Assessment of Key Biodiversity Areas in the Lofa-Gola-Mano-Nimba complexes (West Africa) using ecosystem criteria

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Assessment of Key Biodiversity Areas in the Lofa-Gola-Mano-Nimba complexes (West Africa) using ecosystem criteria

Final Report

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MISSOURI BOTANICAL GARDEN

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Executive Summary

Introduction

The aim of this report consists in identifying ecosystems of special conservation value in order to review the current Key Biodiversity Areas (KBAs) in the Lofa-Gola-Mano and Nimba complexes (Guinea, Liberia, Sierra Leone, Ivory Coast), using up-to-date international standards (Bland et al. 2015; KBA Standards and Appeals Committee 2019; Rodriguez et al. 2015). It includes the first attempt of Red Listing of Ecosystems done at a regional scale for West Africa as well as the following:

- A compilation of ecosystem data from literature
- A synthetic table of threatened ecosystems
- Descriptive notes for threatened ecosystems, including maps
- Description of each KBA, including a list of threatened ecosystems and an evaluation of KBA parameters based on those ecosystems

Ecosystemology

In this work (see III.1), we illustrate more deeply the ecosystemology approach that we described in Senterre et al. (in review). The work produced recently for Mount Nimba (Senterre et al. 2019a) predates the finalization of the paper (in review) presenting the method in its fullest and, although mostly in agreement with the principles of ecosystemology, it lacks the use of explicit synonymies by defining biotypes for names coming from the literature. This gap has been addressed here and ecosystem species have been named for all the studied KBAs. Illustrations and photographs are available in the annexes of Senterre et al. (2019a).

In addition (see IV.1), we describe here into more details the fundamental differences of our ecosystemology approach compared to the four main global typologies of ecosystem available. We develop this comparison regarding both fundamental concepts and pragmatic implications, detailing the correspondences between ecosystem types recognized.

Then (see IV.2), we further discuss the choice of an ecosystemic resolution level for Red Listing of Ecosystems (RLE) and KBA assessment according to the available international guidelines. We first show that our approach is in line with IUCN guidelines. Then, we provide arguments supporting the consideration of bioclimatic gradients to recognize types of ecosystems even within so-called azonal types (putting the law of the minimum into a broader context, i.e. more relativistic, more integrated across scales). Finally, we discuss briefly on how to integrate biogeography for the recognition of ecosystem species. Nevertheless, more has to be done to compile and integrate biogeography literature from the last 15 years, and to look at these from the angle of ecosystemology (where our approach could bring a contribution to unification of global to local scales, historical and ecological biogeography, biogeography and ecology).

Mapping

In a previous study (Senterre et al. 2019a), which focused on Mount Nimba, we have developed maps of ecosystem groups at the scale of West Africa. Here we extended the landform analysis (topographic wetness, based on TauDEM), that was done for Mount Nimba only, to the whole area covered by the studied KBAs. The combinations of those maps allow integrating various ecosystemic scales and provide information on ecosystem types that are meaningfull categories both locally and globally (see Figure 14: an example for the Massif du Ziama showing a landscape with a high ecosystem diversity).

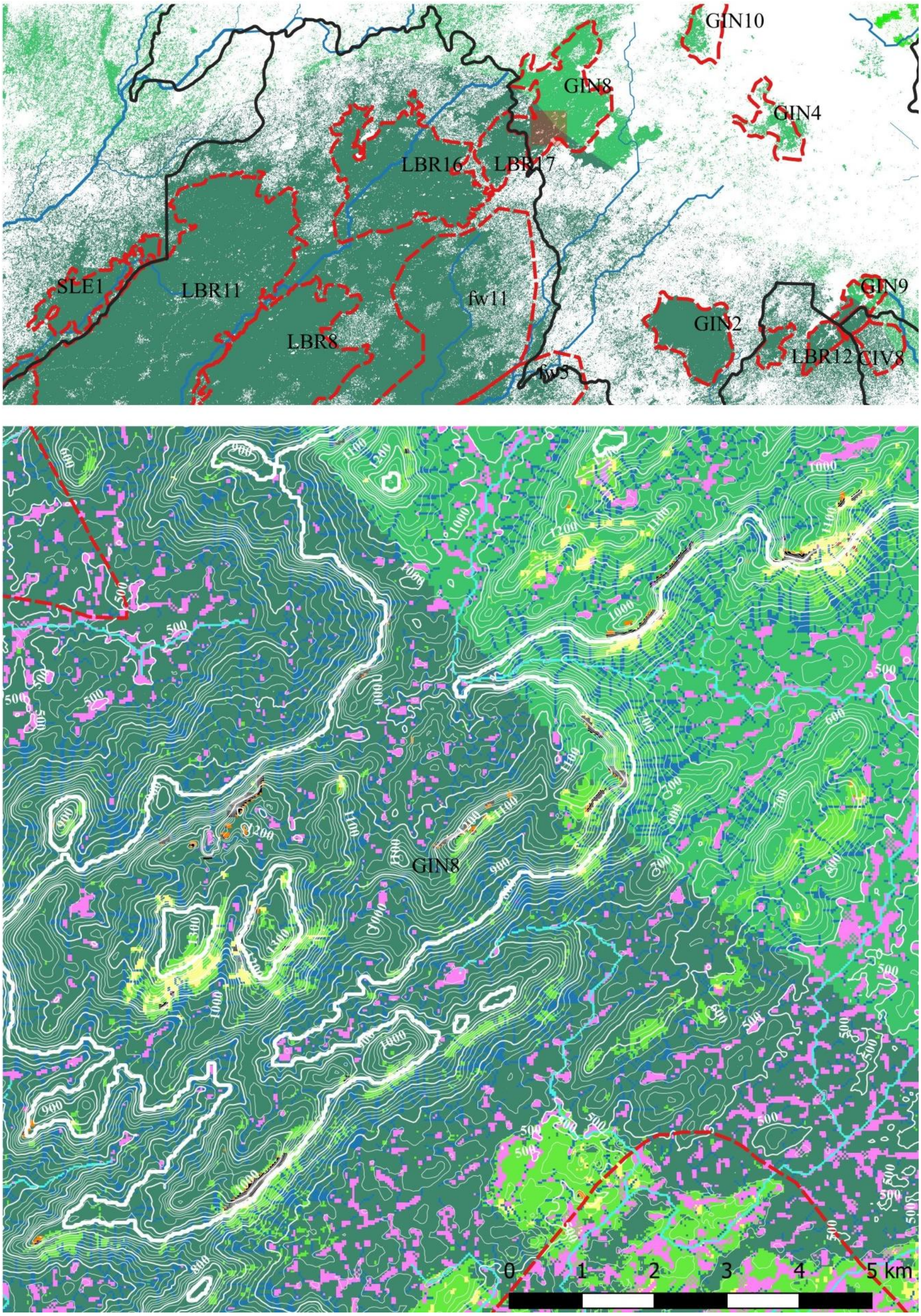

Figure 14. Overview of the stand scale ecosystems mapped for the Ziama (GIN8, Guinea). The complete legend is provided with Figure 9. The zoom area corresponds to the transition zone between the perhumid and humid climatic wetness zones. Granite outcrops are found at all altitudes. Areas mapped as "secondary forests" are either anthropic sites (e.g. in the south-eastern corner) or subsaxicolous dwarf forests (on inselbergs). Our landform analysis even suggests the presence of submontane riparian forests, which would be unique to this site.

Legend:

Top layer: Landform analysis

- 1-Swamp
- 2-Riparian
- 3-Ravine
- 4-Mesic landform (transparent)
- 5-Overdrained
- 6-Cliff
- 7-Waterfall

- Countries
- KBAs
- Altitudinal belt transitions
- Contour lines (100m)
- Contour lines (10m)

Second layer: Dense forests in climax mesic stands under different climatic wetness zones

- 1-Superhumid (Wet sempervirent rainforest)
- 2-Perhumid (Moist sempervirent rainforest)
- 3-Humid (Seasonal/Monsoon moist semi-deciduous rainforest)

Third layer: Land cover class (from EcoStand2019_30m.tif: Senterre et al. 2019a)

- 20-Secondary forest (ESA tree + GLC forest)
- 30-Woodlands, Dry forests (ESA tree + GLC woodlands)
- 40-Shrublands (ESA tree + GLC shrublands OR ESA shrubs)
- 50-Savannas (ESA savannas)
- 81-Swamp forest (ESA wetland + Giri not mangrove + Hansen >=60%)
- 82-Marsh (ESA wetland + Giri not mangrove + Hansen < 60%)
- 91-Mangrove forest (Giri mangrove + Hansen >=60%)
- 92-Mangrove open vegetation (Giri mangrove + Hansen < 60%)
- 100-Water (=ESA + added inland estuaries)
- 111-Anthropic cropland (ESA cropland + HFootprint >12)
- 112-Anthropic land (HFootprint >12)
- 113-Built-up (=ESA)

KBA assessment using ecosystem criteria (A2 & B4)

The KBAs included in the study area have been assessed under criteria A2 and B4, i.e. KBA containing 5% of the global distribution of a CR/EN type of ecosystem, 10% of a VU type of ecosystem or 20% of a type of ecosystem regardless of its threat level (Table 10).

Twenty one KBAs have already been recognized in the study area, which we grouped into 16 units (Table 10). Among them, those with the highest global ecosystem conservation value are the Nimba, the Ziama and the Wologizi KBAs, mostly due to submontane and montane perhumid ecosystems. For lowland perhumid ecosystems, the Lofa-Mano KBA (Liberia) is the most important site. If it could be merged with Kpelle Forest, it would give to the latter access to the status of Global KBA and both would contain nearly 10% of the global distribution of this ecosystem group. Gola and Kambui KBAs have limited value as global KBAs, but have an outstanding conservation value for Sierra Leone. Ecosystems of the lowland humid life zone (considered as EN to CR mostly due to their reduction in distribution, with an historical reduction up to 93%: Senterre et al. 2019a: 66) are poorly represented within the study area, in terms of percentage of the currently remaining global distribution, with several forest blocks remaining mostly in Ghana. Note that considering the extreme fragmentation of this ecosystem group, hardly any KBA alone will likely hold the minimum 5% of global distribution, which is a bit unfortunate. KBAs of Mount Bero, Massif de Man and Pic de Fon are global KBAs mostly thanks to their ecosystems of the submontane and montane humid life zones, but they also include important remains of the lowland humid forest group (together with the northern parts of Ziama and Nimba). Finally, Lake Piso has an outstanding diversity of ecosystems, including several possibly unique and poorly explored.

Table 10. Synthesis of the results proposed for the 21 KBAs grouped into 16 units and assessed here for the first time using the ecosystemic criteria. We propose a few suggestions for ecosystemic exploration priorities.

KBA code	KBA name	Global KBA status under A2 & B4	Exploration priorities
LIB10	Piso	B4([7],[8],[9])	Lowland superhumid mesic and ravine forests of Cape Mount; Coastal rocky shores of Cape Mount; Coastal backshore dunes, savannas and forests (see [7], [8] and [9]); Various types of swamp forests ([27]) especially peat swamps, if existing in the area.
SLE2	Kambui	-	Rupicolous vegetation on subsaxicolous dwarf forests
SLE1	Gola	-	Waterfalls, Inselbergs, Swamps, Ravines
SLE7	Tiwai	-	
LIB11	Lofa-Mano	A2a ([28])	Waterfalls, Inselbergs, Swamps, Ravines
LIB8	Kpelle	-	Could be grouped with Gola-Mano
LIB16	Wologizi	A2a ([41],[42],[74]), B4 ([41])	The few and hardly accessible remains of montane forests of Mount Wuteve having not burn; Large extent of submontane forests East of Mount Wuteve
LIB17	Wonegizi	A2a ([41]), B4 ([58],[68])	Submontane inselbergs
GIN8	Ziama	A2a ([41],[42]), A2b ([44]), B4 ([41],[44])	Riparian forests and swamps mapped in the submontane belt, at the southern limit of the humid climatic wetness zone; Submontane and montane belts of the perhumid and humid zones
GIN10	Fon	A2a ([25],[77],[78]), B4 ([25],[77],[78])	
GIN4	Bero	A2a ([31])	Submontane swamps
CIV7	Man	A2a ([31])	Submontane swamps
GIN9	Nimba	A2a ([42],[75],[84],[29],[41],[74],[20],[26]), A2b ([66]), B4 ([42],[75],[84],[20],[26],[66])	Dwarf forests on overdrained and subsaxicolous stands
LIB12			
CIV14			
CIV8			
LIB15	West Nimba	-	Could be grouped with Liberian Nimba LIB12
GIN2	Diécké	-	
fw4	Saint Paul River	-	
fw5			
fw11			

Acknowledgements

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I. INTRODUCTION

In the hotspot of the Guinean forests of West Africa, the complexes of Lofa-Gola-Mano and of the Nimba Mountains contain some of the last elements of montane Guinean forests and of lowland forests of West Guinea (Brugiere and Kormos 2009; Kouame et al. 2012). Nevertheless, the knowledge on the flora and vegetation of these two complexes remains incomplete and presents significant local differences, a situation exacerbated by the trans-national nature of the complexes.

The Key Biodiversity Areas (KBA) method is an important tool for the identification of conservation priorities. However, the KBA analyses for the two complexes were mainly based on the presence of important fauna and did not include data on flora and ecosystems. Indeed, in light of this incomplete knowledge, it remains impossible to assess whether these KBAs accurately represent the threatened portion of the flora and the ecosystems.

In response to this situation, the CEPF granted in 2019 a project led by the Missouri Botanical Garden, which aims to update the KBA analysis with regard to the threatened components following the IUCN Red List Categories and Criteria for species and ecosystems, within the 21 KBA identified in the Lofa-Gola-Mano and Nimba Mountains complexes.

I.1 Objectives

The aim of this report consists in identifying ecosystems of special conservation value in order to review the current definition of Key Biodiversity Areas in the Lofa-Gola-Mano and Nimba complexes (Guinea, Liberia, Sierra Leone, Ivory Coast), using up-to-date international standards: (Bland et al. 2015; KBA Standards and Appeals Committee 2019; Rodriguez et al. 2015). It includes the first attempt of Red Listing of Ecosystems done at a regional scale for West Africa as well as the following:

- A compilation of ecosystem data from literature
- A synthetic table of threatened ecosystems
- Descriptive notes for threatened ecosystems, including maps
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I.2 Study area

The Main Study Area (Lofa-Gola-Mano and Nimba-Dans complexes) is located in the "Western Guinean lowland forests" and the "Guinean montane forests" ecoregions, reaching to the north the "Guinean forest-savanna mosaic" ecoregion as defined by Olson and Dinerstein (2002: Figure 1; https://ecoregions2017.appspot.com/).

In the Nimba Mountains complex (682,900 ha), 7 KBAs are identified, 2 in Liberia, 2 in Guinea, and 3 in Ivory Coast, for a total of 181,000 ha. The Lofa-Gola-Mano complex is even larger (4,774,500 ha) and contains 14 KBAs, including 8 in Liberia, 3 in Guinea, and 3 in Sierra Leone.

The 21 sites range from the coastal areas of Liberia (Lake Piso) to the drier forest-savannah mosaic at its northernmost site, Pic de Fon. They are representative of the diversity of the landscapes of the region, from lowland forested areas to mountainous savannah. Nevertheless, they are characterized by an important heterogeneity in the availability of biodiversity information, in management procedures, threat levels and local expertise. In Guinea, most of the sites are matching the boundaries of existing protected areas or statutory sites (Biosphere reserves, classified forests, integral reserve), and altogether represent the last remaining patches of forested habitats in the Guinée Forestière region, a situation also noted for Ivory Coast and Sierra Leone (Brugiere and Kormos 2009; Kouame et al. 2012). Guinean sites are notably threatened by mining activities, and small-scale agriculture.

In Liberia, sites do not systematically match the boundaries of protected areas, that are usually smaller in size than the associated KBA. It is notably the case for Gola National Park, a recently designated protected area that only includes a portion of the Lofa-Mano KBA. Some sites are not protected at all, such as the Kpelle Forest (LBR8) or the three freshwater KBAs of St Paul River (fw4, fw7 and fw11). In Liberia, forested habitats have not faced the same level of degradation as in Guinée Forestière, hence forested areas expand beyond the limits of the existing KBAs. In Ivory Coast as well as in Sierra Leone, the KBAs also match protected areas, although effective protection is in place in Sierra Leone, but the KBAs of Ivory Coast face a high level of degradation, especially in the lowland areas.

In light of the high heterogeneity in terms of biodiversity data available among the studied KBAs and in their surrounding landscapes, the inclusion of ecosystem criteria will likely be a key element for a precise evaluation of the global conservation value of those KBAs and for fine tuning of their delineation (outline) using remote sensing and ecosystem modeling data.

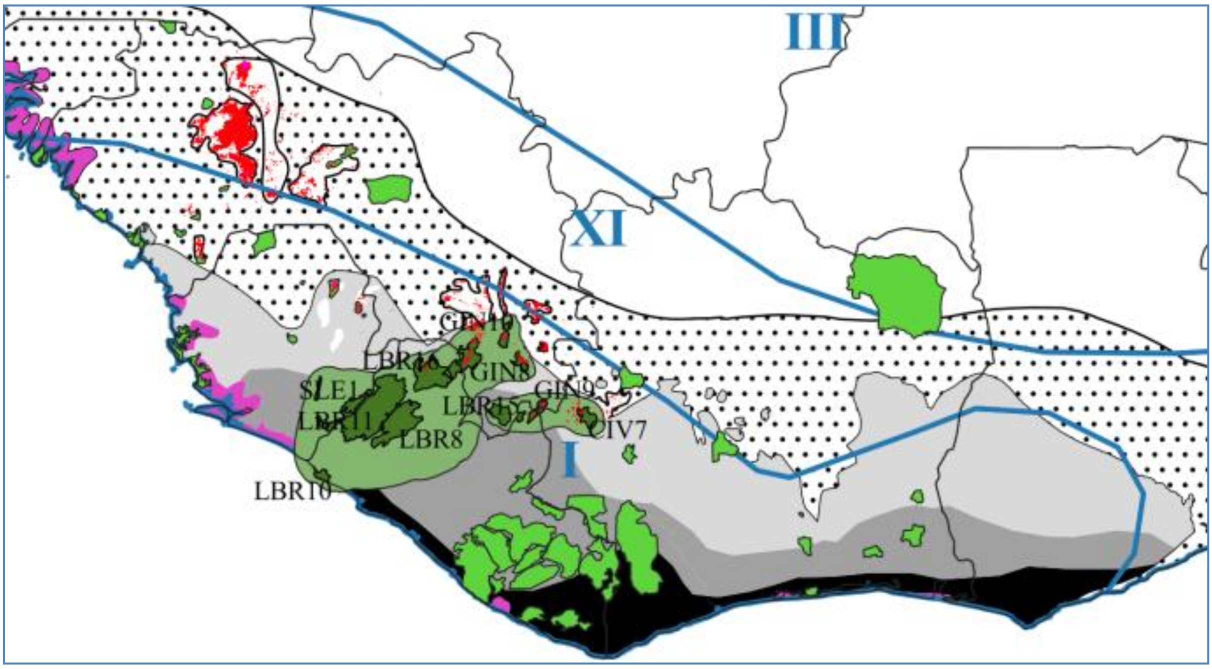


Figure 1. The Lofa-Gola-Mano-Nimba complex and the bioclimatic belts recognized in West Africa by Senterre (Senterre 2005; Senterre et al. 2019a: the black and grey areas). The Guineo-Congolian/Soudanian transition zone (White 1979: XI), or Forest-Savanna Mosaic (Olson and Dinerstein 2002: dotted area), constitutes an anthropic belt almost entirely modified by fire & cultivation (White 1983: 175).

II. METHODS

II.1 Typology and mapping of ecosystems (habitat-types)

II.1.1 Introduction to the main concepts of the approach used

There are abundant vegetation studies and maps for all parts of the world, many of which contain valuable information based on extensive field knowledge. The difficulties involved in developing a habitat typology are not due to the quality or relevance of the available data, but rather the capacity to integrate the results of studies across continents, countries, and sites. In other words, difficulties involve the capacity to identify synonymies in the classes recognized by various authors or to uncover confusion among several entities grouped together on the basis of their flora and the physiognomy of their vegetation. The challenge has to do with the conceptualization of ecosystem types and of developing a common language, without which it is difficult if not impossible to assess ecosystems rarity and threats, and therefore conservation value. In response to these problems, a new approach to the conceptualization of ecosystems was developed by Senterre and Wagner (2014) and further detailed in terms of ecosystem taxonomy by Senterre et al. (in review). This approach is based on the following principles:

- Current (observed) vegetation physiognomy is not a characteristic of a given type of ecosystem but is a character of an individual stand ecosystem at an instant 't'. Therefore the typologies derived from the principles of the Yangambi system cannot be applied to the conceptualization of ecosystem types.
- Plant communities are not discrete entities but entanglements of ecological groups of species (Duvigneaud 1946) which can transgress to different types of environments according to the principle of ecological substitution (Senterre 2005; Figure 2). Plant communities have a species composition fluctuating in time (at a given stand, under a given environmental setting) and space (within the limits of biogeographic areas, reflecting ecological and spatial barriers to species dispersal).
- Regional scale ecosystems are defined based on the concept of life zones (Holdridge 1967), integrating altitudinal belts and local contractions of the bioclimatic gradient due to Foehn or Mass Elevation Effects, excluding any biotic or biogeographic connotation.
- 'Ecosystem genera' are defined by all the possible combinations of stand-scale gradients (edaphic, topographic, lithologic, etc.) and evolutionary gradients (understood as primary series, including disclimaxes, progressive and retrogressive climaxes), excluding any biotic or biogeographic connotation and any bioclimatic factor.
- 'Ecosystem species' are the observed combinations of the life zone (bioclimate), the ecosystem genus (stand-scale type of environment) and biogeographic distinctions (centers of endemism for the ecosystem genus considered), excluding biotic variability linked to secondary series (development) or inter-stand individual variability (stochastic, historic, intra-specific ecosystemic diversity).

