the potential impact on the long-term sustainability of adjustments to the cutting cycle, to the diameter limits and to the cutting intensity.

d) Recommendations towards the long-term sustainability of forest operations in "*commercial forests*".

### c. Reporting

Consultant to submit the following:

d. MS Excel - based model of the development over one cutting cycle of the "*commercial forests*" under a BAU scenario, without and with deforestation.

e. Report describing the methodology, data sources and hypotheses used, the results obtained as well as the difficulties / constraints encountered in the assessment of the long-term sustainability of forest operations in "*commercial forests*" through the modelling, and proposing recommendations to improve the long-term sustainability.

f. PowerPoint presentation summarizing the methodology and the main findings.

## 3. ASSUMPTIONS AND RISKS

### a. Assumption underlying the project intervention

The results of the foregoing TAF -S4 NKE short-term consultancy and the stand and stock tables to be computed by FAO on the basis of the NFI data are available.

### b. Risks

Not receiving timely, the results of the foregoing TAF -S4 NKE short-term consultancy and the stand and stock tables to be computed by FAO on the basis of the NFI data could delay or impede the completion of the TOR.

## 4. ACTIVITIES

See table below for Activities related to level of effort.

## 5. LOGISTICS AND TIMING

The consultancy to start not later than 1st March 2020 for a total of 15 working days. Mission will take place in Monrovia, Liberia.

### a. Tentative agenda

| | | | Expert 1 | |
|---|---|---|---|---|
| Date | Activity | Location | Man-day | Per diem (up to) |
| March 2020 | Acquire all needed data. | Monrovia | 1 | |
| | Build a MS Excel - based model of the development over one cutting cycle of the | | 2 | |

| | | | | |
|---|---|---|---|---|
| | "*commercial forests*" under a BAU scenario, without and with deforestation. | | | |
| | Assess the changes of the "*commercial forests*" conditions over one cutting cycle from the perspective of the long-term sustainability of the forest operations. | | 3 | |
| | Examine the potential impact on the long-term sustainability of adjustments to the cutting cycle, to the diameter limits and to the cutting intensity. | | 3 | |
| | Propose recommendations towards the long-term sustainability of forest operations in "*commercial forests*". | | 2 | |
| | Draft the first version of the report and a summary PowerPoint presentation. | | 2 | |
| | Present and discuss the findings. | | 1 | |
| | Prepare the final version of the report and of the summary PowerPoint presentation. | | 1 | |
| | | **TOTAL** | **15 days** | **18** |

### b. Additional costs / allowances

The consultant expenses while in country to be covered through Per Diem (see above) under Incidental Expenditure budget. However, consultants already resident at the duty station are not eligible for allowance coverage while in the capital Monrovia. The consultant traveling to be covered under Incidental Expenditure budget.

Up to EUR 1,000 to cover meeting and workshop materials allowance under Incidental Expenditure budget. Expenses must be based on actuals with receipts as proof and for approval. Support for this will be managed through the VPA-SU2 Administrative Manager.

The consultant is authorized to work up to 6 days per week.

## 6. REQUIREMENTS

Minimum requirements

- Qualification and skills: A level of qualifications corresponding to B.Sc. or M.Sc. degree in forestry or in similar / related fields; proficient in MS Word, Excel and PowerPoint, and in report writing.
- Excellent spoken and written English.
- General professional experience: at least 10 years of experience in sustainable forest management.
- Specific professional experience: proficient in the use of MS Excel for modelling purposes.

Preferred requirements (additional assets):

- Experienced with selective timber harvesting approaches in natural forests.