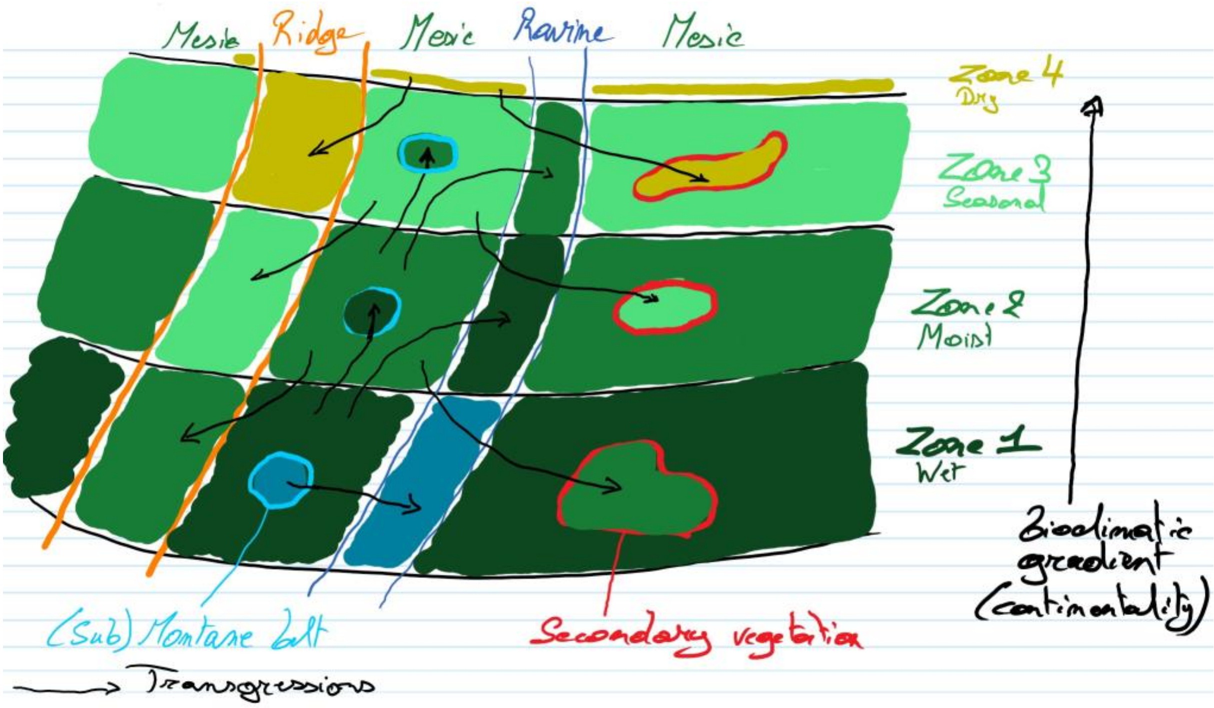


Figure 2. Representation of the ecosystem concept used in this study, based on entanglements of ecological groups of species (represented by the different colors) which are able to transgress between types of ecosystems due to ecological equivalences (e.g. topographic wetness compensating for climatic dryness). Plant communities (phytocoenosia) are therefore not seen as discrete entities, much less deterministic ones, and are characterized by their dominant ecological group. Dry zone species can transgress into the next moister zone of the bioclimatic gradient thanks to secondary series (see also Hawthorne et al. 2010: 34) or topo/edaphically drier stands (e.g. overdrained ridges); and they can transgress even further into moister zones e.g. in situations of pyrophilic disclimaxes (not illustrated). This conceptual model is very useful to interpret 'messy landscapes' (floristically and physiognomically speaking) and can explain many divergences of opinion between researchers regarding bioclimatic zone transitions.

II.1.2 Field data collection

The principles introduced above have the following implications on the field work. Below we explain how we decide where to go to make field observations and what to observe.

Where to go?

Assessing regional gradient(s): The first important thing is to identify the regional ecosystem(s) present within a study area. Whether swamp, mesic or saxicolous stand-scale ecosystems will ultimately be recognized, we need to determine the type of regional ecosystem of which they will be variations. The method consists of studying landscapes from ravines to mesic stands and then to ridges (by walking across the topographic gradients) and doing so in contrasted parts of the study area considering hypothetical climatic gradients, keeping all other ecological factors as constant as possible (e.g. not comparing bowe in zone 1 with granitic outcrops in zone 2).

Exploring major gradients: The objective is to attempt to identify all potential limiting factors within the study area and examine them as independently as possible from one another, e.g. to observe various soil wetness conditions within otherwise similar hydrological conditions (size of water catchment, flushing, seasonality, etc.). It is very important during the field phase to collect GPS data on ecotones for use in the next steps (GIS modeling with threshold values). The interactions of the most important gradients can also be studied if time allows.

Space-for-time substitution (Pickett 1989; Sternberg et al. 2011): Walking the study area extensively is not only important for understanding and describing gradients and their interactions, but also to get a chance to identify and understand gradient-looking (landscape-like) sites, which are in fact not a succession of intrinsically distinct entities but rather time series (series of secondary stands at different developmental stages). As it is not easy to make observations at different points in time, the best solution for the study of vegetation dynamics involves observing different sites that differ 'only' in their development stage.

Consideration of observation cycles: Before, during and after each field observation phase, it is important to combine sources of knowledge (such as literature review and knowledge from local people and local botanists) and review them together in an iterative way. As the main gradients become better understood, it then becomes necessary to use mapping and modeling (with GIS) to identify more sites of interest for field observation in order to refine the understanding of ecosystems. Finally, extensive biotic surveys in vegetation plots are a very important aspect to consider, especially for the most relevant sites identified during exploratory phase.

What to observe?

Wherever a stand (or landscape) is considered potentially interesting with respect to one of the principles detailed above, we make a stand (or landscape) observation point using a newly developed system on Android Smartphone (Senterre et al. in review, 2019b). The data collected include:

- GPS coordinates
- Whether or not the GPS coordinates correspond to an ecotone
- Photos
- Dominant and/or potential indicator species (those with narrow ecological range, after accounting for ecological substitutions). Quantitative plant community inventories (in plots) are very important but should be considered only after the gradient exploratory phase, and such inventories will be time consuming
- Provisional notes, comments, and interpretation of the stand ecology, i.e. potentially diagnostic environmental factors and their intensity (e.g. swampy, sandy, swampy-sandy, etc.). This task can be considerably improved by using the Smartphone survey designed (Senterre et al. in review, 2019b).

Understanding ecosystems in a study area also often involves unrecorded observations, such as those made from a vehicle or between recorded stands. Therefore, it is important to record the exploration paths in order to get an idea of the unexplored areas vs. explored areas without recorded observations. This is done by daily GPS tracking with SWMaps on an Android Smartphone. The personal field knowledge compiled into the current study is illustrated in Figure 3.

During this project, due to the covid situation ongoing since early 2020, only one field trip could be done for the current first author (BS), in place of three originally planned. The field trip was done from mid-September to end of October 2019. It allowed us to collect precious information and field experience over a great diversity of ecosystems in West Africa, by exploring both the Northern and Southern part of the Nimba, the granitic Ziama and the transition from Ziama to Wologizi, all of it within the same time period and season.

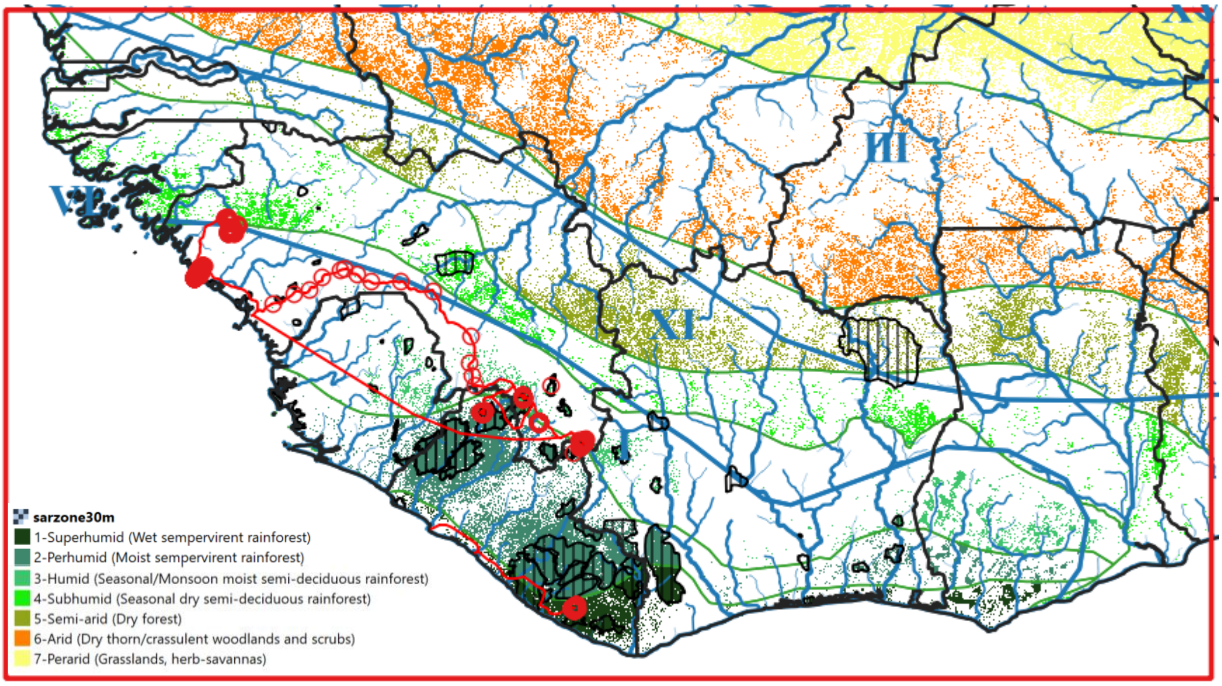


Figure 3. Ecosystemic map according to Senterre et al. (2019a; filtered to show only areas of supposed climax) showing all locations visited by the author in West Africa (from various projects). Red circles = observation sites; Red lines = car and airplane daylight itineraries.

II.1.3 Bibliographic data compilation

The ecosystemic revision intended here, like any taxonomic revision, has to involve (beyond new field observations) the compilation of existing 'names' (named habitat types, etc.), 'specimens' (individual stand descriptions), 'references' (authors and bibliographies), 'characters and states of characters' (Senterre 2016a: 64). Ultimately, a taxonomic revision consists in making the comprehensive list of all specimens and grouping them into piles corresponding to the taxa recognized as per the revision, i.e. establishing a determinavit for each one of them according to the opinion of the author of the revision. Within a pile (a taxon concept), the specimens are organized according to their value, i.e. some being nomenclatural types (holo-, neo-, lecto-), or paratypes and others being simple observations not cited in a published protologue (non-type). This can be done by using the Bio Database (Senterre et al. in review). Below, we give details for a few typical situations.

"*Raphia palma-pinus swamps*" (Jongkind 2007: 23)

In this example, we illustrate a simple case of heterotypic synonymy, when the same ecosystemic species is named differently by different authors.

In a published chapter by Jongkind (2007), the latter author named the above-mentioned type of ecosystem, providing a precise site visited in the Wonegizi (Lorma, site 1), with approximate geographic coordinates (provided in the same report).

Everything needed for ecosystem taxonomy is therefore provided, so that the name published by Jongkind and his corresponding biotype can be entered in the Bio database. Secondly, a determinavit can be added to establish the correspondence with our own ecosystem typology/nomenclature, defined using our own biotype seen directly in the field by us and which we are certain to correspond to our own conceptualization (see [28]).

"*Mesophilous forests of the wet evergreen littoral rain forest zone*" (Senterre 2014: 15)
This example illustrates the definition of a homotypic synonymy, i.e. when a name is changed using reference to an existing biotype (i.e. already used to define a previously proposed name, which is considered less appropriate). In addition, it illustrates a case of lectobiotypification.

In Senterre (2014), we named that type of ecosystem from South-East Liberia and provided a list of referenced sites of occurrence (individual stands). However, we do not agree anymore with the choice made for the name. "Mesophilous" was not an appropriate term because of its predominant bioclimatic connotation (see Table 6), and "Mesic" is preferred to define moderate topo-edaphic conditions. "Littoral" is not ideal because a tropical lowland superhumid bioclimate can occur near other sources of climatic wetness than oceans. Therefore, as we are not changing in any way the concept but only its name, we can simply create a new name that corresponds to our current terminology and define that new name by the same biotype representing the earlier name. In addition, since several reference locations were cited in our 2014 report, it is needed to choose one of them to be the biotype (lectobiotype).

"*Evergreen Forest Zone*" (Voorhoeve 1965: 10, 21)
This case study will allow introducing the concepts of neobiotype, parabiotype and pro parte synonymies (when the conceptualized type of ecosystem according to one author is wider than that of another author).

On Voorhoeve's map at page 10, the ecosystem type "*Evergreen Forest Zone*" is a mixture of what we (Senterre et al. 2019a) consider to be the tropical superhumid lowland life zone and the tropical perhumid lowland life zone (which altogether have often been referred to as evergreen Caesalp forests in both West and Atlantic Central Africa and are often confused: Senterre 2005; Senterre & Wagner 2014). Since Voorhoeve (1965) and until Bongers et al. (2004), ecosystem typology in West Africa has been based mostly on tree species distribution and forestry inventories. This, combined with the lack of consideration for topo-edaphic wetness gradients and with the overall more secondarized landscapes of West Africa (compared to Central Africa), is responsible for a partly misunderstood bioclimatic gradient. Personal observations made at Dugbe, South-Western Nimba, Ziama and Wologizi, combined with observations made by Carel Jongkind (one of the most knowledgeable non-forestry botanists for West Africa and Liberia in particular), lead us to rather model the transition between superhumid and perhumid further South (compared to Voorhoeve's transition). Indeed, according to Jongkind (2007), the Gola National Forest is not "situated in the hyperwet evergreen forest area, […] but is very close to it".

Since no biotype is proposed by Voorhoeve (1965), it is not possible to compare clearly his typology with the one we want to propose. Therefore, to explicit synonymies with that particular author, the definition of a 'neobiotype' is needed, which is located both within the zone mapped by that author and within the zone defined by us and which best corresponds to Voorhoeve's definition and/or mapping, i.e. in this case we consider this to be the perhumid zone. Then, we need to define a 'parabiotype' (i.e. a non-type ecosystemic specimen bearing a determinavit for an ecosystem name, the determinavit being published in the protologue of that ecosystem name: see [39], on page 39) for a location mapped by Voorhoeve as Evergreen Forest Zone and located within the zone considered by us as superhumid zone.

Once all virtual ecosystemic specimens have been defined, so to represent all concepts of all authors, we simply have to create a determinavit for each of them to define our own ecosystemic conceptualization.

II.1.4 Ecosystemologic revision procedure

Considering the examples given above, the exact procedure followed during an ecosystemologic revision using the Bio database (Senterre et al. in review) is the following:

- To select key bibliographical resources, where typologies are either explicit or implicitly described in words.

- To enter Virtual ecosystemic specimens from those references, including a biotype for what is considered a typical stand of a given ecosystem type; and parabiotypes for any number of other locations mentioned/mapped, including in particular some that are non consensual, i.e. which can be identified differently than the holobiotype by another author.

- To enter names of ecosystem types as given from the bibliography, linking them to their biotype (holo-, neo- or lecto-biotype).

- To add determinavit (for the new name entered) by the author of the bibliographic reference on all its corresponding biotypes (holo-, neo-, lecto-) and parabiotypes.

- To take another source, and add biotypes and names in the same way.

- If necessary, to create new names and indicate explicitely that those are new when mentioned in the corresponding publication or report (by indicating the first author's name followed by "nov."). The purpose is to explicitly state when and where a name is created (which means [name]+[authors], even if the [name] already exists by another author, with the same conceptualization or not), as opposed to a pre-existing ecosystem name (by a given author, at a given time: a protologue) to which a reference is being made. The purpose of "nov." names is not to keep counts of who publishes more names, neither to appropriate oneself a name. Unfortunately, species taxonomy has sometimes taken a very egocentric approach to what "sp.nov." really means, i.e. methodology rather than ownership or fame.

- To add new determinavit on biotypes (holo-, neo-, lecto-) and parabiotypes of the first bibliographic reference, discussed above in example, to represent the opinion of the second source/author regarding the ecosystemic taxonomy.

- To add as many identifiable stands found in the literature and not yet dealt with (not linked to named ecosystems) to describe the geographic distribution.

Ecosystem species are defined and described using a format completely analogous to that of classical taxonomic revisions.

[ecosystem numbering as per this report] "***Ecosystem species name EN / FR***" ("authors of the name", "date of name's publication": "page in publication or map code"). Type: "COUNTRY"; "Locality"; "Latitude"; "Longitude"; "Altitude"; "Collectors" "Collectors' reference code or stand numbering/vegetation plot code" ("holo-/neo-/lecto-biotype", "designated by", BIOID: "id from the Bio Holistic Database").

Homotypic synonyms: Same formatting, excluding the typification.

Heterotypic synonyms: Same formatting, each name starting at a new line and being sorted chronologically from the most recent to the oldest name.

Paratypic synonyms (p.p. synonyms): Same formatting, including involved parabiotype.

Other virtual ecosystemic specimens: Same formatting but without ecosystem name.

Description:

Distribution:

RLE status:

Ecosystemologic notes:

II.2 Mapping ecosystems

The methodology and bibliographic references used to produce a map of ecosystems are fully detailed in Senterre et al. (2019a: 19–25). In brief, we used expert knowledge, available maps of life zones, bioclimates or potential vegetation types, as well as data on locally described climaxes and maps of human impact. Altogether, this allowed us to propose a map of lowland life zones, at the scale of West Africa, with a number of bioecological classes corresponding to the classification of Holdridge (1967), i.e. distinguishing a superhumid zone and two different types of semi-deciduous forest zones (see Table 6 and detailed explanation in Senterre et al., in review, 2019a: 29).

The results were then combined with a model of altitudinal belts based on the classification of a Digital Elevation Model (https://www.eorc.jaxa.jp/ALOS/en/aw3d30/data/index.htm), using 850 and 1350 m as threshold values for the transitions lowland-submontane and submontane-montane, respectively.

The third step consisted in developing a map of land cover types (current vegetation physiognomy and mapable ecological classes), using a combination of several sources in a way to reduce as much as possible errors and to increase resolution. Among the sources compiled, we included Hansen et al. (2013) and Turubanova et al. (2018) to produce the map at two different dates: 2000 and 2018 (Figure 4).

The maps of life zones and land cover types were developed at the scale of West Africa. We then used a subset of the jaxa Digital Elevation Model covering the current study area, in the Lofa-Gola-Mano-Nimba complexes, and we developed a landform analysis using TauDEM. The steps differed slightly to those used previously in the Mount Nimba (see Senterre et al. 2019a: 25):

We clipped the West African DEM to the study area and projected to SRC 54032.

We calculated all TauDEM functions (Tarboton 2013)

```
mpiexec -n 8 PitRemove jaxacepf54032.tif
```

mpiexec -n 8 DinfFlowdir -ang jaxacepf54032ang.tif -slp jaxacepf54032slp.tif -fel jaxacepf54032fel.tif

mpiexec -n 8 AreaDinf -ang jaxacepf54032ang.tif -sca jaxacepf54032sca.tif

SlopeAreaRatio -slp jaxacepf54032slp.tif -sca jaxacepf54032sca.tif -sar jaxacepf54032sar.tif

mpiexec -n 8 D8Flowdir -p jaxacepf54032p.tif -sd8 jaxacepf54032sd8.tif -fel jaxacepf54032fel.tif

mpiexec -n 8 AreaD8 -p jaxacepf54032p.tif -ad8 jaxacepf54032ad8.tif

mpiexec -n 8 Threshold -ssa jaxacepf54032ad8.tif -src jaxacepf54032src.tif -thresh 18.0

mpiexec -n 8 Streamnet -fel jaxacepf54032fel.tif -p jaxacepf54032p.tif -ad8 jaxacepf54032ad8.tif -src jaxacepf54032src.tif -ord jaxacepf54032ord3.tif -tree jaxacepf54032tree.dat -coord jaxacepf54032coord.dat -net jaxacepf54032net.shp -w jaxacepf54032w.tif

DinfDistDown -ang jaxacepf54032ang.tif -fel jaxacepf54032fel.tif -src jaxacepf54032src.tif -dd jaxacepf54032dd.tif -m ave v -nc

DinfDistUp -ang jaxacepf54032ang.tif -fel jaxacepf54032fel.tif -du jaxacepf54032du.tif -m ave v -nc

We calculated the distance to stream network (jaxacepf54032src.tif; distance units as georeferenced coordinates; data type UInt16 (0 to 65535)): jaxacepf54032srcdist.tif

With ArcGIS, Spatial Analyst, we calculated the landform 'curvature' (plan, profile, general): jaxacepf54032curvplan.tif, jaxacepf54032curvprof.tif, jaxacepf54032curv.tif

Finally, we used Map Algebra in ArcGIS to compile the various results into a landform analysis:

Swamps.tif: Con((("jaxacepf54032slp.tif" <= 0.05) & ("jaxacepf54032srcdist.tif" <= 3) & ("jaxacepf54032dd.tif" <= 4) & ("jaxacepf54032du.tif" >= 10) & ("jaxacepf54032curvprof.tif" >= - 1) & ("jaxacepf54032curvprof.tif" <= 1)),1,0)

Overdrained.tif: Con((("jaxacepf54032dd.tif" >= 30) & ("jaxacepf54032srcdist.tif" >= 3) & (("jaxacepf54032curvprof.tif" <= - 1.2) | ("jaxacepf54032curvplan.tif" >= 1.2))),1,0)

Riparian.tif=: Con("jaxacepf54032sca.tif" >=230000,1,0)

Waterfall.tif: Con((("jaxacepf54032slp.tif" >= 0.9) & ("jaxacepf54032src.tif" == 1)),1,0)

Cliff.tif: Con((("jaxacepf54032slp.tif" >= 1.05) & ("jaxacepf54032src.tif" != 1) & ("EcoStand2018.tif" != 10) & ("EcoStand2018.tif" != 20)),1,0)

Landform_tmp1.tif: Con(("Riparian.tif" == 1),2,Con(("Cliff.tif" == 1),6,Con(("Waterfall.tif" == 1),7,Con(("Overdrained.tif" == 1),5,Con(("Swamps.tif" == 1),1,Con(("jaxacepf54032src.tif" == 1),3,4))))))

Do twice Majority Filter (ArcGIS/Spatial Analyst/Generalization): Landform_tmp2.tif

Finally, we put back the original results for the ravines, riparian, cliffs and waterfalls, **cepf_landform_54032.tif**: Con(("Waterfall.tif" == 1),7,Con(("Riparian.tif" == 1),2,Con((("jaxacepf54032src.tif" == 1) & ("Landform_tmp2.tif" != 1)),3," Landform_tmp2.tif")))

The result is a map of modeled landforms of all studied KBAs. This map is not of great definition because of the resolution of the DEM (30 m). However, it is good enough to give a general idea of the landforms present within a given KBA and their distribution. It can also be very useful during field exploration, using Smartphone GIS.

The various maps produced (life zones, land cover types, landforms, ecosystems, etc.) have been developed using mostly QGIS, ArcGIS and R. They will be made available in free access on Google Earth Engine (https://code.earthengine.google.com/?asset=users/bsenterre/waf2020).

In addition to this regional mapping effort, we compiled locally described ecosystems and stand observations as individual occurrence records. These records were compiled in the database developed to represent our ecosystemologic approach, namely Bio ("Bio: Holistic Database on Species and Ecosystems"), and their identity was reviewed based on the typology proposed here.

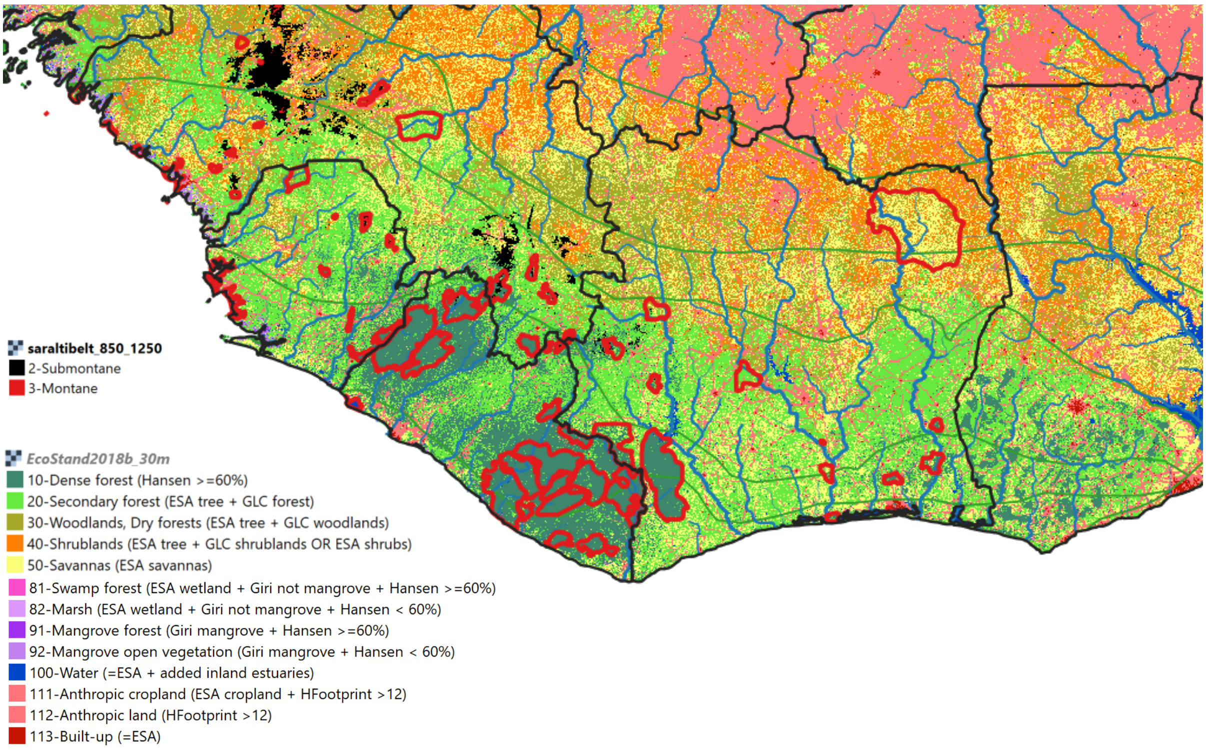


Figure 4. Map of main land cover types for the year 2018. The green lines represent the bioclimatic zones along the aridity gradient from the wet evergreen rainforest to the Sudanian savannas (Senterre et al. 2019a).

II.3 RLE pre-assessment & KBA ecosystemic parameters

The operational units (ecosystem types) used for RLE and for KBA assessments are discussed in the chapter IV, i.e. after having presented and described the typology of ecosystems obtained according to our conceptual approach. In that chapter, we will discuss our approach compared to the main alternatives existing in terms of global typologies of ecosystems, and we will discuss the choice of operational units for RLE according to IUCN and KBA guidelines, which correspond to our concept of 'eco-species' (or 'ecosystem species').

For the RLE and KBA assessments themselves, we deal with the lack of data on eco-species distribution by defining 'ecosystem groups' which are aggregates of eco-species that can be mapped as a group but not individually (i.e. mapping units). For example, we cannot map "West African Ravine forest of the Tropical lowland superhumid evergreen rainforest zone" ([81]), at least not their global distribution (i.e. at the scale of West Africa), but we can map West African forest of the Tropical lowland superhumid evergreen rainforest zone (including without distinction forested ravines, swamps, mesic, riparian, subsaxicolous, and overdrained stands).

Firstly, we used the maps produced at the regional scale to calculate parameters needed for RLE (using the R package Redlistr: Lee et al. 2019) for the mapped "groups of ecosystems": AOO, EOO and forecast of decline over the time span 2000-2050. Secondly, we evaluated the IUCN threat level for each group of ecosystems using the IUCN guidelines and criteria (Bland et al. 2015; Keith et al. 2013; Rodriguez et al. 2015). Thirdly, we detailed the various specific types of ecosystems (eco-species) included within each group and we discussed their individual threat level assessment based on the results obtained for the group. Those results are presented within the description of individual ecosystem species given in the next chapter. We complemented the analysis done in Senterre et al. (2019a) for Mount Nimba by adding ecosystem groups present in the other KBAs of the current study.

Regarding the parameters needed for the assessments of global KBAs, as done previously with the RLE, we have used calculations based on the sole thing that we can map, i.e. the ecosystem groups. We calculated for each ecosystem group the percentage of the global distribution contained within each KBA. Secondly, we evaluated the status of each KBA based on a discussion of the results for ecosystem groups, reinterpreted for the potential trigger eco-species. The main criteria used from the KBA guidelines are the criteria A2 (threatened ecosystem types) and B4 (geographically restricted ecosystem types) (KBA Standards and Appeals Committee 2019: 63).

Each KBA will be presented following the format below:

KBA Name
Bibliography: List or references providing significant descriptions of the KBA.
Life zones: List of all life zones occurring; altitudinal range.
Eco-genera/species: List of all eco-genera occurring followed by the codes of eco-species within each eco-genus and its REL threat status ([xx]: EN; [xx]: VU; etc.).
Description: General overview. Detailed biotic descriptions are detailed within the chapter III.1.
KBA assessment: We mention criteria and subcriteria used, and for each of them we give the ecosystem species that trigger a global KBA status, e.g. A2a ([xx],[xx]), A2b (xx), B4 (xx)

III. RESULTS

III.1 Typology of Ecosystems

The geographic area covered here is huge and goes from highly complex coastal areas in the superhumid wet evergreen rain forest life zone of Lake Piso to humid semi-deciduous areas and forest-savannas mosaics in the NE of Mount Nimba and in the Pic de Fon. Because of this much higher complexity of coastal and wetland landscapes (compared to our recent ecosystem study of Mount Nimba), it becomes increasingly difficult to present a comprehensible list of detailed types of ecosystems in the shape of a linear text document. Beyond the levels of ecosystem integration (regional and stand scales), some additional hierarchy is needed for the sole purpose of organizing the information, i.e. without taxonomic value. For this, we propose to use a concept introduced in Senterre et al. (in review) which consists in grouping ecosystem genera into ecosystem 'families' and 'orders'. Unlike in typologies derived from Yangambi system, regional gradients (life zones) and developmental gradients (secondary series) are factored out before such groups are made, and the groups conceptualized (families and orders) are created in order to be strictly mutually exclusive.

The two most important stand scale gradients on Earth, that separate contrasted groups of ecologists, contrasted groups of organisms, and that are strongly entangled to each other, are the gradients from marine to terrestrial and from wetland to upland. We therefore use combinations of these two gradients to define ecosystemic 'Orders', including the important distinction between frontshore and backshore to detail the wetland-upland gradient in a correct bioecological way (see detailed discussion in Senterre et al. 2015: 3–15)

The other solution proposed to facilitate the synthesis of the complete list of ecosystem species recognized here consists in complementing the linear reporting of those in the current text by a non-linear, multi-entry identification key developed in XPer3 (or simply in MS Excel), which is under development. To our knowledge, this will be the first time that such numerical taxonomy tools are applied to ecosystem taxonomy.

Below we present the complete list of all ecosystem species recognized, cited or expected within the study area. These ecosystem species are numbered in brackets [x] using a continued numbering series throughout this report. They are grouped in chapters based on proposed ecosystem orders and subchapters based on proposed ecosystem genera. Ecosystem Families are not detailed in the text version of our typology (this report). Illustrations and photographs are available in the annexes of Senterre et al. (2019a).

III.1.1 Coastal backshore extratidal wetland (Or.)

Coastal zone not fully exposed to sea sprays and tides, situated beyond the shoreline, at the back of a beach crest or river mouth, and at the upland edge (with concentration of salt from exceptional tides, not being flushed by river stream).

III.1.1.1 Coastal backshore hyperhaline dwarf mangrove forest (Ge.)

[1] Atlantic Coastal backshore hyperhaline dwarf mangrove forest of the Tropical lowland superhumid evergreen rainforest zone / *Mangrove naine d'arrière-côte hyper-saline atlantique de la zone des Forêts tropicales superhumides sempervirentes de plaine* (Senterre, Bruno nov.). Type: Liberia: Lake Piso, based on Google Earth; 6.718; -11.32825; 1; *Senterre, Bruno 20200811145852* (holo-, BIOID: 20200811145852).

Description: In the same way that montane forests are often confused altogether as one single entity, mangroves are rarely suspected to be as complex as they actually are. Nevertheless, specialized literature on mangroves clearly recognized multiple types of mangroves according to several important gradients such as salinity, flushing, freshwater influence, seasonality, etc. Although different types of mangroves can have a priori similar plant communities, the full biotic communities and landscape functions can be very contrasted. Dwarf mangroves (Feller 2020; Hernández-Arana et al. 2015; Lugo et al. 2014) are characterized by a canopy (closed or most often not so) at ca. < 5 m high. Here we consider dwarf mangroves resulting from hyper salinity, at the upland ecotone of a coastal backshore (at the back of an estuary stream network).

Distribution: Land and sea barriers to species dispersal are very different for mangroves vs. non-coastal ecosystems. It seems that mangroves, in general, are not segregated biogeographically between e.g. West and Central Africa but rather e.g. Atlantic (African + American) vs. Indian Oceans (Triest 2008). There is no information on the biogeographic subdivision of Atlantic mangrove ecosystems. We therefore assume that Coastal backshore hyperhaline dwarf mangrove forests from America and Africa belong to the same ecosystem species. Bioclimatically, it is also hard to assess the distinctiveness of mangrove types, but several evidences suggest that mangroves from arid tropical zones vs. humid, perhumid or superhumid are distinct (Ellison and Simmonds 2003; López-Medellín et al. 2011; Lugo et al. 2014; Lugo and Snedaker 1974; Saenger and Bellan 1995; Saravanakumar et al. n.d.; Ximenes et al. 2016).

RLE status: DD. This ecosystem is unlikely to be a trigger for KBA recognition because of its relatively good conservation state and its relative rarity within the studied KBAs.

III.1.1.2 Coastal backshore hyperhaline grassland on muddy soil (back of mangrove) (Ge.)

[2] ***West African Coastal backshore hyperhaline grassland on muddy soil (back of mangrove) of the Tropical lowland superhumid evergreen rainforest zone*** / *Prairie d'arrière-côte hyper-saline sur sol boueux (d'arrière-mangrove), atlantique, de la zone des Forêts tropicales superhumides sempervirentes de plaine* (Senterre, Bruno nov.). Type: Liberia: Lake Piso, based on Google Earth; 6.71753; -11.32543; 1; *Senterre, Bruno 20200811150106* (holo-, BIOID: 20200811150106).

Description: Truly at the edge of upland ecosystems, further in the backshore of the dwarf mangrove [1]. Generic ecosystem illustrated in Senterre et al. (2017: 131, annex 6: 22).

Distribution: This ecosystem is intermediate between marine and terrestrial realms. For marine ecosystems, it does not matter to be near the coasts of Western vs. Central Africa. They form an Atlantic bioregion based on sea currents and sea barriers to dispersal. On the contrary, for a Mesic forest, it is now the ocean being the strongest barrier to dispersal and consequently Mesic forests typically follow the terrestrial biogeography (i.e. Western vs. Central Africa). Therefore, half way on the gradient from marine to mesic upland (which is the position of the currently discussed ecosystem species), the biogeographic situation is the most unclear. More extensive knowledge on the biogeography of hyperhaline grasslands would be needed to take the most appropriate decision. In the meantime, because of the smaller size of the organisms (compared to dwarf hyperhaline mangroves) we suggest to follow the biogeography of uplands, i.e. West African ecoregion.

RLE status: DD but unlikely a trigger to KBAs (see notes in [1])

III.1.2 Coastal backshore tidal estuarine wetland (Or.)

Coastal area with combined influence of tide (upstream) and freshwater (mesohaline). Although we do not discuss aquatic ecosystems here (poorly known and not discussed in the literature), it will be needed at some point to include streams, rivers, pools, mud flats, and probably more types of mangroves such as flushed/overwashed variants (see Sepkoski and Rex 1974).

[3] ***Atlantic Coastal backshore tidal estuarine backshore/sheltered mangrove forest of the Tropical lowland superhumid evergreen rainforest zone*** / *Mangrove d'arrière-côte abritée, atlantique, de la zone des Forêts tropicales superhumides sempervirentes de plaine* (Senterre, Bruno nov.). Type: Liberia: Lake Piso; 6.7965; -11.3573; identified based on Google maps and Giri's mangrove distribution data (Giri et al., 2011); representing possibly the most typical 'mangrove forest' of other authors; *Senterre, Bruno 20200807164404* (holo-, BIOID: 20200807164404).

Heterotypic synonyms:

Southern Upper Guinea Mangrove Forests (Abell et al. 2008: 512). Type: Liberia: No location, based on maps; *Abell, Robin s.n.* (holo-, BIOID: 20200820100727).

Mangrove Forest (Voorhoeve 1965: 21). Type: Liberia: silty lagoons along the coast; Three *Rhizophora* species (see Rhizophoraceae), characterized by high, slender stilt-roots, and *Avicennia africana*, a tree with pneumatophores, form the main constituents of this forest; *Voorhoeve, Alexander George s.n.* (holo-, BIOID: 20200807164933).

Description: This seems to be the most typical mangrove forest within the studied area.

Distribution: See notes in [1]. According to Poorter et al. (2004: 11), "Mangrove forests are found in tidal and silty areas in lagoons, and along the rivers, up to 100 km inland. The mangrove forests are up to 20 m tall, and dominated by *Rhizophora* species with stilt roots, or *Avicennia africana* with pneumatophores."

RLE status: DD, but considering the small size of mangrove forests in the studied KBAs (Lake Piso) compared to Atlantic mangrove forests in general (and in West Africa in particular, e.g. Guinea, Nigeria), including extensive areas within superhumid zones, we consider this ecosystem species unlikely to be a trigger for Lake Piso KBA.

III.1.3 Coastal backshore tidal freshwater wetland (Or.)

Coastal area with some influence of tide (upstream) but dominant influence of freshwater (oligohaline). *Acrostichum*, *Talipariti*, *Heritiera* zone (e.g. upland ward in the Indian Ocean). It includes situations without river or stream on coral islands and atolls where the freshwater supply depends on the local rainfall and the tidal backshore influence can be due to underground channels in karstic raised limestone islands (e.g. Aldabra, Seychelles). Although tidal freshwater swamps are likely to be present in the Lake Piso KBA, those are not mentioned in the bibliography and it is hard to suggest possible locations without field work. We therefore present here only aquatic (open water) ecosystems. We do not develop streams, rivers, pools, mud flats, Coastal backshore tidal freshwater marshes or swamp forests due to lack of data.

III.1.3.1 Coastal backshore tidal freshwater lake (Ge.)

[4] ***West African Coastal backshore tidal freshwater lake of the Tropical lowland superhumid evergreen rainforest zone*** / *Lac saumâtre d'arrière-côte, ouest africain, de la zone des Forêts tropicales superhumides sempervirentes de plaine* (Senterre, Bruno nov.). Type: Liberia: Lake Piso (based on Google Earth); *Senterre, Bruno 20200811160259* (holo-, BIOID: 20200811160259).

Description: According to bibliography on Lake Piso (Kollie 2007; Siaffa Sambolah 2007), the tidal (brackish) influence extends up to about 8 to 10 km from the seacoast inland. "Lake

Piso is a coastal and brackish water body. The lake covers an area of approximately 100 km² (c. 40 sq miles) and has a maximum depth of approximately 4-5 m. The area falls within Liberia's maximum rainfall zone receiving up to 6000 mm, annually. […] Lake Piso is surrounded by rivers, creeks/streams, lakelets and lagoons. […] The water bodies in the area taste salty most of the time." (Kollie 2007).

Distribution: There are a number of coastal lagoons over the coast of West Africa. They surely play an important role for marine and freshwater life as well as for birds, mammals and reptiles.

RLE status: DD. As for many coastal wetlands, but even more so for the aquatic part of those wetlands, the RLE criteria A and B (regressing distribution and restricted distribution, respectively) are maybe not so essential to consider, or at least not as much as criteria C and D (environmental degradation and disruption of biotic processes, respectively). The latter criteria are even more complex to assess and largely Data Deficient, especially for these wetlands.

Ecosystemologic notes: More than for any other type of ecosystem, wetlands perfectly illustrate the artificiality of 'ecoregions' understood as discrete entities. Biogeography depends on types of ecosystems (e.g. Atlantic vs. Indian Ocean mangroves; West vs. Central African forests) and it depends on the types of organisms considered. Based on birds, wetland ecoregions could be defined much more broadly than they would be if they were based on mammals, plants or micro-invertebrates. Therefore, the Upper Guinea ecoregion does not make sense for mangrove ecosystems, or for the birdlife of open water wetlands. Just like for phytocoenosia where there are always some species with a wide ecological range, ecoregions always have some widespread ecosystems and non-endemic species in them (with wide biogeographic range). Just like phytocoenosia, ecoregions are not really discrete entities (giga-organisms) but they can be conceptualized as such, being characterized by their main 'biogeographic group', in analogy to the conceptual approach of Duvigneaud (1946) for phytocoenosia, i.e. based on the concept of ecological groups (thus here "biogeoecological groups"). Seen this way, the Upper Guinea ecoregion does make sense. Nearby or distant ecoregions (i.e. areas showing endemism for at least some taxonomic groups and some ecosystems) that share some similar biogeoclimatic types of environments will most likely influence each other by some biogeographic transgressions.

III.1.4 Coastal frontshore upland (Or.)

On shorelines with a distinctive beach crest, the herbaceous-shrubby fringe represents the frontshore while the forest fringe behind represents the backshore (sheltered by the shrubby fringe but still exposed to storms and sea sprays). This group also includes other habitat-types with a distinctive shoreline.

III.1.4.1 Coastal frontshore sandy beach (Ge.)

[5] ***West African Coastal frontshore sandy beach of the Tropical lowland superhumid evergreen rainforest zone*** / *Plage sableuse du front côtier, ouest africaine, de la zone des Forêts tropicales superhumides sempervirentes de plaine* (Senterre, Bruno nov.). Type: Liberia: Lake Piso, based on Google Earth; 6.68613; -11.31011; 2; *Senterre, Bruno 20200811133818* (holo-, BIOID: 20200811133818).

Description: This ecosystem is simply what we usually call "the beach". Although for us humans a beach is a beach, for micro-, macro-invertebrates and other microscopic organisms, there might be a whole lot of different kinds of beaches depending on bioclimates, bioregions, beach slope, grain size, sand chemistry and tide range. Sometimes, the sand can be removed and a beachrock becomes exposed, which would have to be considered as another type of ecosystem (a saxicolous coastal one, not discussed here).

Distribution: Widespread, although very narrow and possibly being squeezed between the rising sea level and the developing human infrastructures (roads, houses, walls) in the backshore.

RLE status: DD, but unlikely to be a trigger for the Lake Piso KBA.

Ecosystemologic notes: Although this generic ecosystem is poorly studied from a biogeographic point of view, a few recent studies exist which suggest that the relatively small-sized biota of this ecosystem follow the biogeography of terrestrial ecoregions (Barboza and Defeo 2015; Zhang et al. 2018).

III.1.4.2 Coastal frontshore sandy beach open vegetation fringe (Ge.)

[6] ***West African Coastal frontshore Sandy beach open vegetation fringe of the Tropical lowland superhumid evergreen rainforest zone*** / *Végétation ouverte sur plage sableuse du front côtier, ouest africaine, de la zone des Forêts tropicales superhumides sempervirentes de plaine* (Senterre, Bruno nov.). Type: Liberia: Lake Piso, based on Google Earth; 6.68603; -11.30955; 2; *Senterre, Bruno 20200811134407* (holo-, BIOID: 20200811134407).

Description: Many species of the highly dynamic beach crests (Kent et al. 2001) have a widespread distribution, either amphiatlantic or pantropical, but this ecosystem also has a Guinean littoral element (Berghen 1979: 199).

Distribution: As for mangroves, some biogeographic links are stronger with the Americas compared to the Indo-Pacific (e.g. Araujo and Pereira 2009; Howarth et al. 2003; Lüttge 2008; Seeliger 1992). The distinctions between Western and Central Africa, or along aridity gradient, are poorly known.

RLE status: DD but unlikely to be a trigger for the KBA of Lake Piso.

III.1.5 Coastal backshore upland (Or.)

Narrow strip of vegetation under the direct influence of the ocean (sea sprays), but not the influence of the daily tides. It also includes coastal dunes. It can extend relatively more inland when there is a coastal plateau (until the direct influence of the sea disappears, which can be a very stretched gradient). Due to lack of data and bibliographic evidences, we do not develop here several coastal upland ecosystemic genera which might be present such as Rocky shore on slopes; Exposed sandy beach with hyperhaline sparse shrubland; Backshore coastal forest fringe on slopes; Backshore coastal plateau mesic forest on alluvial soil; Backshore coastal plateau on hardpans (saxicolous stress).

III.1.5.1 Coastal backshore dunes shrubland (Ge.)

[7] ***West African Coastal backshore dunes shrubland (incl. gapped periodic) of the Tropical lowland superhumid evergreen rainforest zone*** / *Végétation arbustive ouverte (parfois tachetée) sur dunes d'arrière-côte, ouest africaine, de la zone des Forêts tropicales superhumides sempervirentes de plaine* (Senterre, Bruno nov.). Type: Liberia: Lake Piso, based on Google Earth; 6.67866; -11.28663; 10; Primary progression, maturing stage; *Senterre, Bruno 20200811144109* (holo-; BIOID: 20200811144109).

Heterotypic synonyms:
Coastal savanna woodlands and grasslands (Siaffa Sambolah 2007). Type: Liberia: Lake Piso; The savanna woodlands are found in patches forming mosaic with secondary forests throughout the area, especially in the south-eastern and north-western strips of the area. Characteristic features of this ecosystem are coastal savanna grass fields often with the

presence of fire-resistant dwarf trees (*Parinari macrophylla*). Other dominant tree species found are oil palm (*Elaeis guineensis*) and African spice (*Xylopia staudtii*); *Siaffa Sambolah, Richard s.n.* (holo-, BIOID: 20200812084010).

Description: Coastal plains are very dynamic landscapes, dominated by primary disturbances, retrogressions and progressive climaxes. In many rain forest areas, backshore sandy plateau have sometime horizontally regularly structured patterns, more or less shrubby, woody and patchy (gapped periodic). Coastal plains are also a preferred habitat for humans, and this complex natural landscape is most often obscured by the degradation (secondary and non-natural primary successions) in coastal forests.

Distribution: Poorly known.

RLE status: DD. Considering the degradation of coastal ecosystems in general, and in particular in West Africa, combined with the possibility of local plant endemism in this generic ecosystem (see Senterre et al. 2017: 37, 91, 92), the ecosystem species presented here requires more detailed studies. Meanwhile, we suggest adopting a precautionary approach and try to preserve any area of possibly natural Coastal backshore dunes shrubland in the Lake Piso KBA.

III.1.5.2 Coastal backshore dunes grassland (Ge.)

[8] ***West African Coastal backshore dunes with sparse vegetation of the Tropical lowland superhumid evergreen rainforest zone*** / *Végétation éparse sur dunes d'arrière-côte, ouest africaine, de la zone des Forêts tropicales superhumides sempervirentes de plaine* (Senterre, Bruno nov.). Type: Liberia: Lake Piso, based on Google Earth; 6.6801; -11.28626; 7; *Senterre, Bruno 20200811143540* (holo-, BIOID: 20200811143540).

Description: In the superhumid zone, this ecosystem is not as extensive as it can be in dryer climatic zones. It represents early stages of a primary progression, which is certainly faster for moister climates. It is partly included in the *Coastal savanna woodlands and grasslands* (Siaffa Sambolah 2007), but is also probably confused with secondary series on anthropically degraded lands or even with [2] *West African Coastal backshore hyperhaline grasslands*.

Distribution: Poorly known.

RLE status: DD. It is hard to hypothesize on the likeliness of local endemism for this type of ecosystem. Being an early primary progression stage, we would expect a biotic community without local endemism, made up by elements transgressive from other ecosystems.

III.1.5.3 Coastal backshore forest fringe on sandy beach (Ge.)

[9] ***West African Coastal backshore forest on sand of the Tropical lowland superhumid evergreen rainforest zone*** / *Forêt psammophile d'arrière-côte, ouest africaine, de la zone des Forêts tropicales superhumides sempervirentes de plaine* (Senterre, Bruno nov.). Type: Liberia: Lake Piso, based on Google Earth; 6.69; -11.30809; 16; Probably a very interesting site to visit; *Senterre, Bruno 20200811141636* (holo-, BIOID: 20200811141636).

Description: This ecosystem is the most mature stage of a primary progression on sand (posterior to some kind of disturbance more or less distant in the past, anthropic or not). It follows the development of the type [7].

Distribution: Poorly known. This type of ecosystem is not mentioned in the literature. It might correspond (at least at generic level) to the "*West African dry coastal forest*", in the Accra Plains (White 1983: 76). However, the moist climate at Lake Piso is likely to result in a richer biodiversity, and possibly more local endemic species.

RLE status: DD. Likely to be threatened, it requires further studies. Analysis of remotely sensed imagery can help but is not enough to identify the distribution and conservation of this type of ecosystem. Field work is required, and the locality identified here (holobiotype) should be visited during the current project.

III.1.6 Inland (non-coastal) wetland (incl. floating vegetation) (Or.)

Non-coastal areas can start just 30 m after the shoreline (e.g. sloped rocky shores), or much more inland in plateau areas. There, wetlands appear in concave landforms and in association with stream network of large water catchment areas. It includes temporary wetlands (seasonal, intermittent, or irregularly).

In West Africa, within the study area covered here, Abell et al. (2008) have recognized two ecoregions: the Southern Upper Guinea (512) and the Nimba highland (513); the former containing 5 different types of ecosystems (streams of the rocky upper courses; rivers of the lower courses; waterfalls of the lower courses; freshwater swamps; mangrove forests) and the latter containing 2 different types of ecosystems (rivers on steep slopes; waterfalls). According to our vision of ecosystemology (Senterre et al. in review) and some support found in specialized literature on aquatic freshwater ecosystems, we propose to enrich the categories recognized by Abell et al. (2008) using the regional ecosystems as recognized here, based on different bioclimates. For example, Dodds et al. (2019, 2015) have provided support to the Stream Biome Gradient Concept which "is based on the hypothesis that many abiotic and biotic features of streams change predictably along climate (temperature and precipitation) gradients because of direct influences of climate on hydrology, geomorphology, and interactions mediated by terrestrial vegetation."

III.1.6.1 Inland stream (Ge.)

[10] ***West African inland stream of the Lowland tropical perhumid moist evergreen rainforest zone*** / *Ruisseau ouest africain de la zone des Forêts tropicales perhumides sempervirentes de plaine* (Senterre, Bruno nov.). Type: Liberia: Massif du Wologizi, Sud de Wuteve; 8.12871; -9.94399; 687; lit de ruisseau intermittant entaillant une cuirasse caillouteuse cimentée; *Senterre, Bruno & Bidault, Ehoarn BS61-97* (holo-, BIOID: BS61-20191018-1000-97).

Other virtual ecosystemic specimens:

Liberia: Gola National Forest; 7.452; -10.692; Waterside vegetation and streams: On rocks in and above the streams the small specialized herb *Argostemma pumilum* was found in abundance. *Anubias gracilis* and ferns like *Bolbitis salicina* were also abundant on such rocks. The streams in this area definitely held the most interesting waterside vegetation among the three study sites; *Jongkind, Carel s.n.* (BIOID: 20200810094242, in Jongkind, 2007).

Liberia: North Lorma National Forest, Lawa River; 8.0258; -9.7319; 390; In small, rocky streams we often encountered *Anubias gracilis* and several fern species, such as *Bolbitis salicina*; *Jongkind, Carel s.n.* (BIOID: 20200810080646, in Jongkind, 2007).

Description: According to Abell et al. (2008, p. 512) "the relatively short, partly torrential rivers and streams of this ecoregion [Southern Upper Guinea] support a highly endemic freshwater fish and crab fauna".

Distribution: See Senterre et al. (2019a: 36); widespread from Sierra Leone to Ghana, but remaining more undisturbed in Liberia, Diécké and Nimba; they are more abundant in hilly and mountainous landscapes.

RLE status: DD. Surrounding ravine forests were assessed as VU (see Senterre et al. 2019a: 71, [2]), but here criteria C and D have to be considered.

[11] ***West African inland stream of the Submontane tropical perhumid moist evergreen rainforest zone*** / *Ruisseau ouest africain de la zone des Forêts tropicales perhumides sempervirentes submontagnardes* (Senterre, Bruno nov.). Type: Guinea: Massif du Mont Nimba, Seringbara; 7.63843; -8.42357; 900; *Senterre, Bruno 20200811153626* (holo-, BIOID: 20200811153626).

Description: Poorly known.

Distribution: Rare, SE Nimba, South Ziama, Wologizi, Western Area Peninsula Non-Hunting Forest Reserve in Sierra Leone (see Senterre et al. 2019a: 40, [8]).

RLE status: DD. Surrounding ravine forests were assessed as VU(LC-VU) (see Senterre et al., 2019a: 71, [8]), but here criteria C and D have to be considered.

[12] ***West African inland stream of the Lowland tropical humid moist seasonal semi-deciduous rainforest zone*** / *Ruisseau ouest africain de la zone des Forêts tropicales humides saisonnières semi-décidues de plaine* (Senterre, Bruno nov.). Type: Guinea: Massif du Mont Nimba, Monts des Génies; 7.70583; -8.3642; 616; *Senterre, Bruno 20200811154226* (holo-, BIOID: 20200811154226).

Description: Poorly known.

Distribution: Widespread from Guinea to Ghana, in hilly and mountainous landscapes (see Senterre et al. 2019a: 44, [17]), best preserved in the NE Ziama and NE Nimba.

RLE status: DD. Surrounding ravine forests were assessed as EN (EN-CR) (see Senterre et al. 2019a: 71, [17]), but here criteria C and D have to be considered.

[13] ***West African inland stream of the Submontane tropical humid moist seasonal semi-deciduous rainforest zone*** / *Ruisseau ouest africain de la zone des Forêts tropicales humides saisonnières semi-décidues submontagnardes* (Senterre, Bruno nov.). Type: Guinea: Massif du Mont Nimba, Haut Cavally; 7.6615; -8.39068; 1078; *Senterre, Bruno 20200811154529* (holo-, BIOID: 20200811154529).

Description: Poorly known.

Distribution: Widespread, scattered from Guinea to Ghana (see Senterre et al. 2019a: 48, [23])

RLE status: DD. Surrounding ravine forests were assessed as VU (see Senterre et al. 2019a: 71, [23]), but here criteria C and D have to be considered.

[14] ***West African inland stream of the Montane tropical humid moist seasonal semi-deciduous rainforest zone*** / *Ruisseau ouest africain de la zone des Forêts tropicales humides saisonnières semi-décidues montagnardes* (Senterre, Bruno nov.). Type: Guinea: Massif du Mont Nimba, haut de la vallée de Wolanda; 7.65533; -8.37421; 1404; *Senterre, Bruno 20200811154752* (holo-, BIOID: 20200811154752).

Description: Poorly known. Abell et al. (2008): "Rivers descending the steep slopes of Mount Nimba run swiftly, often experiencing torrential floods during the rainy season. Rheophytes, plants that can live in running water, dominate the riparian vegetation (Hughes & Hughes 1992). Within the highlands, Mount Nimba's relative high elevation, the presence of rapids and waterfalls that has led to isolation, and the stability of the aquatic environment over time have promoted speciation.".

Distribution: Rare, restricted to NE Ziama and NE Nimba (see Senterre et al. 2019a: 50, [28]).

RLE status: VU (VU-EN) according to criterion B2 (see Senterre et al. 2019a: 50, [28]).

III.1.6.2 Inland river (Ge.)

[15] ***West African inland river of the Tropical lowland superhumid evergreen rainforest zone*** / *Rivière ouest africaine de la zone des Forêts tropicales superhumides sempervirentes de plaine* (Senterre, Bruno nov.). Type: Liberia: Dugbe HummingBird site (Sinoe County, ca. 20 km South of Sapo National Park, ca. 50 km East of Greenville), north of the road from Dugbe to Tuzon; 5.09871; -8.51884; 78 m; *Senterre, Bruno HB2-915* (holo-, BIOID: 45e46a92-67dc-476e-b719-c699b97ef23f).

Homotypic synonym:

Rivers of the wet evergreen littoral rain forest zone (Senterre 2014: 23).

Description: Poorly known.

Distribution: Mostly in a narrow belt near the coast of Liberia, SW Ivory Coast and SW Ghana, in the plains (see Figure 7a).

RLE status: DD. See comment in [4]: RLE criteria C and D need to be evaluated.

[16] ***West African inland river of the Lowland tropical perhumid moist evergreen rainforest zone*** / *Rivière ouest africaine de la zone des Forêts tropicales perhumides sempervirentes de plaine* (Senterre, Bruno nov.). Type: Sierra Leone: Tiwai Island, seen on Google Earth; 7.5327; -11.36245; 102; *Senterre, Bruno 20200811095241* (holo-, BIOID: 20200811095241).

Description: Poorly known. Corresponds mostly to the "Southern Upper Guinea rivers of the lower courses" of Abell et al. (2008), together with rivers from other rain forest areas.

Distribution: Widespread from Sierra Leone to SW Ghana, in the plains (see Senterre et al. 2019a: 37, [4]). Abell et al. (2008): "Major rivers of the Southern Upper Guinea ecoregion include the Mano, Lofa, St. Paul, St. John, Cestos, and Cavally."

RLE status: DD. See comment in [4]: RLE criteria C and D need to be evaluated.

[17] ***West African inland river of the Lowland tropical humid moist seasonal semi-deciduous rainforest zone*** / *Rivière ouest africaine de la zone des Forêts tropicales humides saisonnières semi-décidues de plaine* (Senterre, Bruno nov.). Type: Guinea: Massif du Mont Nimba, Monts des Génies; 7.70584; -8.36338; 600; *Senterre, Bruno & Bidault, Ehoarn 20200811102618* (holo-, BIOID: 20200811102618).

Description: Poorly known. Included in the "Southern Upper Guinea rivers of the lower courses" by Abell et al. (2008).

Distribution: Widespread from Guinea to Ghana, in the plains (see Senterre et al. 2019a: 45, [19]).

RLE status: DD. See comment in [4]: RLE criteria C and D need to be evaluated.

III.1.6.3 Inland waterfall (Ge.)

According to Couch et al. (2019: 42): "Waterfalls and rapids (white water) contain highly developed, if often sparse and inconspicuous, plant species that grow in no other habitat. These plants are adapted to both fast-flowing water and to large seasonal changes in flow. Many species are confined to short sections of river systems or even individual waterfalls. It appears that a higher proportion of waterfall species are threatened with higher levels of extinction than species in any other habitat in Guinea." … "The Loma-Man highlands also contains threatened waterfall species, such as *Inversodicraea pepehabai* at Ziama, Sérédou. Waterfall plants are most diverse on sandstone and granitic rock, less so on ferralitic rocks." … "the Loma-Man Highlands of Guinea are very poorly studied for such plants". Other important taxonomic groups to consider for the biogeoecologic study of waterfalls include freshwater insects and gastropods (Rackemann et al. 2013; Vogler et al. 2019).

[18] ***West African waterfall of the Lowland tropical perhumid moist evergreen rainforest zone*** */ Cascade ouest africaine de la zone des Forêts tropicales perhumides sempervirentes de plaine* (Senterre, Bruno nov.). Type: Sierra Leone: Gola East, Wemago, near site 2, on the side of Bagra Hill, which is the highest point of Gola East; 7.45; -11.0666; There were few steep slopes, except at one point where a waterfall flowed into the Wemago river; *Davies, A. Glyn s.n.* (holo-, BIOID: 20200810183205, in Davies 1987).

Description: Poorly known. Included in the "Southern Upper Guinea rivers of the lower courses" (Abell et al. 2008).

Distribution: Scattered within the area mapped by Senterre et al. (2019a: 36). According to Abell et al. (2008): "The relief along the coast is relatively steep and cataracts abound in the courses of the rivers. The Mano River, for example, encounters over 15 waterfalls throughout its lower course".

RLE status: DD. See comment in [4]: RLE criteria C and D need to be evaluated.

[19] ***West African waterfall of the Submontane tropical humid moist seasonal semi-deciduous rainforest zone*** */ Cascade ouest africaine de la zone des Forêts tropicales humides saisonnières semi-décidues submontagnardes* (Senterre, Bruno nov.). Type: Guinea: Nimba; 7.6558; -8.3979; Cascade submontagnarde; *Senterre, Bruno & Bidault, Ehoarn 20200811105102* (holo-, BIOID: 20200811105102).

Description: Above 850-900 m altitude; They correspond mostly to the "*Nimba highland Waterfalls*" (Abell et al. 2008). Couch et al. (2019: 43): "Apart from *Inversodicraea pepehabai* (Ziama Biosphere Reserve), *Impatiens nzoana* (Nimba World Heritage Site) and *Macropodiella garrettii* (proposed Moyen-Bafing National Park), all other 17 threatened waterfall species are not currently in a Protected Area (2019). However, all but three species (including *Inversodicraea pygmaea* (CR(PE))) are encompassed by proposed TIPAs".

Distribution: Scattered within the area mapped by Senterre et al. (2019a: 47), including mountain ranges of Dans, Nimba, Ziama, Kindia. Also present in Basse Guinée (Couch et al., 2019: 42), while the waterfalls of the Fouta Djalon are mostly in a dryer bioclimate zone.

RLE status: DD; Possibly VU (see Senterre et al. 2019a: 48, [23]).

Ecosystemologic notes: It might be necessary to further distinguish waterfalls with contrasted lithologies, as suggested by Couch et al. (2019).

[20] ***West African waterfall of the Montane tropical humid moist seasonal semi-deciduous rainforest zone*** */ Cascade ouest africaine de la zone des Forêts tropicales humides saisonnières semi-décidues montagnardes* (Senterre, Bruno nov.). Type: Guinea: Massif du Mint Nimba, haut de la vallée de Wolanda; 7.6542; -8.37325; 1362; cascade de montagne; *Senterre, Bruno & Bidault, Ehoarn BS61-38* (holo-, BIOID: BS61-20191003-1155-38).

Description: Above 1350 m altitude; They correspond partly to the "*Nimba highland Waterfalls*" Abell et al. (2008).

Distribution: Poorly known, but this seems to be the only record of a montane waterfall within the study area.

RLE status: CR(DD-CR) according to criterion B2c, as long as no other site exists.

III.1.6.4 Inland pool (Ge.)

[21] ***West African freshwater pool of the Tropical lowland superhumid evergreen rainforest zone*** / *Pièce d'eau douce ouest africaine de la zone des Forêts tropicales superhumides sempervirentes de plaine* (Senterre, Bruno nov.). Type: Liberia: Dugbe HummingBird site (Sinoe County, ca. 20 km South of Sapo National Park, ca. 50 km East of Greenville), south-east of Tuzon; 5.07609; -8.5001; characterized by plants such as *Nymphea* spp.; *Senterre, Bruno 20200804145535* (holo-, BIOID: 20200804145535).

Homotypic synonyms:

Marshy open water of the wet evergreen littoral rain forest zone (Senterre 2014: 24).

Description: Open water surface (not under canopy), corresponding to a relatively large basin with little water flow.

Distribution: Isolated, probably rare, within the superhumide lowland zone. Likely present in the northern part of Lake Piso.

RLE status: DD.

III.1.6.5 Freshwater marsh (Ge.)

[22] ***West African freshwater marsh of the Tropical lowland superhumid evergreen rainforest zone*** / *Végétation ouverte marécageuse ouest africaine de la zone des Forêts tropicales superhumides sempervirentes de plaine* (Senterre, Bruno nov.). Type: Liberia: Dugbe HummingBird site (Sinoe County, ca. 20 km South of Sapo National Park, ca. 50 km East of Greenville), south-east of Tuzon; 5.07609; -8.5001; 24 m; natural habitat, shrubby fringe of a freshwater marsh, lowland belt; *Senterre, Bruno HB2-886* (holo-, BIOID: 03a379a7-6031-4e9f-88af-752f50356e9d).

Homotypic synonyms:

Open marshes of the wet evergreen littoral rain forest zone (Senterre 2014: 24).

Description: This habitat-type marks the transition between swamp forest and open water areas, and is characterized by species such as *Thelypteris* sp. Where open marshes have been affected by human impact, *Cyrtosperma senegalense* is generally observed.

Distribution: Isolated, probably rare, within the superhumide lowland zone (Figure 7a). Likely present in the northern part of Lake Piso.

RLE status: DD.

[23] ***West African freshwater marsh of the Lowland tropical perhumid moist evergreen rainforest zone*** / *Végétation ouverte marécageuse ouest africaine de la zone des Forêts tropicales perhumides sempervirentes de plaine* (Senterre, Bruno nov.). Type: Sierra Leone: Tiwai Island, seen on Google Earth; 7.5321; -11.36165; 106; *Senterre, Bruno 20200811094026* (holo-, BIOID: 20200811094025).

Description: Poorly known.

Distribution: Poorly known.

RLE status: DD.

III.1.6.6 Seasonal marsh on ironstone rock sheet (Ge.)

[24] ***West African Saxicolous seasonal marsh grassland on ironstone of the Lowland tropical rainforest zone*** / *Prairie ouest africaine périodiquement marécageuse saxicole sur cuirasse ferrugineuse de la zone des Forêts tropicales de plaine* (Senterre et al. 2019a: 55).

Type: Guinea: Massif du Mont Nimba, NE; *Senterre, Bruno & Bidault, Ehoarn BS61-26g* (holo-, BIOID: BS61-20191001-1605-26g).

Heterotypic synonyms:

Groupement à Eriocaulon pumilum et Utricularia subulata (Schnell 1952: 382). Type: Guinea: Mont Nimba; *Schnell, Raymond s.n.* (holo-, BIOID: Schnell-19520101-1942-382).

Terre humide éphémère / ephemeral wetland (Golder 2013: 12). Type: Guinea: Mount Nimba; *Golder s.n.* (holo-, BIOID: Golder-20130101-1722-12).

Végétation hydrophile sur bowal (Aussel 2018: 4124). Type: Guinea: GM, MG, HG, GF; *Aussel, Alexia s.n.* (holo-, BIOID: Aussel-20181211-1122-4124).

Description: See Senterre et al. (2019a: 55, [34]); Schnell (1952: 382): "Caractéristiques probables: *Utricularia subulata, Drosera indica, Eriocaulon pumilum, Xyris straminea, Pycreus capillifolis, Fimbristylis exilis, Cyperus pustulatus, Rhytachne rottboellioides* var. *guineensis* A. Camus et R. Schn., *Sporobolus Schnellii A.*Chev., *S. pauciflorus* A.Chev. Autres *espèces: Cyperus Haspan, Cyperus pustulatus, Bulbostylis trichobasis.* Toutes ces plantes sont très basses (de 3 à 15-20 cm. de hauteur)." "Ce groupement correspond à de petits marécages temporaires sur cuirasse, développés aux endroits recouverts d'une fine couche d'eau pendant plusieurs mois par an. Même par temps couvert, l'eau s'échauffe, dans la journée, au-dessus de la température de l'air. Une mince couche de terre (1-2 cm.) s'accumule entre les racines, à la surface de la dalle rocheuse; suivant sa composition, sa teinte varie du jaune (limon) au brun très foncé. Pour un tel sol très foncé le pH était de 5,4, et la composition granulométrique: gravier fin 16,41; sable grossier 29,91; sable fin 28,41; limon 16,95; argile 8,32."

Distribution: There is little data on the distribution of bowe in West Africa, but those are not particularly rare (Figure 5; Figure 6). Among those bowe, seasonal ironstone marshes are likely to be rarer.

RLE status: DD. Likely to have an AOO and EOO large enough, and little reduction in distribution, resulting in a non-threatened status.

[25] ***West African Saxicolous seasonal marsh grassland on ironstone of the Submontane tropical rainforest zone*** / *Prairie ouest africaine périodiquement marécageuse saxicole sur cuirasse ferrugineuse de la zone des Forêts tropicales submontagnardes* (Senterre, Bruno nov.). Type: Guinea: Pic de Fond (coordinates defined here); 8.5343; -8.8936; Schnell (1961: 32): Marécage de bowal, vers 1050 m: le milieu se distingue du précédent par la présence d'une fine couche d'eau limpide, avec un léger courant, à la surface de la dalle ferrugineuse affleurante. Les especes les plus representatives de cette prairie marécageuse sont: *Drosera indica*, *Neurotheca loesellioides*, *Adelostigma senegalensis*, *Utricularia subulata*, *U. pubescens*, *Burmannia bicolor*, *Fimbristylis* sp., *Pycreus* sp., *Cyperus esculentus*, *Rhytachne* sp. (*aff. rottboellioides*), *Panicum congoense*,... Sur des affleurements rocheux, vers 1100-1200 m, vit en abondance un *Cyanotis* à tiges et feuilles grèles, qui parait à rattacher à *C. longifolia* (var. *fonensis*); *Schnell, Raymond s.n.* (holo-, BIOID: 20200904145659).

Heterotypic synonyms:

Seasonal swamp vegetation (Cheek et al. 2006: 51). Type: Guinea: Simandou, Oueleba; 8.64; -8.89028; 1220 m; p.51: The wetland grass *Panicum aff. walense* was dominant (30-40 % cover, c. 30 cm tall), followed by several species of sedge (Cyperaceae), usually with perennating rootstocks, in order of ecological importance: *Nemum bulbostyloides*, *N. spadiceum*, *Pycreus capillifolius*, *Fimbristylis pilosa*, *Bulbostylis densa*, all but the last of which were not seen elsewhere on Simandou. Several dicotyledonous herbs, often annual, also occurred, such as *Xyris straminea*, *Eriocaulon* sp., *Polygala lecardii*, *Rotala stagnina*, *Commelina aspera* and *Adelostigma senegalensis*, almost all of which were found nowhere else in the survey. The bare rocks within the swamps supports several rock-specific species such as *Ctenium newtonii* (also seen in Wooded grassland on rock) and *Schizachyrium rupestre* and *Rhytachne rottboellioides*. Species of conservation interest: An annual *Eriocaulon* at the main Oueleba swamp may be of conservation importance since so many species of that genus are local and rare, but a flowering specimen is needed to identify it fully; *Kotschya micrantha*; *Nemum bulbostyloides*; *Cheek, Martin M29* (lecto-, designated here, BIOID: 20200907135549, in Cheek et al. 2006).

Végétation herbacée saxicole sur cuirasse ferralitique ou gravillonnaire (bowal) dans dépression humide de haute altitude (Aussel 2018: 32154). Type: Guinea: MG (coordinates defined by B. Senterre, 4/9/2020, based on Couch et al. 2019, TIPAS mapping); 10.38; -11.954; 980; Végétation herbacée saxicole sur cuirasse ferralitique ou gravillonnaire (bowal) dans dépression humide de haute altitude. Bowal temporairement humide, végétation hydrophile, floristiquement riche au dessus de 500m d'altitude. *Rhytachne rottboellioides*, *Bryaspis lupulina*, *Loudetiopsis tristachyoides*, *Nemum spadiceum*, *Anadelphia macrochaeta*, *Adelostigma senegalensis*, *Drosera indica*, *Nerophila gentianoides*, *Scleria* spp., *Burmannia madagascariensis*, *Utricularia spiralis*, *Eriocaulon* spp., *Xyris* spp.; *Aussel, Alexia s.n.* (neo-, designated here, BIOID: Aussel-20181211-2211-32154).

Description: According to Couch et al. (2019: 33), "micro-habitats[1]" of bowe are not well known, e.g. they mention for the "*Shallow basins with shallow water in the wet season*" of the "*High-Altitude Lateritic Bowal*" the characteristic species *Kotschya micrantha* and *Nemum bulbostyloides*. This description can be complemented by the descriptions provided above in the biotypes mentioned. Couch et al. (2019) record no less than 17 species of submontane bowe, in general, being endemic to Guinea (although bowe from other countries are likely less explored and less studied).

Distribution: Couch et al. (2019: 32): "The high-altitude lateritic bowal of the Fouta Djallon (Maps 2, 6, & 7) is often locally referred to simply as 'bowal' or 'bowé', since sandstone bowal is distinguished as 'kapété'. It is generally flat or gently sloping, sometimes with surface rocks. It covers large areas of the 'core' Fouta Djallon area and is particularly common around Dalaba and Boulivel, reaching 1200 m alt. In contrast, sandstone bowal is restricted to the Pita area and the western part of the Fouta Djallon. The high-altitude bowal of the Loma-Man Highlands is much smaller in total area (Map 6). It is mainly confined to the steeply sloping free-draining ridges, above the submontane forest of the Nimba and Simandou ranges (reaching 1,752 m and 1,658 m respectively). It appears to be absent from the Loma Mts and Tingi Hills, and from Mt Ziama. A small outcrop occurs on Mt Bero. It is often referred to as 'submontane grassland' or 'ferralitic mountain grassland'. The bowal of the ridge tops of Nimba and Simandou, unlike those of other locations, are formed over deep iron-rich rocks of sedimentary origin, making these attractive for iron-ore mining, depending on the purity of the iron.". We mapped approximately submontane bowe based on Couch et al. (2019: 31) map, reclassified according to the altitudinal threshold of 850 m rather than 500 (see Figure 6). Among those submontane bowe, ironstone wetlands are certainly much rarer and more localized, but detailed data are lacking.

RLE status: EN (DD-EN). Based on our mapping (see above), submontane bowe have an AOO of 215 (10x10 km occupied grid cells) and extend over an EOO of 145,252 km² (Figure 8). If we consider that marshes occur on less than 10 % of the bowe, this ecosystem type

[1] Note that according to our conception of ecosystemology (Senterre et al. in review), wetlands on bowe are not "microhabitats" of bowe but habitat-types on their own. Although their absolute spatial scale is very contracted, they represent the same relative scale as any other stand, e.g. a swamp forest of several hectares.

could be considered as EN according to criterion B2b (AOO<20 and inferred threatening processes due to climate change.

[26] ***West African Saxicolous seasonal marsh grassland on ironstone of the Montane tropical rainforest zone*** / *Prairie ouest africaine périodiquement marécageuse saxicole sur cuirasse ferrugineuse de la zone des Forêts tropicales montagnardes* (Senterre et al. 2019a: 57). Type: Guinea: Massif du Mont Nimba, Mare d'hivernage; 7.66086; -8.37986; 1602; *Senterre, Bruno & Bidault, Ehoarn BS61-63b* (holo-, BIOID: BS61-20191007-1453-63b).

Heterotypic synonyms:

Terre humide de haute altitude / high-altitude wetland (Golder 2013: 13). Type: Guinea: Mount Nimba; *Golder s.n.* (holo-, BIOID: Golder-20130101-1639-13).

Groupement à Panicum pusillum var. glabriglumatum (Schnell 1952: 384). Type: Guinea: Mont Nimba; *Schnell, Raymond s.n.* (holo-, BIOID: Schnell-19520101-1251-384).

Groupement à Xyris decipiens (Schnell 1952: 384). Type: Guinea: Mont Nimba; *Schnell, Raymond s.n.* (holo-, BIOID: Schnell-19520101-1017-384).

Description: Schnell (1952: 384): "Groupement *Panicum pusillum* var. *glabriglumatum* R. Schn.: cette Graminée, dominante, y est associée à *Panicum congoense*, *Bulbostylis trichobakis*, *Habenaria anaphysema*, *Xyris straminea*, *Cyanotis rupicola*, *Genlisea africana*.".

Distribution: Possibly endemic to Mount Nimba, and restricted to a single site (see biotype).

RLE status: CR according to Senterre et al. (2019a).

III.1.6.7 Freshwater swamps

[27] ***West African Swamp forest of the Tropical lowland superhumid evergreen rainforest zone*** / *Forêt ouest africaine marécageuse de la zone des Forêts tropicales superhumides sempervirentes de plaine* (Senterre, Bruno nov.). Type: Liberia: Dugbe HummingBird site (Sinoe County, ca. 20 km South of Sapo National Park, ca. 50 km East of Greenville), East of old Sackor village; 5.09886; -8.56369; 148 m; *Senterre, Bruno HB-33* (holo-, BIOID: 185bccb5-ad1a-412d-9ceb-44b51eff8f3a).

Homotypic synonyms:

Swamp forests of the wet evergreen littoral rain forest zone (Senterre 2014: 21).

Other virtual ecosystemic specimens:

Liberia: Lake Piso, Zoi (Google Earth); 6.78649; -11.23967; 8; The site observed here on Google Earth possibly corresponds to that and seems an interesting area to visit because of its apparent good conservation state and complexity of wetland-upland gradients, beyond coastal influence and within the superhumid bioclimatic zone; *Senterre, Bruno 20200812082928* (para-, BIOID: 20200812082928).

Description: According to Siaffa Sambolah (2007): "The inland wetlands ecosystem is found beyond 8–10 kilometers from the seashore. This ecosystem is mainly characterized by non-brackish streams, creeks and ponds, *Raphia* palm and *Mitragyna* species.".

Distribution: Spread within the area mapped in Figure 7a, but detailed data lacking.

RLE status: DD (DD-EN). Criteria A, C and D need to be evaluated, but are DD. This type of ecosystem is potentially threatened, simply based on the reduction in distribution of lowland superhumid rainforests in general (Figure 7a; see also [39]), depending on the relative deforestation for swamps (for agriculture) compared to mesic lands (for timber).

[28] ***West African Swamp forest of the Lowland tropical perhumid moist evergreen rainforest zone*** / *Forêt ouest africaine marécageuse de la zone des Forêts tropicales perhumides sempervirentes de plaine* (Senterre et al. 2019a: 37). Type: Guinea: Massif du Mont Nimba, rivière Ya; 7.59357; -8.46403; 622; *Senterre, Bruno & Bidault, Ehoarn BS61-78* (holo-, BIOID: BS61-20191011-1125-78).

Heterotypic synonyms:

Raphia palma-pinus swamps (Jongkind 2007: 23). Type: Liberia; North Lorma National Forest, Lawa River, Site 1; 8.0258; -9.7319; 390; In low areas between the hills several *Raphia palma-pinus* swamps occurred, with other swamp plants like *Halopegia azurea*; *Jongkind, Carel s.n.* (holo-, BIOID: 20200807181635).

Swamp Forest of the Evergreen Forest Zone (Voorhoeve 1965: 21). Type: Liberia; Gola-Mano; *Mitragyna ciliata* is often a dominant species in this forest, accompanied by *Heritiera utilis* and *Gilbertiodendron splendidum*. *Nauclea* aff. *Vanderguchtii* is frequently found with *Mitragyna ciliata* and is more or less restricted to the evergreen zone; *Voorhoeve, Alexander George 20200807165710* (neo-, designated here, BIOID: 20200807165710).

Other virtual ecosystemic specimens:

Liberia: West Nimba, Gangra, site DBSF05; 7.55844; -8.63052; 710; Swampy (SW); p.26: in the valley lands, with abundance of swamp pioneers like *Hallea ledermannii* and *Voacanga thouarsii* which are less common in less secondary riverine forest; p.30: *Hallea ledermanii* a tree characteristic of secondary, often clayey, swampy lands; p. 28: Figure 18 *Garcinia epunctata*, a small tree of swampier forests. *Gilbertiodendron limba* and *G. preussii* are similarly distributed; *Hawthorne, William D. DBSF05* (BIOID: 20200813153827, in Hawthorne et al. 2010).

Sierra Leone: Gola North, Mogbai catchment and the floodplains around the Kwadi and Makoi Rivers; 7.65; -10.8667; *Klop, Erik s.n.* (BIOID: 20200810180923, in Klop et al. 2008).

Sierra Leone: Gola East, site 4, Mahoi; 7.3666; -11.2; ; *Raphia*-palm swamps in poorly drained areas; Wet swamps of Gola east and west: *Gilbertiodendron* spp. and *Mitragyna stipulosa* (Small 1953); *Davies, A. Glyn s.n.* (BIOID: 20200810184839, in Davies 1987).

Description: Bioclimatic variability of swamp forests is poorly known. Indicator species used so far in studies are too focused on trees. It is indispensable to extend those studies to include understorey ground and epiphyte herbs, and possibly some animal groups such as invertebrates, amphibians, etc.

Distribution: Spread within the area mapped in Figure 7b, but detailed data lacking. More common in non-mountainous landscapes, e.g. plains or gentles hills.

RLE status: EN (DD-EN) according to Senterre et al. (2019a).

[29] ***West African Swamp forest of the Submontane tropical perhumid moist evergreen rainforest zone*** / *Forêt ouest africaine marécageuse de la zone des Forêts tropicales perhumides sempervirentes submontagnardes* (Senterre et al. 2019a: 40). Type: Guinea: Massif du Mont Nimba, Seringbara; 7.58525; -8.44726; 1100; Site non-observé, mais identifié sur Google Earth; *Senterre, Bruno & Bidault, Ehoarn BS61-64d* (holo-, BIOID: BS61-20191008-1306-64d).

Description: Poorly known, not observed so far although expected in the Mount Nimba (see Senterre et al. 2019a: 40).

Distribution: Considering the distribution of perhumid submontane areas (Figure 7d), this type of ecosystem is certainly very rare. We have identified a possible site in the SW of Mount Nimba (Senterre et al. 2019a). Other sites could be searched in the SW of the Ziama.

RLE status: EN according to Senterre et al. (2019a).

[30] ***West African Swamp forest of the Lowland tropical humid moist seasonal semi-deciduous rainforest zone*** / *Forêt ouest africaine marécageuse de la zone des Forêts tropicales humides saisonnières semi-décidues de plaine* (Senterre et al. 2019a: 44). Type: Guinea: Massif du Mont Nimba, Monts des Génies; 7.71312; -8.36107; 550; *Senterre, Bruno & Bidault, Ehoarn BS61-47b* (holo-, BIOID: BS61-20191004-1553-47b).

Heterotypic synonyms:

Terre humide de basses terres / rizière / lowland wetland / rice field (Golder 2013: 5). Type: Guinea: Mount Nimba; *Golder s.n.* (holo-, BIOID: Golder-20130101-2235-5).

Lowland moist riverine / groundwater forest (Astron 2019: 2). Type: Guinea: Mount Nimba; *Astron s.n.* (holo-[2], BIOID: Astron-20190101-1311-2).

Forêts marécageuses à Uapaca paludosa et Mitragyna ciliata (Schnell 1952: 363). Type: Guinea: Mont Nimba; *Schnell, Raymond s.n.* (holo-, BIOID: Schnell-19520101-1020-363).

Swamp Forest of the Moist Semi-deciduous Forest Zone (Voorhoeve 1965: 21). Type: Liberia: same as for evergreen zone but without *Nauclea* aff. *Vanderguchtii*; *Voorhoeve, Alexander George s.n.* (holo-, BIOID: 20200807170127).

Forêt marécageuse sur sol hydromorphe (Aussel 2018: 3151). Type: Guinea: GM, GF; *Aussel, Alexia s.n.* (holo-, BIOID: Aussel-20181211-0722-3151).

Description: Schnell (1952: 363, 395): "Les forêts de ces bas-fonds, remarquables par leurs racines échasses *(Uapaca)* et aérifères *(Mitragyna)*, comportent un groupement caractérisé par: *Uapaca paludosa. Macaranga rosea, Mitragyna ciliata, Gardenia imperial, Raphia Hookeri, Guyonia tenella, Halopegia azurea.* Autres espèces rencontrées: *Xylopia aethiopica, Cleistopholis patens, Peddiea zenkeri, Pentadesma butyracea, Aframomum longiscapum, Ancistrophyllum secundiflorum*, etc.". "Leur sol, imprégné d'eau, est à prédominance sableuse (pour l'un d'eux, boisé: débris végétaux: 7,35 %; matière organique: 9,25; gravier fin: 11,6; sable grossier: 29,35; sable fin: 36,25; limon: 1,75; argile: 4,45). Même par temps ensoleillé, le déficit de saturation reste faible dans le sous-bois (2,6 dans le thalweg boisé du Blanmbaya, le 14 septembre 1947, à 16 heures, avec une hygrométrie de 87,6 % et une température des 25° contre 4,8, 82,5 % et 25° dans la forêt des versants, et 7,5, 74,5 % et 27° dans la savane voisine)".

Distribution: Widespread within the lowland humid zone, although largely converted for agriculture.

RLE status: **CR** (EN-CR) according to Senterre et al. (2019a).

[31] ***West African Swamp forest of the Submontane tropical humid moist seasonal semi-deciduous rainforest zone*** / *Forêt ouest africaine marécageuse de la zone des Forêts tropicales humides saisonnières semi-décidues submontagnardes* (Senterre et al. 2019a: 48). Type: Guinea: Massif du Ziama, route du Mont Kinadou; 8.35445; -9.32521; 867; Rizières de bas fond; *Senterre, Bruno & Konate, Lansana BS61-20190922-1259-4* (holo-, BIOID: BS61-20190922-1259-4).

Description: Schnell (1952: 363, 395): "Quelques espèces non marécageuses sont intrusives (sous forme généralement de jeunes individus), différenciant ces bas-fonds de ceux, plus constamment humides, de régions plus basses. Les blocs rocheux émergeant du sol portent

[2] Not "neo-, designated here" because I am not adding any information to the original map. If I added exact coordinates to explicit, to me, what Astron most typically ment, then the undetailed original holobiotype would have been replaced by a new one, i.e. a neobiotype.

une végétation hygrophile banale: *Coleus repens, Bolbitis salicina, B. aerostichoides, Selaginella*, Bryophytes.".

Distribution: Very rare in the NE of Mount Nimba, according to Schnell (1952: 363, 395); we observed one site (degraded) in the NE Ziama, and a few others are suspected (Senterre et al. 2019a: 48).

RLE status: **EN** (VU-EN) according to Senterre et al. (2019a).

III.1.6.8 Seasonal swamp on ironstone rock sheet (Ge.)

[32] ***West African Swamp dwarf forest on ferruginous shield of the Montane tropical humid moist seasonal semi-deciduous rainforest zone*** / *Forêt ouest africaine naine marécageuse sur cuirasse ferrugineuse de la zone des Forêts tropicales humides saisonnières semi-décidues montagnardes* (Senterre et al. 2019a: 51). Type: Guinea: Massif du Mont Nimba, Mare d'hivernage; 7.66066; -8.37846; 1614; *Senterre, Bruno & Bidault, Ehoarn BS61-62* (holo-, BIOID: BS61-20191007-1430-62).

Description: Poorly known; *Craterispermum laurinum* is abundant; ironstone not visible, covered by a thin layer of organic matter (see Senterre et al. 2019a).

Distribution: Only known from the type locality, and therefore endemic to Mt. Nimba.

RLE status: CR according to Senterre et al. (2019a).

III.1.6.9 Riparian forest on alluvial soil (Ge.)

[33] ***West African Riparian forest of the Tropical lowland superhumid evergreen rainforest zone*** / *Forêt ouest africaine ripicole de la zone des Forêts tropicales superhumides sempervirentes de plaine* (Senterre, Bruno nov.). Type: Liberia: Dugbe HummingBird site (Sinoe County, ca. 20 km South of Sapo National Park, ca. 50 km East of Greenville), north of the road from Dugbe to Tuzon; 5.0966; -8.51888; 77 m; *Senterre, Bruno HB2-913* (lecto-, designated here, BIOID: d1391fb0-ca68-44fe-baa9-e1cc1b6b83c1).

Homotypic synonyms:

Riparian forests of the wet evergreen littoral rain forest zone (Senterre 2014: 23).

Description: Poorly known, generally undifferentiated from riparian forests of the perhumid zone, but based on insufficient data.

Distribution: On the side of large rivers located within the superhumid lowland zone; probably not uncommon and relatively well preserved but detailed data are lacking.

RLE status: DD. Criteria A and B insufficiently known, and criteria C and D even more so.

[34] ***West African Riparian forest of the Lowland tropical perhumid moist evergreen rainforest zone*** / *Forêt ouest africaine ripicole de la zone des Forêts tropicales perhumides sempervirentes de plaine* (Senterre et al. 2019a: 37). Type: Guinea: Massif du Mont Nimba, rivière Ya; 7.59207; -8.46534; 611; *Senterre, Bruno & Bidault, Ehoarn BS61-77* (holo-, BIOID: BS61-20191011-1120-77).

Heterotypic synonyms:

River-side forest (Hawthorne et al. 2010: 10, 38). Type: Liberia: West Nimba; 500; p.10: River-side forest (RS): banks of large rivers; p.38: *Stelecantha ziamaeanum* (Figure 29) is a particularly frequent shrub along rivers and in swampy parts of the landscape in the Liberian foothills, and is much less so in Guinea – it does occur in some riverine samples there, but a lower proportion of the Guinean samples were in flat lowland forest. *Strephonema pseudocola* is similarly a very common tree in the Liberian low-lying, riverine and lower slope samples (also in several patches of secondary forest), but is not represented in the Guinea samples; *Hawthorne, William D. s.n.* (holo-, BIOID: 20200813155845).

Galerie forestière (Diabaté et al. 2019a: 16). Type: Liberia: Wologizi, Luyema, Placette 18; 8.05747; -9.71246; 393; Galerie forestière: Formation végétale de type édaphique le long des cours d'eau, fermée (85% à 95%) à des endroits et fortement ouvertes à d'autres endroits (45% à 65%). Formation caractérisée par trois strates bien distinctes qui sont : la strate supérieure avec une hauterur variant entre 5 à 20 m, la strate moyenne avec une hauteur comprise entre 1,50 à 5 m et la strate inférieure avec une hauteur comprise entre 0 à 1,50 m. Quelques espèces caractéristiques sont : *Raphia hockerii*, *Uapaca* spp., *Cathormion altissimum*, *Pseudospondias microcarpa*, *Pterocarpus santalinoides*; *Diabaté, Moussa s.n.* (lecto-, designated here, BIOID: 20200812094236).

River border Forest of the Evergreen Forest Zone (Voorhoeve 1965: 21). Type: Liberia: riparian species are *Cathormion altissimum*, *Monopetalanthus pteridophyllus* (in the moist semi-deciduous zone replaced by *M. compactus*), *Plagiosiphon emarginatus* (a small tree with blunt spines on the bole), *Gluema ivorensis* and, locally gregarious, *Pandanus* sp.; *Voorhoeve, Alexander George s.n.* (holo-, BIOID: 20200807170321).

Other virtual ecosystemic specimens:

Liberia: North Lorma National Forest, Lawa River; 8.03166; -9.73583; 390; Riverine forest with abundant *Plagiosiphon emarginatus* mixed with many wet evergreen forest species such as *Achyrospermum oblongifolium*, *Costus deistelii*, *Cryptosepalum tetraphyllum*, *Mapania* spp., *Strephonema pseudocola* and *Triphyophyllum peltatum*, the latter mixed with many more widespread forest species; *Jongkind, Carel s.n.* (BIOID: 20200807175239, in Jongkind 2007).

Sierra Leone: Gola East, site 4, Mahoi, 200m away from the Mahoi river, on a small tributary; 7.3666; -11.2; The area was flat, low lying and probably partly flooded when the Mahoi was in spate during the rainy season; *Davies, A. Glyn s.n.* (BIOID: 20200810184402, in Davies 1987).

Description: See descriptions from the biotypes.

Distribution: Widely distributed within the lowland perhumid zone (Figure 7b).

RLE status: VU according to Senterre et al. (2019a).

[35] ***West African Riparian forest of the Lowland tropical humid moist seasonal semi-deciduous rainforest zone*** / *Forêt ouest africaine ripicole de la zone des Forêts tropicales humides saisonnières semi-décidues de plaine* (Senterre et al. 2019a: 45). Type: Guinea: Massif du Mont Nimba, Monts des Génies; 7.70584; -8.36338; 601; Petite forêt ripicole à rebords alluviaux de 5-20 m de large; *Senterre, Bruno & Bidault, Ehoarn BS61-45* (holo-, BIOID: BS61-20191004-1450-45).

Heterotypic synonyms:

Forêt galerie de basses terres dégradé / degraded lowland gallery forest (Golder 2013: 6). Type: Guinea: Mount Nimba; *Golder Golder-201311-440-6* (holo-, BIOID: Golder-20130101-0440-6).

River border Forest of the Moist Semi-deciduous Forest Zone (Voorhoeve 1965: 21). Type: Liberia: *Monopetalanthus pteridophyllus* is replaced by *M. compactus*; *Voorhoeve, Alexander George s.n.* (holo-, BIOID: 20200807170902).

Gallery forest (Couch et al. 2019: 19, 49). Type: Guinea: Guinée Maritime; *Couch, Charlotte s.n.* (holo-, BIOID: 20200812163333).

Forêt galerie périodiquement inondée sur sol hydromorphe profond guinéenne (Aussel 2018: 31312). Type: Guinea: MG, GF, GM; Le substrat est fait d'alluvions sablo-argileuses. La forêt est périodiquement submergée par la crue du cours d'eau. *Raphia sudanica*, *Uapaca heudelotii*, *Cathormion altissimum*, *Samanea dinklagei*, *Pseudospondias microcarpa*, *Gardenia imperialis*, *Pterocarpus santalinoides*, *Carapa procera*, *Syzygium guineense*, *Pentadesma butyracea*, *Cleistopholis patens*, *Myrianthus arboreus*, *Macaranga heterophylla*, *Anthostema senegalensis*, *Erythrophleum suaveolens*; *Aussel, Alexia s.n.* (holo-, BIOID: Aussel-20181211-0436-31312).

Paratypic synonyms (p.p. synonyms):

Galerie forestière (Diabaté et al. 2019b: 16). Guinea: Ziama, Massadou; 8.3587; -9.4158; 528; Formation végétale plus ou moins fermée, édaphique bordant les cours d'eau. La hauteur des arbres de la strate supérieure varie entre 7 à 20 m, celle de la strate moyenne est de 1,75 à 6 m et la hauteur de la strate inférieure est comprise entre 0 à 1,50 ; *Diabaté, Moussa s.n.* (para-, BIOID: 20200812104501).

Description: Bioclimatic distinction with riparian forests of the perhumid and superhumid zones is poorly known and has been little studied, with a focus on trees only.

Distribution: Widely distributed within the lowland humid zone (Figure 7c). In Mount Nimba, we have observed them near rivers corresponding to a flow accumulation of at least 675 ha (upstream water catchment area).

RLE status: EN (DD-EN) according to Senterre et al. (2019a).

III.1.7 Inland (non-coastal) upland (Or.)

This category includes the vast majority of land areas, i.e. everything that is not coastal and not wetland. It excludes temporary wetlands (treated as wetlands), which by definition are also temporary dry uplands.

III.1.7.1 Pyrophilic disclimax herb-savanna on mesic landform (Ge.)

[36]***African Pyrophilic disclimax savanna of the Lowland tropical rainforest zone*** / *Savane africaine pyrophile disclimacique de la zone des Forêts tropicales de plaine* (Senterre et al. 2019a: 58). Type: Guinea: Massif du Mont Nimba, NE; 7.70869; -8.45839; 519; Non-observé directement mais sur une image Google Earth du 31/12/2017; *Senterre, Bruno & Bidault, Ehoarn BS61-26h* (holo-, BIOID: BS61-20191001-1606-26h).

Heterotypic synonyms:

Savane de basses terres / lowland savanna (Golder 2013: 15). Type: Guinea: Mount Nimba; *Golder s.n.* (holo-, BIOID: Golder-20130101-1722-15).

Lowland Guinea savanna (Astron 2019: 15). Type: Guinea: Mount Nimba; *Astron s.n.* (holo-, BIOID: Astron-20190101-0230-15).

Groupement à Hyparrhenia diplandra et Loudetia arundinacea (Schnell 1952: 380). Type: Guinea: Mont Nimba; Caractéristiques probables: *Terminalia glaucescens*, *Bridelia ferruginea*, *Hyparrhenia diplandra*, *Scleria canaliculotriquetra*, *Aedesia glabra*. Autres espèces de ces savanes: *Sarcocephalus esculentus*, *Aspilia helianthoides*". "Savanes dégradées pyrophiles […] Ce groupement est réalisé dans les savanes arborées des bas contreforts. I1 vit sur un sol meuble, plus ou moins épais (quelques décimètres à plusieurs mètres), recouvrant la cuirasse, et ayant une composition d'arène argileuse. Ces savanes sont parcourues chaque année par les feux. Leur vie active correspond à la saison humide; *Schnell, Raymond s.n.* (holo-, BIOID: Schnell-19520101-1629-380).

Description: This type of ecosystem has been responsible for a considerable amount of confusion and debates throughout the literature on the vegetation of Africa. It extends over a vast area looking like a bioclimatic belt, giving it a look of regional ecosystem. On the other hand, it shows also local spatial patterns that contradict the idea of a regional ecosystem, i.e. what has often been called the forest-savanna mosaic. Our conceptual approach to ecosystemology allows clarifying the conceptualization of this type of ecosystem: see Senterre et al. (2019a: 31). Humans have been around for quite a while, throughout the Quaternary, coevolving with ice ages and natural-non-natural forest or bush fires (Archibald et al. 2012; Bodini and Clerici 2016; Gowlett 2016). Of course, the fire belt is correlated with bioclimates, but fires remain a local ecosystemic factor, i.e. a stand scale factor, even though the absolute spatial scale of pyrophilic disclimaxes can sometimes be very large. Where fires are regularly occurring, the ecosystem is a disclimacic one. Where fires have stopped, the ecosystem follows a primary progression, slowly rebuilding the climax corresponding to the undisturbed stand, going through intermediate stages which are progressive shrubby and then wooded savannas, sharing biotic elements with dryer bioclimatic belts. Where fires have just recently destroyed the forest repeatedly, soil erosion and sun baking can lead to a primary retrogression, i.e. to a state of apparently stable savanna rather than just a normal pioneer bush. The chaotic pattern of the forest-savanna mosaic is due to the partly random and partly human/ethnic determinism on the space-time patterns of fires and non-fires. In addition, just to make things more complicate, in some places the forest-savanna mosaic does reflect polyclimacic stand gradients, e.g. the northernmost so-called gallery forests (beyond the Guineo-Congolian region). According to Schnell (1952: 358), the disclimacic nature of the savannas found at the foot of the Mont Nimba is supported by the poverty of their tree flora, lacking most of the characteristic species of the climatic Guinean savannas, further North.

Distribution: Widespread in West Africa and beyond; see grasslands, shrublands and woodlands of the perhumid to subhumid bioclimatic zones (Figure 3 & Figure 4).

RLE status: LC according to Senterre et al. (2019a).

[37]***African Pyrophilic disclimax savanna of the Submontane tropical rainforest zone*** / *Savane africaine pyrophile disclimacique de la zone des Forêts tropicales submontagnardes* (Senterre et al. 2019a: 59). Type: Guinea: Massif du Mont Nimba, Vallée de la Zouge; 7.67891; -8.3854; 989; grandes herbes indiquant le caractère dégradé, sol caillouteux argilleux rouge, sur horizon gravillonnaire; *Senterre, Bruno & Bidault, Ehoarn BS61-13* (holo-, BIOID: BS61-20191001-0825-13).

Heterotypic synonyms:

Savane submontagnarde (Poilecot & Loua 2009: 55). Type: Guinea: Mont Nimba; Le peuplement ligneux, très ouvert, est constitué d'espèces communes aux savanes de piémont auxquelles est associé un arbuste grégaire, *Protea madiensis* subsp. *occidentalis*, qui disparaît ensuite aux plus hautes altitudes. Les savanes submontagnardes, à partir de 800-900m, occupent des sols généralement minces recouvrant une roche ferrugineuse, très dure et souvent plissée; *Poilecot, Pierre s.n.* (holo-, BIOID: Poilecot-20090101-1807-55).

Savane de moyenne altitude / medium-altitude savanna (Golder 2013: 16). Type: Guinea: Mount Nimba; *Golder s.n.* (holo-, BIOID: Golder-20130101-1329-16).

Nimba medium altitude savanna (Astron 2019: 16). Type: Guinea: Mount Nimba; *Astron s.n.* (holo-, BIOID: Astron-20190101-0331-16).

Prairie altimontaine/ prairie sub-montagnarde (Aussel 2018: 3213). Type: Guinea: GF, Massif du Nimba, Simandou (Rio Tinto); *Aussel, Alexia s.n.* (holo-, BIOID: Aussel-20181211-0415-3213).

Savane arbustive sur sol mince de montagne (Aussel 2018: 33221). Type: Guinea: GF; *Aussel, Alexia s.n.* (holo-, BIOID: Aussel-20181211-0042-33221).

Description: Schnell (1952: 394): "I1 existe plusieurs variantes du groupement prairial, ayant probablement la valeur d'unités phytosociologiques, caractérisées respectivement par *Protea angolensis*, *Syzygium guineense* var. *macrocarpa*, *Euphorbia depauperata* ...". See also biotypes' notes above.

Distribution: Mount Nimba, Pic de Fon, South of Fouta Djalon.

RLE status: LC according to Senterre et al. (2019a).

[38]***African Pyrophilic disclimax savanna of the Montane tropical rainforest zone*** / *Savane africaine pyrophile disclimacique de la zone des Forêts tropicales montagnardes* (Senterre et al. 2019a: 59). Type: Guinea: Massif du Mont Nimba, Pierre Richaud; 7.67302; -8.36495; 1575; Non-observé directement mais sur une image Google Earth du 24/1/2013; *Senterre, Bruno & Bidault, Ehoarn BS61-26i* (holo-, BIOID: BS61-20191001-1607-26i).

Heterotypic synonyms:

Eriosemeto-Loudetietum Kagerensis (prairie montagnarde) (Schnell 1952: 397). Type: Guinea: Mont Nimba; *Schnell, Raymond s.n.* (holo-, BIOID: Schnell-19520101-2005-397).

Description: Schnell (1952: 397): "Dans l'étage montagnard, la dégradation de la végétation par les feux parait se faire en général suivant le schéma suivant: Forêt à *Parinari excelsa*; Forêt éclaircie à sous-bois secondaire; *Dissoteto-Setarietum Chevalieri*; *Eriosemeto-Loudetietum Kagerensis* (prairie montagnarde). On notera l'homologie qui existe entre certains groupements montagnards et planitiaires: *Setarietum Chevalieri* et *Dissoteto-Setarietum Chevalieri*, *Loudetietum arundinaceae* et *Eriosemeto-Loudetietum kagerensis*." "Dans la prairie voisine, la température varie, en saison des pluies, de 14 à 22 ° (19 ° par temps de brouillard), avec une hygrométrie de 90 à 100 % et un déficit de saturation de 0 à 1,7 mm. En saison sèche, la température de l'air, en prairie, varie de 15 à 26 ° et même 27° avec une hygrométrie de 40 à 90 % et un déficit de saturation s'é1evant parfois jusqu'à 13 mm. Les brouillards, persistants en saison des pluies, égalisent les microclimats de la prairie et du sous-bois forestier.".

Distribution: In West Africa, montane savannas are found at Mount Nimba and Pic de Fon. Pyrophilic disclimax savannas also occur on other ridges of the African mountains at the periphery of the Guineo-Congolian region (in humid-subhumid zones), also dominated by *Loudetia kagerensis*, e.g. in East Africa and Angola (Thomas 1941; Fischer 2013: 25). Some of those montane savannas are found within montane forests dominated by *Parinari excelsa*, in a way very similar to the situation observed at Mont Nimba (Schnell 1979, in East Kivu: 130; Bizuru et al. 2014). We therefore consider this type of ecosystem as being widespread in tropical Africa.

RLE status: LC according to Senterre et al. (2019a).

III.1.7.2 Mesic forest (Ge.)

[39]***West African mesic forest of the Tropical lowland superhumid evergreen rainforest zone*** / *Forêt ouest africaine mésique de la zone des Forêts tropicales superhumides sempervirentes de plaine* (Senterre, Bruno nov.). Type: Liberia: Dugbe HummingBird site (Sinoe County, ca. 20 km South of Sapo National Park, ca. 50 km East of Greenville), North of "Killer Mountain", ca. 1,3 km East of Sackor village; 5.0798; -8.57217; 144 m; *Senterre, Bruno HB-20* (holo-, BIOID: 16334f9f-458e-4bc7-802a-a0c2d59aaa31).

Homotypic synonyms:

Mesophilous forests of the wet evergreen littoral rain forest zone (Senterre 2014: 15).

Heterotypic synonyms:

Highland montane forest (Siaffa Sambolah 2007). Type: Liberia: Lake Piso, Cape Mount Forest; *Siaffa Sambolah, Richard s.n.* (holo-, BIOID: 20200812084725).

Paratypic synonyms (p.p. synonyms):

Evergreen Forest Zone (Voorhoeve 1965: 21). Liberia: Robertsport (location identified using map at page 10); 6.7287; -11.3556; *Voorhoeve, Alexander George s.n.* (para-, BIOID: 20200805172123).

Other virtual ecosystemic specimens:

Liberia: Cestos-Senkwen National Park; 5.351; -9.311; p.39: only place where littoral forest remains untouched in West Africa; *Verschuren, Jacques s.n.* (BIOID: 20200811100517, in Verschuren 1983).

Description: These forests are tall (> 30 m) and their canopy is undulated. The species composition appears to be quite variable from site to site, with many species known from only a few locations and thus of little or no value as indicators, or with an unresolved vegetation pattern linked to smaller environmental variations (Jongkind 2014: 6). Indeed, some studies tend to demonstrate that mesic conditions (i.e. an absence of limiting factors) allow usually fewer important factors to have more importance on vegetation patterns (Pansonato et al. 2013). The influence of such factors is otherwise masked or attenuated by the dominance of one or more limiting factors (Rübel 1935; Senterre 2005: 62). Therefore, a portion of the observed floristic variability might result from undetected environmental patterns (non-macroscopic factors such as soil properties, etc.). There is also no doubt that mesic conditions allow for the coexistence of a larger number of less specialized species, resulting in a greater influence of dispersal limitations and chance (see neutral theories, Hubbell 2001). There are, however, some useful indicators of the superhumid mesic forests. As suggested by Jongkind (2014), it is rarely a case of the strict presence (or absence) of species that could be considered as indicators (the 'differential' species of phytosociologists), but rather their abundance vs. rarity combined with their occurrence (or not) in azonal habitat-types. The most characteristic species of the mesic forests include *Sacoglottis gabonensis*, found abundant outside of ravines (Schnell 1952: 337; Senterre 2005: 224). Nevertheless, it is clear that the best indicator species should be searched with more focus on the understorey flora, especially ground herbs and epiphytes (e.g. *Didymoglossum liberiense*, lowland *Crepidomanes* spp.).

Distribution: Mostly found in Liberia (Cestos-Senkwen, Grand Kru, South of Grebo and on Cape Mount Forest of Lake Piso), also in the southern part of the Taï National Park (Ivory Coast) and in the South-West of Ghana (Figure 7a). According to Jongkind (2007), the superhumid lowland rainforests do not reach the Gola-Mano and Kpelle KBAs, although the transition zone is not far from their southern limit.

RLE status: EN. This type of ecosystem is the most widespread/typical of the lowland superhumid zone. We produced here the same analysis as previously done by Senterre et al (2019a) for the perhumid and humid zones. This type of ecosystem can be considered at least VU according to the criterion A2b (30-50% reduction over 50 ans) (Table 1). Nevertheless, most of these forests are concentrated in Liberia, and if deforestation in that country continues at the same pace (Absolute Rate of Decline, ARD), the rate of decline would be close to 50%, which would lead to a threat status category EN (same criterion). When using criterion B (restricted distribution), this ecosystem can be considered LC.

[40] ***West African mesic forest of the Lowland tropical perhumid moist evergreen rainforest zone** / Forêt ouest africaine mésique de la zone des Forêts tropicales perhumides sempervirentes de plaine* (Senterre et al. 2019a: 35). Type: Liberia: Massif de Wologizi, pentes du Mt. Wuteve; 8.12976; -9.94828; 756; Forêt mésique, sol profond rocailleux, rouge, schiste, pas de laterite; *Senterre, Bruno & Konate, Lansana BS61-84* (holo-, BIOID: BS61-20191016-0828-84).

Heterotypic synonyms:

Forêt ombrophile de l'étage inférieur à Tarrietia utilis et Lophira procera (Schnell 1952: 365). Type: Guinea: Mont Nimba, localisé dans les régions basses du Nimba S.O. (particulièrement sur les basses pentes, à sol schisteux, dominant la vallée du Ya), c'est-à-dire dans une région à pluviosité forte; 7.51407; -8.54726; *Schnell, Raymond s.n.* (holo-, BIOID: Schnell-19520101-0354-365).

Evergreen Forest Zone (Voorhoeve 1965: 21). Type: Liberia: Gola North (location identified using map at page 10); 7.83; -10.37; Evergreen Forest Zone: Mixed form: Characteristic are such species as *Lophira alata* in the story of emergent trees, *Heritiera utilis*, *Sacoglottis gabonensis*, *Calpocalyx aubrevillei* and *Dialium* spp. in the closed canopy and lower stories. The single dominant forests are characterized by the dominance of one single species: *Cynometra ananta* or *C. leonensis*, *Gilbertiodendron preussii*, *Monopetalanthus compacta*, *Parinari excelsa*, *Tetraberlinia tubmaniana*. This dominance may be most evident in the upper canopy (*Parinari* forest, *Gilbertiodendron* forest), in the middle story (*Chidlowia sanguinea* forest, *Stachyothyrsus stapfiana* forest) or in all stories (*Tetraberlinia* forest); *Voorhoeve, Alexander George s.n.* (lecto-, designated here, BIOID: 20200805171908).

Forêt humide sempervirente / moist evergreen forest (Golder 2013). Type: Guinea: Mont Nimba; *Golder s.n.* (holo-, BIOID: Golder-20130101-1917-1).

Moist evergreen forest (Astron 2019: 1). Type: Guinea: Mount Nimba; *Astron s.n.* (holo-, BIOID: Astron-20190101-1700-1).

Forêt dense humide de moyenne altitude (forêt de flanc de montagne ou sub montagnarde) (Diabaté et al. 2019a: 15). Type: Liberia: Wologizi, Wobeyamai, Placette 4; 8.16667; -9.97854; 727; Formation végétale climacique plus ou moins fermée (65% à 80%), sur flanc des montagnes avec une élévation supérieure de 650 m, sol peu profond et mince. Formation végétale caractérisée par une strate supérieure peu haute (6 à 15 m), une strate moyenne de 1,5 à 6 m et une strate inférieure de 0 à 1,5 m. Les espèces caractéristiques de ce type de formation sont: *Parinari excelsa*, *Benophora coffoides*, *Diospyros* spp., *Hymenocardia lyrta*, *Caloncoba echinata*; *Diabaté, Moussa s.n.* (lecto-, designated here, BIOID: 20200812092547).

Forêt dense humide de basse altitude (Diabaté et al. 2019a: 15). Type: Liberia: Wologizi, Luyema, Placette 17; 8.15561; -9.99541; 390; Formation végétation climacique fermée (75% à 90%) située à une altitude de moins de 300 à 550 m ; mais les strates arborées (20 à 40 m) et arbustives (3 à 10 m) sont élevées, la strate herbacée est représentée par des espèces à feuilles large. Quelques espèces dominantes sont : *Lophira alata*, *Heritiera utilis*, *Anopyxis klaineana*, *Lovoa trichilioides*; *Diabaté, Moussa s.n.* (lecto-, designated here, BIOID: 20200812093536).

West African Lowland Evergreen Forest (Couch et al. 2019: 71). Type: Guinea: Diécké Classified Forest; 7.535; -8.937; 420; *Couch, Charlotte s.n.* (lecto-, designated here, BIOID: 20200812154308).

Guinea Moist evergreen forest (Hawthorne et al. 2010: 10, 31, 39). Type: Liberia: West Nimba, Gangra, site DBSL07; 7.55577; -8.62457; 610; Flat Land (FL), Nuveg6 includes forest that is the typical of the flatter lands (410-720m), around the lower slopes of the mountains and is the predominant forest type of the western part of our survey area, north of

Vanyampa. It also covers much of the eastern, mid-and lower slopes Tokadeh, and all foothills of Nimba. It corresponds most closely to Guinea Moist evergreen forest (Guinean type 5), and to part of the Guinea groundwater forest samples (Guinean type 4), merging into the Nuveg 4 forest class. It is not clear whether the term Wet evergreen forest might be more appropriate, but this would require a broader regional appraisal than possible here. As with the Nuveg 4 class, distinguishing and circumscribing riverine variants of forest from the rest is problematic due to the close mixing of river-bank specialists with non riverine forest species. Typical species are: *Heritiera utilis* (93%), *Newtonia aubrevillei*, *Anthonotha fragrans* (84%), *Anopyxis klaineana* (54%), *Chrysophyllum subnudum* (64%), *Coula edulis* (69%), *Dialium aubrevillei* (79%), *Drypetes chevalieri* (81%), *Schizolcolea linderi* (67%), *Greenwayodendron oliveri* (82%) and *Vitex micrantha* (57%); *Hawthorne, William D. DBSL07* (lecto-, designated here, BIOID: 20200813145046).

Forêt dense tropicale humide sempervirente guinéenne de Guinée Forestière de basse altitude (<500m) (Aussel 2018: 31111). Type: Guinea: Guinée Forestière, GF, Diécké, Ziama; La pluviosité est supérieure à 2000 mm par an, la saison sèche est très courte (seulement 2 mois secs par an). *Lophira alata*, *Tarrietia utilis*, *Combretodendron africanum*, *Uapaca guineensis*, *Turraenthus africana*, *Cryptosepalum tetraphyllum*, *Anopyxis klaineana*, *Khaya ivorensis*, *Mammea africana*, *Mapania linderi*, *Hypolytrum africanum*, *Xylia evansii*. Très rares: *Entandrophragma* spp., *Khaya* spp., *Lovoa*; *Aussel, Alexia s.n.* (holo-, BIOID: Aussel-20181211-2033-31111).

Other virtual ecosystemic specimens:

Guinea: Forêt Classée de Diéké; espèce dominantes: *Lophira alata*, *Heritiera utilis*; *Pecher, Susanne s.n.* (BIOID: 20200812180011, in Pecher and Smida 2009).

Liberia: Grebo; 5.4027; -7.7322; Except for one small area, all forest we saw was open, with only isolated huge trees such as *Antiaris toxicaria*, *Pentaclethra macrophylla*, *Piptadeniastrum africanum*, *Sacoglottis gabonensis*, *Terminalia superba* and *Triplochiton scleroxylon*, which were giving shade to abundant forest re-growth. The abundant presence of *Psychotria kwewonii* was interesting. It is a recently discovered species occurring in east Liberia and southwest Côte d'Ivoire that is currently being described. …, as is a species of *Rhaphiostylis* found also at Gola National Forest; *Jongkind, Carel s.n.* (BIOID: 20200810095048, in Jongkind 2007).

Liberia: West Nimba, Tokadeh, site EPHT11; 7.45536; -8.6726; 750; p.10: Disturbed Forest (DS); p.29, p.39, NUVEG 3, with transgression of semi-deciduous species; *Hawthorne, William D. s.n.* (BIOID: 20200813152425, in Hawthorne et al. 2010).

Liberia: Gola National Forest; 7.4527; -10.6925; p.23, The study site was a completely forested area with good evergreen forest species including *Anisophyllea meniaudii*, *Cola buntingii*, *Costus deistelii*, *Delpydora gracilis*, *Dicellandra barteri*, *Diospyros chevalieri*, *Heinsia crinita*, *Physacanthus batanganus*, *P. nematosiphon*, *Renealmia longifolia*, and *Strephonema pseudocola*. The primary forest canopy had an open structure, probably because of the presence of steep slopes. Lower vegetation was dense in most areas and huge lianas were present. Because of the open structure of the forest, many specialized forest undergrowth species, herbs as well as shrubs, occurred. Not situated in the hyperwet evergreen forest area, where I would expect the highest percentage of Upper Guinea endemic plants, but the site at Gola National Forest is very close to it; *Jongkind, Carel s.n.* (BIOID: 20200810093544, in Jongkind 2007).

Sierra Leone: Gola East, site 4, Mahoi; 7.3666; -11.2; Half of the survey area was a better drained small knoll. The vegetation was a mixture of swamp/marsh formations, riverine tree species and some dry forest species on the knoll; *Davies, A. Glyn s.n.* (BIOID: 20200810185547, in Davies 1987).

Sierra Leone: Gola North, Mogbai, hills near site 1; 7.65; -10.8667; Primary evergreen forest, *Didelotia idea*, *Brachystegia leonensis*; *Davies, A. Glyn s.n.* (BIOID: 20200810174927, in Davies 1987).

Sierra Leone: Kambui Hills; p.428: "The total number of trees species recorded from the ten sample quadrats were 36 belonging to 22 families with 122 individual trees species. Quadrats 1, 4, and 7 accounted for 34.4% of the total number of individual trees enumerated. Subsequently, quadrats 3, 4 and 9 were the only quadrats with trees recording 100 cm (4.1%) and above dbh. *Parinari excelsa* recorded the highest dbh (122 cm) and a height of 49 m. Three species (*Paracrolobium coeruleum*, *Daniella thurifera* and *Parinari excelsa*) accounted for 14.8% of the total individual species. Quadrats 4, 6 and 7 recorded more families than others. Caesalpinaceae is recorded as the most species rich family accounting for 36.4% of the total plant families, followed by Rosaceae and Sterculiaceae each accounting for 13.6% of the species respectively. More than 60% of the stems dbh were ≤ 30 cm. The total stem volume of the 36 plant species was 391.78 m3. *Parinari excelsa*,(49.67 m3), *Parkia bicolor* (32.37 m3), and *Chlorophora regia* (28.53 m3), recorded the highest volume while the mean volume was (10.9 m3 /ha). p.435: Plant families such as Caesalpinaceae, Rosaceae and Sterculiaceae (36.4%, 13.6%, 13.6%) were found to be the most abundant families among the 22 families. On the contrary, Klop et al. (2008) found that the Gola Forest (also in the Eastern region of the country) is dominated by Leguminosae, with common species such as *Cynometra leonensis* and *Brachystegia leonensis*. These two findings show how unique the flora biodiversity of Sierra Leone is with each ecosystem exhibiting different plant species and families"; Fayiah, Moses s.n. (BIOID: 20200814082532, in Fayiah et al. 2018).

Description: This ecosystem corresponds to the West African form of the typical "Caesalpiniaceae Forests", or evergreen rainforests. Different species can dominate different stands, but *Lophira alata* and *Tarrietia utilis* are generally characteristic. Overall, characteristic tree species are shared with the lowland superhumid mesic rainforests (also evergreen), but hygrophilous understorey species such as lowland Hymenophyllaceae (common in the mesic stands of the superhumid zone) are rare or absent here, being restricted to ravines, river-sides and swamps of the perhumid zone. Ground herbs belonging to Cyperaceae, monocaule understorey shrubs (e.g. Rubiaceae, Ochnaceae) and tree climbing ferns (such as *Lomariopsis* spp) are common everywhere (while restricted to the ravines, river-side or swamps of the humid bioclimatic zone) (see Figure 2).

Distribution: Mostly found in Liberia, it is spread from the Kambui hills in Sierra Leone to the Northern part of the Taï National Park, and in fragments to the South-West of Ghana (Figure 7b).

RLE status: VU (VU-EN) according to Senterre et al. (2019a).

[41] ***West African Mesic forest of the Submontane tropical perhumid moist evergreen rainforest zone*** / *Forêt ouest africaine mésique de la zone des Forêts tropicales perhumides sempervirentes submontagnardes* (Senterre et al. 2019a: 38). Type: Guinea: Massif du Mont Nimba, Seringbara; 7.63791; -8.4246; 957; Forêt mesique submontagnarde; *Senterre, Bruno & Bidault, Ehoarn BS61-64* (holo-, BIOID: BS61-20191008-1309-64).

Heterotypic synonyms:

Forêt ombrophile à Lophira procera et Parinari excelsa (Schnell 1952: 369). Type: Guinea: Nimba S.O.; Localisé vers 1000 mètres, ce groupement, à structure de forêt planitiaire, constitue la transition vers les forêts montagnardes. Il représente une variante du groupement à *Lophira* caractérisé par la présence d'espèces différentielles issues de l'étage montagnard: *Parinari excelsa, Uapaca togoensis, Memecylon polyanthemos, Garcinia polyantha, Asplenium Dregeanum, Begonia rubromarginata.* On note de plus la présence de *Pachylobus* *trimera*, *Manilkara lacera*, *Chrysophyllum Le-Testuanum*, *Usnea* af. *hispida*. Ce groupement est localisé juste en-dessous du plafond inférieur moyen des brouillards persistants. La température journalière du sous-bois y varie de 18-19° à 23,5-25° en avril et de 18° à 24° en juillet. L'hygrométrie du sous-bois, en avril 1942, variait de 90-100 % (nuit) à 70-85 % (14 heures), avec un déficit de saturation s'élevant, vers 14 heures, à 4 mm environ (exceptionnellement 8 mm). Le sol meuble est relativement épais (jusqu'à 3 mètres), essentiellement sableux (gravier fin: 4,3; sable grossier: 15,2; sable fin: 48,4; limon: 32,05; argile: 0,45); *Schnell, Raymond s.n.* (holo-, BIOID: Schnell-19520101-1450-369).

Forêt humide sempervirente de hautes terres / upland evergreen forest (Golder 2013: 2). Type: Guinea: Mont Nimba; *Golder s.n.* (holo-, BIOID: Golder-20130101-0648-2).

Nimba upland evergreen forest (Astron 2019: 12). Type: Guinea: Mount Nimba; *Astron s.n.* (holo-, BIOID: Astron-20190101-0016-12).

Forêt dense humide de haute montagne / Forêt dense humide de haute altitude (Diabaté et al. 2019a: 14). Type: Liberia: Wologizi, Lisco 2, Placette 8; 8.16222; -9.92656; 1179; Formation végétale climacique plus ou moins fermée (70% à 90%), située à une altitude au-dessus de 700 m; avec une strate arborée (15 à 25 m), une arbustive (2 à 10 m) et une herbaceae (0 à 1,50 m) à sous bois dégagé sur sol faiblement profond. Les espèces végétales caractéristiques sont : *Parinari excelsa*, *Trichoscypha* spp., *Lophira alata*, *Ochna membranacea*, *Gouarea cedrata*; *Diabaté, Moussa s.n.* (lecto-, designated here, BIOID: 20200812091358).

Hill Top Forest (Hawthorne et al. 2010: 10, 31, 39). Type: Liberia: West Nimba, Yuelliton, site EPHT04; 7.56467; -8.62737; 970; p.10, 31, 39, Hill Top (HT), ridges peaks, upper slopes, 830-1270 m; *Hawthorne, William D. EPHT04* (lecto-, designated here, BIOID: 20200813143844).

Forêt dense tropicale humide sempervirente guinéenne de Guinée Forestière submontagnarde (> 500m) (Aussel 2018: 31112). Type: Guinea: Ziama; La pluviosité est supérieure à 2000 mm par an, la saison sèche est très courte (seulement 2 mois secs par an); *Aussel, Alexia s.n.* (holo-, BIOID: Aussel-20181211-1135-31112).

Other virtual ecosystemic specimens:

Guinea: Ziama, South; 8.16918; -9.43455; 960; *Senterre, Bruno 20200812114128* (BIOID: 20200812114128).

Description: Poorly known; Schnell (1948, 1952) supports the idea that submontane forests (and montane forests also) have to be distinguished according to climatic wetness gradient, for example on the basis of the epiphytic flora (including non-vascular plants). However, the exact ecosystemic differences are poorly known, as well as the difference with the lowland and montane belts of a given climatic wetness belt.

Distribution: This type of submontane forest is much less widespread (AOO ca. 10 times lower) compared to submontane forests of the humid climatic zone (moist semi-deciduous forest zone). They occur only in the SE of Mt. Nimba (Guinea), S of Ziama, Wologizi & Wonegizi (Liberia) and in the Western Area Peninsula Non-Hunting Forest Reserve (Sierra Leone) (Figure 17).

RLE status: EN according to Senterre et al. (2019a).

[42] ***West African Mesic forest of the Montane tropical perhumid moist evergreen rainforest zone** / Forêt ouest africaine mésique de la zone des Forêts tropicales perhumides sempervirentes montagnardes* (Senterre et al. 2019a: 41). Type: Guinea: Massif du Mont Nimba, Seringbara; 7.59126; -8.43766; Site non-observé, mais identifié sur Google Earth; *Senterre, Bruno & Bidault, Ehoarn BS61-64e* (holo-, BIOID: BS61-20191008-1305-64e).

Heterotypic synonyms:

Mountain Forest (Hawthorne et al. 2010: 10, 39). Type: Liberia: Yekepa, Liberian Nimba near the border (see p.39, 42); 7.55026; -8.4832; 1150; p.10: Mountain Forest (MF); p.39: Nuveg 1 samples are at high altitudes (1150-1330m) and correspond most closely to Guinean Nimba Gallery forest (980-1320m). In Liberia, this type has only been seen towards its northern border in part of the Nimba range. Typical species found more commonly in this type of vegetation than elsewhere include *Acridocarpus platycalyx* (in 60% of samples), *Albizia zygia* (in all, but also common in secondary vegetation elsewhere), *Alchornea floribunda* (60%), *Anthonotha macrophylla* (80%), *Bersama abyssinica* (80%), *Eugenia pobequinii* (60%), *Gaertnera paniculata* (60%), *Harungana madagascariensis* (80%), *Parinari excelsa* (100%), *Psychotria limba* (80%), *Rhaphiostylis preussii* (80%), *Salacia erecta* (60%), *Trichoscypha smythei* (80%), *Vangueriella vanguerioides* (60%) and *Vernonia conferta*. Many of these are pioneers, indicating a history of disturbance, but several are (like *T. smythei*) also favouring high altitudes; *Hawthorne, William D. s.n.* (lecto-, designated here, BIOID: 20200813150301).

Other virtual ecosystemic specimens:

Guinea: Ziama, South; 8.17694; -9.42677; 1330; This mountain summit is very important to explore in detail as it is the wettest summit above 1250 m, situated 20 km South of the montane peaks of Seredou and therefore quite significantly more into the perhumid zone. Montane peaks further south, in Liberian Wologizi are not on granite and more instable; this mountain in the South of Ziama is the only granitic peak possibly in the perhumid zone; *Senterre, Bruno 20200812111613* (BIOID: 20200812111613).

Description: Poorly known (see notes in [41]). Detailed explorations in the Southern part of the Ziama are needed.

Distribution: Very rare (Figure 7e). Most of the montane forests of the perhumid zone are either on ironstone shield, or on overdrained landforms, or in ravines. In the highest parts of the Wologizi, almost all montane forests have recently (20th century to present) been affected by fires and are currently covered by open woodlands and thickets in primary succession. The only place in West Africa where this ecosystem might remain relatively abundant seems to be the Southern part of the Ziama.

RLE status: EN according to Senterre et al. (2019a).

[43] ***West African Mesic forest of the Lowland tropical humid moist seasonal semi-deciduous rainforest zone** / Forêt ouest africaine mésique de la zone des Forêts tropicales humides saisonnières semi-décidues de plaine* (Senterre et al. 2019a: 43). Type: Guinea: Massif du Ziama, Manikara; 8.39139; -9.32973; 792; Forêt dense humide, mesique, bien conservée; *Senterre, Bruno & Konate, Lansana BS61-20190924-929-1* (holo-, BIOID: BS61-20190924-0929-1).

Heterotypic synonyms:

Forêt mésophile de l'étage inférieur à Chrysophyllum perpulchrum et Triplochiton scleroxylon (Schnell 1952: 371). Type: Guinea: Nimba N.E.; Les forêts mésophiles (deciduous-forests, forêts tropophiles), comparables aux forêts ombrophiles par leur structure générale, occupent la portion NE du territoire, moins humide. Ce groupement occupe les régions basses, en-dehors des vallées. Il s'agit d'une forêt haute, moins riche en épiphytes que les forêts ombrophiles. *Terminalia superba*, *T. ivorensis*, *Triplochiton scleroxylon*, *Bombax flammeum*, *Aubrevillea Kerstingii*, *Celtis Zenkeri*, *Morus mesozygia*, *Antiaris africana*, *Chrysophyllum perpulchrum*, ...; *Schnell, Raymond s.n.* (holo-, BIOID: Schnell-19520101-0105-371).

Moist Semi-deciduous Forest Zone (Voorhoeve 1965: 21). Type: Liberia: North-West Liberia; occupies the northern half of Liberia (p.23); in particular to the more marked dry season in the north-west of the country (p.22); Meliaceous species are more common, and typical trees of the semi-deciduous forest such as *Nesogordonia papaverifera* and *Aningeria robusta* may be found. Single dominant leguminous species are less common or absent. True deciduous forest with such indicator species as *Celtis* spp., *Mansonia altissima*, *Morus mesozygia*, *Pericopsis elata* (formerly *Afrormosia elata*) is extremely rare; *Voorhoeve, Alexander George s.n.* (holo-, BIOID: 20200807153608).

Forêt humide semi-caduque de basse terre / moist semi-deciduous forest (Golder 2013: 3). Type: Guinea: Mount Nimba; *Golder s.n.* (holo-, BIOID: Golder-20130101-1949-3).

Moist semi-deciduous lowland forest (Astron 2019: 8). Type: Guinea: Mount Nimba; *Astron s.n.* (holo-, BIOID: Astron-20190101-1744-8).

Semi-deciduous forest (Couch et al. 2019: 49). Type: Guinea: Pic de Fon; 8.5268; -8.93076; 710; *Triplochiton scleroxylon*, an indicator of semi-deciduous forest throughout West Africa, occurs in the lowland Banko forest in the western fringes of the Pic de Fon Forêt Classée; *Couch, Charlotte s.n.* (holo-, BIOID: 20200812162153).

Forêt dense tropicale humide semi-sempervirente de basse altitude (<500m) (Aussel 2018: 31113). Type: Guinea: GF, GM; La pluviosité est comprise entre 1600 et 2000 mm par an. Si la pluviosité est supérieure à 2000 mm par an, la saison sèche est très marquée et peut durer jusqu'à 6 mois. Mais dans ce cas, une forte humidité ambiante est maintenue par la proximité de la côte; *Aussel, Alexia s.n.* (holo-, BIOID: Aussel-20181211-0509-31113).

Forêt dense guinéenne mésophile (Aussel 2018: 3112). Type: Guinea: région de Kindia, Dubreka, Coyah, GF; La pluviosité est comprise entre 1200 et 1600 mm par an, avec une saison sèche durant plus de 2 mois. Chute des feuilles des grands arbres en saison sèche; structure des arbres simple en rapport aux forêts ombrophiles; strate herbacée très persistante; hauteur des arbres basse; *Aningeria altissima*, *Pycnanthus angolensis*, *Piptadeniastrum africanum*, *Alstonia boonei*, *Uapaca guineensis*, *Dialium guineense*, *Milicia regia*, *Ceiba pentandra*, *Zanthoxylon gilletii*, *Anthocleista djalonensis*, *Trichilia heudelotii*, *Canarium schweinfurthii*, *Albizia ferruginea*. GF (Ziama) : *Triplochiton scleroxylon*, *Gambeya perpulchra*, *Morus mesozygia*, *Sterculia tragacantha*, *Terminalia superba*, *T. ivorensis*, *Aubervillea platycarpa*, *Celtis zenkeri*, *Chidlowia sanguinea*, *Amphimas pterocarpoides*, *Parkia bicolor*, *Milicia excelsa*. Simandou: *Piptadeniastrum africanum*, *Khaya grandifolia*, *Canarium schweinfurthii*, *Anitaris toxicaria* subsp. *africana*, *Morus mesozygia*, *Alstonia boonei*, *Pycnanthus angolensis*, *Terminalia ivorensis*, *Terminalia superba*, *Afrosersalisia cerasifera*, *Gambeya perpulchra*; *Aussel, Alexia s.n.* (holo-, BIOID: Aussel-20181211-0930-3112).

Paratypic synonyms (p.p. synonyms):

Forêt dense humide de moyenne altitude (forêt de flanc de montagne ou sub montagnarde) (Diabaté et al. 2019b: 15). Guinea: Ziama, Balassou; 8.39255; -9.3227; 761; Formation végétale climacique plus ou moins fermée, sur une altitude qui est supérieure ou égale 650 m généralement sur flanc des montagnes, sol peu profond et mince avec des affleurements rocheux. Formation caractérisée par une strate supérieure peu haute; *Diabaté, Moussa s.n.* (para-, BIOID: 20200812103609).

Forêt dense humide de basse altitude (Diabaté et al. 2019b: 15). Guinea: Ziama, Zoboromai; 8.39137; -9.34568; 525; Formation végétation climacique fermée située à une altitude de moins de 400 à 600 m ; mais les strates arborées (25 à 50m) et arbustives (3,5 à 7m) sont élevées, la strate herbaceae est représentée par des espèces à feuilles large; *Diabaté, Moussa s.n.* (para-, BIOID: 20200812102802).

West African Lowland Evergreen Forest (Couch et al. 2019: 200). Guinea: Ziama; Thirty-three rare, threatened and/or endemic plant species have been documented, including ... *Tarenna hutchinsonii* (CR) and *Gymnosiphon samoritoureanus* (EN) in the lowland forest; *Couch, Charlotte s.n.* (para-, BIOID: 20200812155122). Guinea: Nimba (mostly NE); <500m; *Couch, Charlotte s.n.* (para-, BIOID: 20200812155613)

<u>Other virtual ecosystemic specimens</u>:

Côte d'Ivoire: Massif des Dans, Mont Tonkoui (Google Earth); 7.44953; -7.65814; 590; *Senterre, Bruno 20200813095320* (BIOID: 20200813095320).

Guinea: Guinée Maritime; 9.5341; -12.9582; p. 45: Guinée Maritime does have a dry season of six months, so much of the long-lost original forest may have been semi-deciduous rather than evergreen; *Couch, Charlotte s.n.* (para-, BIOID: 20200812161405, in Couch et al. 2019: 49).

<u>Description</u>: The "semi-deciduous" nature of this type of ecosystem has to be taken with caution. In fact, we should observe and identify this ecosystem based on a complex approach, accounting for ecological transgressions (Figure 2) and looking more at indicator species than at caducity of the leaves in the canopy (see Schnell 1952: 361, who preferred for that reason to talk about "mesophilous" forests rather than "semi-deciduous" forests). Although Caesalpiniaceae remain an important family, Meliaceae, Ulmaceae and Sterculiaceae gain importance compared to forests of the perhumid zone. Monocaule understorey shrubs and tree climbing ferns disappear, or are restricted to moist ravines.

<u>Distribution</u>: Widespread from Guinée maritime to North of Sierra Leone, Guinée forestière, Ivory Coast and Ghana (Figure 7c).

<u>RLE status</u>: EN (EN-CR) according to Senterre et al. (2019a).

[44] ***West African Mesic forest of the Submontane tropical humid moist seasonal semi-deciduous rainforest zone*** / *Forêt ouest africaine mésique de la zone des Forêts tropicales humides saisonnières semi-décidues submontagnardes* (Senterre et al. 2019a: 47). Type: Guinea: Massif du Mont Nimba, Haut Cavally; 7.66218; -8.39145; 1116; *Senterre, Bruno & Bidault, Ehoarn BS61-54* (holo-, BIOID: BS61-20191005-1030-54).

<u>Heterotypic synonyms:</u>

Forêts mésophiles submontagnardes à Parinari excelsa et Carapa procera (Schnell 1952: 371). Type: Guinea: Nimba N.E.; Ce groupement, localisé sur les pentes moyennes (vers 700-850 m), en dehors des ravins, dérive du groupement à *Chrysophyllum-Triplochiton* par la présence de quelques espèces de l'étage supérieur (*Parinari excelsa*, *Uapaca togoensis, Salacia alpestris, Asplenium dregeanum*) et par l'abondance de *Carapa procera* et de *Sersalisia djalonensis*. Ce groupement submontagnard est l'homologue mésophile du groupement à *Lophira procera* et *Parinari excelsa* de la série ombrophile. Dans ces forêts mésophiles submontagnardes, le déficit de saturation, en juin, varie de 0 à 5 mm (exceptionnellement 7 ou 9 mm). Le pH des sols y est de l'ordre de 5,4, soit un peu plus élevé que dans les forêts de ravins; *Schnell, Raymond s.n.* (holo-, BIOID: Schnell-19520101-1718-371).

Forêt galerie de hautes terres / upland gallery forest (Golder 2013: 8). Type: Guinea: Mount Nimba; *Golder s.n.* (holo-, BIOID: Golder-20130101-2353-8).

Guinean Highland Submontane Forest (Couch et al. 2019: 160). Type: Guinea: Nimba (mostly NE); >500m; The submontane forests have plants globally endemic to the Nimba Mountains, such as *Osbeckia porteresii*, *Sporobolus pauciflorus*, *Impatiens nzoana*, and *Begonia quadrialata* subsp. *nimbaensis*; *Couch, Charlotte s.n.* (holo-, BIOID: 20200812155937).

Forêt dense tropicale humide semi-sempervirente submontagnarde (>500m) (Aussel 2018: 31114). Type: Guinea: GF, GM; La pluviosité est comprise entre 1600 et 2000 mm par an, la saison sèche peut durer jusqu'à 6 mois. Si c'est le cas, une forte humidité ambiante est maintenue par la proximité de la côte; *Aussel, Alexia s.n.* (holo-, BIOID: Aussel-20181211-1205-31114).

Paratypic synonyms (p.p. synonyms):

Forêt dense humide de haute montagne / Forêt dense humide de haute altitude (Diabaté et al. 2019b: 14). Guinea: Ziama, Sérédou vavamé; 8.40403; -9.27404; 1032; Formation végétale climacique plus ou moins fermée, située à une altitude au-dessus de 900-1000 m; avec une strate arborée (25 à 30 m), une arbustive (2 à 10 m) et une herbaceae (0 à 1,50 m) à sous bois dégagé sur sol à affleurement rocheux présentant ici; *Diabaté, Moussa s.n.* (para-, BIOID: 20200812104044).

Other virtual ecosystemic specimens:

Côte d'Ivoire: Massif des Dans, Mont Tonkoui; 7.44725; -7.64454; 1110; p.176: Vers 1100-1200 mètres, la forêt de montagne comporte: *Parinari excelsa* (dominant dans la strate supérieure), *Piptadeniastrum africanum*, *Parkia bicolor*, *Alstonia boonei*, *Stereospermum acuminatissimum*, *Afrosersalisia cerasifera*, *Memecylon polyanthemos*, *Carapa procera*, *Schefflera barteri*, *Garcinia polyantha*, etc. ... avec comme épiphytes *Peperomia fernandopoiana*, *Diaphananthe pellucida*, *Hymenophyllum polyanthos*, *Asplenium dregeanum* (très abondant), des Bryophytes (*Pilotrichella*, *Plagiochila*, etc.) et des lichens (notamment des *Usnea* sur les branches supèrieures); *Schnell, Raymond s.n.* (BIOID: 20200813093558, in Schnell 1979: 176).

Guinea: Massif du Ziama, proche du Macenta, du côté Est du massif; p.177: Aux altitudes moyennes, vers 1000-1200 métres, on trouve une forêt de transition, déjà riche en *Parinari excelsa* dans la strate supérieure (où il peut déjà dominer), mais renfermant encore de nombreuses espèces banales de basse altitude: *Piptadeniastrum africanum*, *Parkia bicolor*, *Amphimas pterocarpoides*, *Canarium schweinfurthii*, *Anthonotha macrophylla*, *Garcinia polyantha*, *Chrysophyllum perpulchrum*, etc. avec des épiphytes déjà nombreux: *Polystachya*, *Asplenium dregeanum*, Bryophytes, Lichens, *Usnea*, -etc.; *Schnell, Raymond s.n.* (BIOID: 20200813101658, in Schnell 1979: 177).

Guinea: Massif du Ziama, pentes du Mont Tambakula; 8.38257; -9.33179; 929; *Senterre, Bruno & Konate, Lansana BS61-20190924-1313-3* (BIOID: BS61-20190924-1313-3).

Guinea: Ziama; >500m; p. 200: Thirty-three rare, threatened and/or endemic plant species have been documented, including *Cassipourea adamii* (EN) in submontane forest; *Couch, Charlotte s.n.* (para-, BIOID: 20200812160457, in Couch et al. 2019).

Guinea: Mont Béro, on the flanks; The submontane forest, characterised by *Uapaca chevalieri* and *Trichilia djalonis*, has the world's largest population of the threatened mass-flowering *Brachystephanus oreacanthus*, and *Isoglossa dispersa*. There is also a population of the range-restricted species *Dorstenia astyanactis* and *Brachystephanus jaundensis* subsp. *nimbae*; *Couch, Charlotte s.n.* (para-, BIOID: 20200812180248, in Couch et al. 2019).

Description: See description in biotypes cited above; It shares elements with the lowland humid and the submontane perhumid zones. Mass-flowering Acanthaceae seem to be a characteristic element.

Distribution: Widespread in West Africa (Figure 7f), from Guinea (Kounounkan, Kindia, South of Fouta Djalon, North Ziama, Pic de Fon, Mount Béro, Mount Nimba NE) to Sierra Leone (Mount Loma), West of Ivory Coast (Mounts Guéoulé, Glo, Péko), and with a remote element isolated in the South-East of Ghana (Atewa Range Forest Reserve: McCullough et al. 2007).

RLE status: VU (VU-EN) according to Senterre et al. (2019a).

[45] ***West African Mesic forest of the Montane tropical humid moist seasonal semi-deciduous rainforest zone*** / *Forêt ouest africaine mésique de la zone des Forêts tropicales humides saisonnières semi-décidues montagnardes* (Senterre et al. 2019a: 49). Type: Guinea: Massif du Mont Nimba, haut de la vallée du Zie; 7.66262; -8.37222; 1602; *Senterre, Bruno & Bidault, Ehoarn BS61-27* (holo-, BIOID: BS61-20191002-0940-27).

Heterotypic synonyms:

Forêt galerie de haute altitude / high altitude gallery forest (Golder 2013: 9). Type: Guinea: Mount Nimba; *Golder s.n.* (holo-, BIOID: Golder-20130101-1919-9).

Gallery forest (Astron 2019: 5). Type: Guinea: Mount Nimba; *Astron s.n.* (holo-, BIOID: Astron-20190101-0259-5).

Forêts denses guinéennes hautes de haute montagne (Aussel 2018: 31133). Type: Guinea: Ziama (et Hauts plateaux de la dorsale Loma-Man: Nimba, Fon); Très homogènes et semblables aux forêts denses ombrophiles des basses et moyennes altitudes, mais strates arborées et arbustives moins élevées (25 à 35 m), situées à une altitude au-dessus de 800m, dominées par *Parinari excelsa*. *Parinari excelsa*, *Syzygium staudtii*, *Dracaena arborea*, *Trichilia heudelotii*, *Beilschmiedia mannii*, *Bersama abyssinica* subsp. *paullinioides*, *Vernonia frondosa*, *Vernonia andohii*, *Memecylon fasciculare*, *Trichoscypha oba*, *Polyscias fulva*, *Schefflera barteri*, *Garcinia smeathmannii*, *Popowia nimbana*, *Ochna membranacea*, *Gaertnera cooperi*, *Rhaphiostylis beninensis*; *Aussel, Alexia s.n.* (holo-, BIOID: Aussel-20181211-2213-31133).

Description: Poorly known. This ecosystem of montane forest differs from its perhumid homologous ecosystem (perhumid montane mesic) by the reduced diversity of epiphyte species (incl. non-vascular plants); it differs from its subhumid homologous ecosystem (subhumid montane mesic, e.g. in the Northern half of the Fouta Djalon) by the presence of epiphyte species vs. absence in the subhumid zone.

Distribution: Restricted to a few high mountains in West Africa, e.g. in the extreme south of the Fouta Djalon (Guinea, a few kilometers to the South-West of Dalaba), also in the North-Eastern part of the Ziama and the Mt. Nimba, in the Mounts Loma (Sierra Leone), possibly with very small degraded areas in the Pic de Fon and Massif des Dans (Figure 7g).

RLE status: VU (VU-EN) according to Senterre et al. (2019a).

III.1.7.3 Overdrained forest (Ge.)

[46] ***West African Overdrained dwarf forest of the Lowland tropical superhumid wet evergreen rainforest zone*** / *Forêt ouest africaine naine sur-drainée de la zone des Forêts tropicales superhumides sempervirentes de plaine* (Senterre, Bruno nov.). Type: Liberia: Dugbe HummingBird site (Sinoe County, ca. 20 km South of Sapo National Park, ca. 50 km East of Greenville), South of Tuzon; 5.07712; -8.51042; 100 m; *Senterre, Bruno HB-48* (holo-, BIOID: 70ad7c4f-cd8d-4c69-b8b4-dde988047c78).

Homotypic synonyms:

Dry ridge forests of the wet evergreen littoral rain forest zone (Senterre 2014: 16).

Description: Poorly known.

Distribution: Rare and localized within the superhumid lowland zone (Figure 7a).

RLE status: DD.

[47] ***West African Overdrained dwarf forest of the Lowland tropical perhumid moist evergreen rainforest zone*** / *Forêt ouest africaine naine sur-drainée de la zone des Forêts tropicales perhumides sempervirentes de plaine* (Senterre et al. 2019a: 38). Type: Guinea: Massif du Mont Nimba, Seringbara; 7.64245; -8.44596; 750; Site non-observé, mais identifié sur Google Earth; *Senterre, Bruno & Bidault, Ehoarn BS61-64b* (holo-, BIOID: BS61-20191008-1308-64b).

Paratypic synonyms (p.p. synonyms):

Moist semi-deciduous lowland forest (Astron 2019: 8). Type: Liberia: West Nimba, Tokadeh, site EPSL26; 7.4626; -8.6698; 680; p.10: Slope (SL); p.29, p.39: Nuveg 3 represents a spectrum of landscape and forest types transitional between Vegnum 2 and 4, often on slopes and in some cases quite possibly successional towards, or disturbed and "broken" variants of type 4; *Hawthorne, William D. EPSL26* (para-, BIOID: 20200813151716, in Hawthorne et al. 2010).

Other virtual ecosystemic specimens:

Sierra Leone: Gola North; 7.633; -10.95; on steep rocky slopes, *Erythrophloeum ivorense*, *Nesogordonia papaverifera*; *Klop, Erik s.n.* (BIOID: 20200810181553, in Klop et al. 2008).

Description: Poorly known. This ecosystem is likely to be characterized by species transgressive from saxicolous forests of the same bioclimatic zone and species from mesic stands of the dryer bioclimatic zone (i.e. of the moist semi-deciduous forest zone) (Figure 2). This is partly supported by the descriptions and discussions found in Hawthorne et al. (2010: 34).

Distribution: Poorly known. Probably scattered and very localized within the perhumid lowland zone (Figure 7b).

RLE status: DD according to Senterre et al. (2019a).

[48] ***West African Overdrained dwarf forest of the Submontane tropical perhumid moist evergreen rainforest zone*** / *Forêt ouest africaine naine sur-drainée de la zone des Forêts tropicales perhumides sempervirentes submontagnardes* (Senterre et al. 2019a: 40). Type: Guinea: Massif du Mont Nimba, Montagne Ton Bgomgbomg; 7.6335; -8.42864; 1104; Forêt mesique sur cuirasse en decomposition; *Senterre, Bruno & Bidault, Ehoarn BS61-75* (holo-, BIOID: BS61-20191010-1152-75).

Description: Poorly known.

Distribution: Very rare, restricted to narrow ridges between 850 and 1250 m of altitude, in the SW of Mt. Nimba, in the Wologizi, also possibly in the South of Ziama (then on granite bedrock).

RLE status: DD according to Senterre et al. (2019a).

[49] ***West African Overdrained dwarf forest of the Montane tropical perhumid moist evergreen rainforest zone*** / *Forêt ouest africaine naine sur-drainée de la zone des Forêts tropicales perhumides sempervirentes montagnardes* (Senterre et al. 2019a: 42). Type: Guinea: Massif du Mont Nimba, Seringbara; 7.61782; -8.41703; 1394; Site non-observé, mais

identifié sur Google Earth (image du 13/01/2018); *Senterre, Bruno & Bidault, Ehoarn BS61-64h* (holo-, BIOID: BS61-20191008-1302-64h).

Paratypic synonyms (p.p. synonyms): see Senterre et al. (2019a; parabiotypes not defined); *Undetermined upland forest* p.p. (Golder 2013); *High altitude gallery forest or thickets* p.p. (Astron 2019); *High altitude low forest or thickets* p.p. (Astron 2019: shapefile); *Forêt dense guinéenne basse de très haute montagne sur sol squelettique de Guinée Forestière* p.p. (Aussel 2018: 3.1.1.3.1).

Description: The distinction between dwarf forests on overdrained landforms and subsaxicolous dwarf forests is challenging. Steep slopes are often with shallow soils and, in the Mt. Nimba (NE), steep slopes often have an ironstone shield. Nevertheless, observations of dwarf forests on interruptions of the ironstone shield at Mt. Nimba and on non-saxicolous ridges at Wologizi, as well as observations in other regions, support such distinction. Some climax dwarf forests can only be explained by their topographic landform.

Distribution: SW of Mt. Nimba, S of Ziama and in the Wologizi.

RLE status: DD-NE according to Senterre et al. (2019a).

[50] ***West African Overdrained dwarf forest of the Lowland tropical humid moist seasonal semi-deciduous rainforest zone*** / *Forêt ouest africaine naine sur-drainée de la zone des Forêts tropicales humides saisonnières semi-décidues de plaine* (Senterre et al. 2019a: 46). Type: Guinea: Massif du Mont Nimba, Monts des Génies; 7.71069; -8.36436; 697; Forêt sèche de crête, sur sol profond; *Senterre, Bruno & Bidault, Ehoarn BS61-40* (holo-, BIOID: BS61-20191004-1108-40).

Heterotypic synonyms:

Forêt sèche semi-caduque / drier semi-deciduous forest (Golder 2013: 7). Type: Guinea: Mount Nimba; *Golder s.n.* (holo-, BIOID: Golder-20130101-1649-7).

Drier semi-deciduous forest (Astron 2019: 11). Type: Guinea: Mount Nimba; *Astron s.n.* (holo-, BIOID: Astron-20190101-1746-11).

Description: Poorly known. Probably characterized by elements transgressive from the mesic forests of the lowland subhumid zone (i.e. Schnell's septentrional semi-deciduous forests).

Distribution: Rare ecosystem; it has been largely converted into pyrophilic disclimax savannas (Schnell 1948, 1952).

RLE status: DD according to Senterre et al. (2019a).

[51] ***West African Overdrained dwarf forest of the Submontane tropical humid moist seasonal semi-deciduous rainforest zone*** / *Forêt ouest africaine naine sur-drainée de la zone des Forêts tropicales humides saisonnières semi-décidues submontagnardes* (Senterre et al. 2019a: 49). Type: Guinea: Massif du Mont Nimba, NE; 7.70018; -8.37592; 951; sur Google Earth image du 24/1/2013; *Senterre, Bruno & Bidault, Ehoarn BS61-26d* (holo-, BIOID: BS61-20191001-1559-26d).

Paratypic synonyms (p.p. synonyms): see Senterre et al. (2019a; parabiotypes not defined); *High altitude gallery forest or thickets* p.p. (Astron 2019); *High altitude low forest or thickets* p.p. (Astron 2019: shapefile).

Description: Poorly known.

Distribution: Poorly known. Potentially found on narrow ridges of the humid submontane bioclimatic zone (Figure 7f), from Guinea to Ghana. In Mt. Nimba, it has been almost entirely replaced by pyrophilic disclimax savannas. Based on the study of Google Earth images and landform analysis (Senterre et al. 2019a), remains of this type of ecosystem might be found at Monts des Génies (NE Mt. Nimba).

RLE status: CR according to Senterre et al. (2019a).

[52] ***West African Overdrained dwarf forest of the Montane tropical humid moist seasonal semi-deciduous rainforest zone*** / *Forêt ouest africaine naine sur-drainée de la zone des Forêts tropicales humides saisonnières semi-décidues montagnardes* (Senterre et al. 2019a: 52). Type: Guinea: Mont Nimba, haut de la vallée du Zie; 7.66206; -8.37176; 1622; *Senterre, Bruno & Bidault, Ehoarn BS61-20190930-1524-12* (holo-, BIOID: BS61-20190930-1524-12).

Heterotypic synonyms:

Forêt dense guinéenne basse de très haute montagne sur sol squelettique de Guinée Forestière (Aussel 2018: 31131). Type: Guinea: Ziama (et Hauts plateaux de la dorsale Loma-Man: Nimba, Fon); Forêt basse sur les sols superficiels des sommets des pentes et crêtes, dominé par *Parinari excelsa*. Au dessus de 1200m d'altitude. Les arbres ont des troncs minces et effilés et mesurent jusqu'à 8-12 m. Le sous-bois est peu dense et les lianes sont rares. *Parinari excelsa*, *Craterispermum laurinum* s.l., *Cryptosepalum tetraphylum*, *Drypetes leonensis*, *Eugenia leonensis*, *Gaertnera* sp., *Hymenodictyon floribundum*, *Schefflera barteri*, *Syzygium guineense* subsp. *occidentale*; *Aussel, Alexia s.n.* (holo-, BIOID: Aussel-20181211-0525-31131).

Paratypic synonyms (p.p. synonyms): see Senterre et al. (2019a; parabiotypes not defined); *High altitude gallery forest or thickets* p.p. (Astron 2019); *High altitude low forest or thickets* p.p. (Astron 2019: shapefile); *Fourrés de haute altitude / high altitude thicket* p.p. (Golder 2013).

Description: Poorly known; possibly not occurring anymore in the Mt. Nimba, but still to be found in the NE of the Ziama.

Distribution: NE Nimba?, NE Ziama, Mt. Loma.

RLE status: CR (CR-EN) according to Senterre et al. (2019a).

Ecosystemologic notes: In Senterre et al. (2019a), we had considered the "*Forêt basse ombrophile à Parinari excelsa et Eugenia leonensis*" (Schnell 1952: 385) as synonym of this ecosystem type. Nevertheless, Schnell clearly made reference to the SW part of Mt. Nimba and therefore the biotype of his name must be located in the dwarf subsaxicolous forests on ironstone shield, nearby Seringbara 2.

III.1.7.4 Granite rock (Ge.)

We only briefly develop the granite rock ecosystems, based on available data from literature. Granite outcrops occur (within the study area) in the Wologizi, Wonegizi, Ziama, at Mont Béro and in the Massif des Dans, spanning a wide range of bioclimates (from perhumid to humid and from lowland to montane). We expect potentially 6 different types of specific ecosystems on granite rocks (with the highest diversity in the Ziama). Submontane and montane granite rock surfaces are relatively rare in West Africa.

[53] ***West African Granite rock surface of the Lowland tropical humid moist seasonal semi-deciduous rainforest zone*** / *Affleurement rocheux de granite de la zone des Forêts tropicales humides saisonnières semi-décidues de plaine d'Afrique de l'ouest* (Senterre, Bruno nov.). Type: Guinea: Study site 3: inselberg at Macenta; p. 318: mostly covered by cyanobacteria (*Stigonema* spp., *Scytonema* spp.). Saxicolous lichens (e.g. *Toninia bumama*) restricted to

slightly raised rocks which dry up quickly after rain; *Porembski, Stefan s.n.* (holo-, BIOID: 20200909093605, in Porembski et al. 1994).

Homotypic synonyms:

Exposed rock surfaces of granite inselbergs (Porembski et al. 1994: 318).

Description: Poorly known; see descriptions made by Porembski et al. (1994: 318) and Couch et al. (2019: 39, under "cryptogamic crust microhabitat").

Distribution: Although there is no comprehensive map of granite inselbergs of West Africa, they are widespread. Lowland humid zone inselbergs are abundant in the region of Macenta (Guinea), also in Guinée Maritime (from Forécariah to Dubréka), in Sierra Leone, and in Ivory Coast.

RLE status: DD.

Ecosystemologic notes: Very little is known on the ecosystemic distinction of granite rock surfaces according to bioclimates (continentality and altitudination) and to ecoregions (rock surface biogeography). Along with recent molecular developments, there has been a proliferation of studies on the biodiversity, ecology and biogeography of ecosystems previously taken for granted such as rock surfaces, atmosphere, etc. (Womack et al. 2010). According to Foissner (2006), the famous metaphor "in micro-organisms everything is everywhere" can be challenged by a simple question: If the world is teeming with cosmopolitan unicells, where is everybody? For rock surfaces in particular, some studies suggest only limited geographic patterns (Büdel 1999; Büdel et al. 2002; Main 1997) while others consider that rock surface organisms may serve as bioindicators of atmospheric and/or climate change (Gorbushina 2007). In West Africa, Porembski et al. (1996: 52) distinguished the granite inselberg vegetation from the South of Taï National Park (Mt. Niénokoué: 5.42916°N,-7.19417°W), located in the wet evergreen rainforest zone, from the granite inselbergs of the dryer climatic zones. Wet inselbergs generally harbored less species, no endemism, and absence of species typical of the ephemeral flush vegetation (e.g. Lentibulariaceae, Eriocaulaceae and Xyridaceae).

[54] ***West African Granite rock surface of the Submontane tropical humid moist seasonal semi-deciduous rainforest zone*** / *Affleurement rocheux de granite de la zone des Forêts tropicales humides saisonnières semi-décidues submontagnardes d'Afrique de l'ouest* (Senterre, Bruno nov.). Type: Guinea: Mt. Konossou; 8.88369; -10.36515; 1000; p.39: Rock crevaces microhabitat of granite inselbergs; p.114: This is the only known site for the Guinean endemic *Feliciadamia stenocarpa*, rediscovered in 2017. This species of Melastomataceae is a monospecific genus and is only known to grow in moist, shaded overhangs in the granite between 900m and 1350m altitude; *Couch, Charlotte s.n.* (holo-, BIOID: 20200812152525, in Couch et al. 2019).

Description: Poorly known.

Distribution: Guinea (Mt. Konossou, NE Ziama, Mt. Béro), Sierra Leone (Mt. Loma) and Ivory Coast (Massif des Dans).

RLE status: DD. It could (and should) be evaluated using criterion B, but this requires GIS work and some local verifications which are beyond the time available here.

III.1.7.5 Ironstone rock (Ge.)

[55] ***West African Rocky cliff on ironstone shield edge of the Montane tropical rainforest zone*** / *Falaise rocheuse en corniche de cuirasse ferrugineuse de la zone des Forêts tropicales montagnardes d'Afrique de l'ouest* (Senterre et al. 2019a: 60). Type: Guinea: Massif du Mont

Nimba, près de la base géologique; 7.65719; -8.37437; 1496; Observed on Google Earth, image du 24/1/2013; *Senterre, Bruno & Bidault, Ehoarn BS61-34c* (holo-, BIOID: BS61-20191003-0946-34c).

Heterotypic synonyms:

Groupement méso-héliophile à Lonchitis reducta et Oleandra articulata (Schnell 1952: 383). Type: Guinea: Mont Nimba; *Schnell, Raymond s.n.* (holo-, BIOID: Schnell-19520101-1706-383).

Description: Poorly known. Schnell (1952: 383): "*Begonia quadrialata*, *Lonchitis reducta*, *Oleandra articulata*, *Asplenium Schnellii*, Lichens spp.". "Localisé sur des falaises verticales en retrait, ombragées une partie de la journée, et ayant en saison des pluies de légers suintements d'eau".

Distribution: Only at Mt. Nimba and Pic de Fon (Guinea).

RLE status: DD according to Senterre et al. (2019a).

III.1.7.6 Ultramafic rock (Ge.)

[56] ***West African Rocky outcrop of quartzite of the Montane tropical rainforest zone** / Affleurement rocheux de quartzite de la zone des Forêts tropicales montagnardes d'Afrique de l'ouest* (Senterre et al. 2019a: 60). Type: Guinea: Massif du Mont Nimba, près de la base géologique; 7.65805; -8.37396; 1560; Observé sur Google Earth, image du 24/1/2013; *Senterre, Bruno & Bidault, Ehoarn BS61-34b* (holo-, BIOID: BS61-20191003-0945-34b).

Heterotypic synonyms:

Groupements licheniques (Schnell 1952: 383). Type: Guinea: Mont Nimba; Sur les crêtes du Nimba vit une association lichénique incrustante qui parait caractéristique des sommets; *Schnell, Raymond s.n.* (holo-, BIOID: Schnell-19520101-0445-383).

Groupement hélio-hygrophile à Panicum pusillum (Schnell 1952: 384). Type: Guinea: Mont Nimba; Cette association ne dépasse pas 2 à 7 cm. de hauteur; elle renferme: *Panicum pusillum* (dominant), *Fimbristylis* sp., *Utricularia striatula*, et des Mousses. Localisé le long des fissures humides de falaises rocheuses; *Schnell, Raymond s.n.* (holo-, BIOID: Schnell-19520101-1046-384).

Affleurement rocheux / rock outcrop (Golder 2013: 17). Type: Guinea: Mount Nimba; *Golder s.n.* (holo-, BIOID: Golder-20130101-1606-17).

Description: see above for Schnell's biotypes.

Distribution: In West Africa, this type of ecosystem seems to be restricted to the summit of Mount Nimba. They are more common in East Africa, where they harbor some endemism (Porembski et al. 1997).

RLE status: DD according to Senterre et al. (2019a).

III.1.7.7 Saxicolous open vegetation on granitic outcrops (Ge.)

[57] ***West African Saxicolous open vegetation on granitic outcrop of the Lowland tropical perhumid moist evergreen rainforest zone** / Végétation ouverte ouest africaine saxicole sur inselberg granitique de la zone des Forêts tropicales perhumides sempervirentes de plaine* (Senterre, Bruno nov.). Type: Liberia: North Lorma National Forest, Lawa River; 8.01761; -9.74029; 500; Slightly uphill from the Lawa River, in some places this vegetation gave way to predominantly herbaceous vegetation with several species of Labiatae and Acanthaceae, such as *Plectranthus epilithicus* that are usually found on seasonally wet, rocky areas and

occasionally, the succulent *Sansevieria liberica* and the climbing *Asparagus drepanophyllus*; *Jongkind, Carel s.n.* (holo-, BIOID: 20200807180813, in Jongkind 2007).

Heterotypic synonyms:

Savane herbeuse sur sol mince (Diabaté et al. 2019a: 16). Type: Liberia: Wologizi, Badezou, Placette 19; 7.88355; -9.67564; 540; Formation naturelle sur sol squelettique mince à tapis herbacé dense. Quelques espèces caractéristiques d'herbes sont : *Afrotrilepis pilosa, Andropogon gayanus, Hyparrhenia* spp., *Monocymbium* sp.; *Diabaté, Moussa s.n.* (lecto-, designated here, BIOID: 20200812094744).

Other virtual ecosystemic specimens:

Guinea: Ziama, Kpoda; 8.17211; -9.35903; 579; Formation naturelle d'herbes graminéennes développée sur sol granitique ou squelettique ; la végétation ligneuse (arbres, arbustes, arbrisseaux et sous-abrisseaux) sont isolées ou groupées en îlots; *Diabaté, Moussa s.n.* (para-, BIOID: 20200812104851, in Diabaté et al. 2019b).

Sierra Leone: Gola North, Koye, near site 2; 7.633; -10.95; The steep hillside was dominated by large boulders and sheets of bare rock were encountered at several places; *Davies, A. Glyn s.n.* (BIOID: 20200810175536, in Davies 1987).

Description: Poorly known. Specialized studies on the inselberg vegetation of West Africa have focused mostly on the humid lowland life zone (Porembski et al. 1994). Nevertheless, the study of one inselberg of the superhumid lowland life zone (Mt. Niénokoué, in the Taï National Park: Porembski et al. 1996) suggests that there are ecosystemic differences over the bioclimatic gradient. Ephemeral flush vegetation is likely to be poorly developed, but shrubby fringes and patches deserve attention (Mignaut et al. 2010).

Distribution: Restricted to the southern slopes of Ziama (Guinea), many isolated outcrops in the Wonegizi and Wologizi (Liberia), and a few outcrops in the Gola Forests (Sierra Leone).

RLE status: DD.

[58] ***West African Saxicolous open vegetation on granitic outcrop of the Submontane tropical perhumid moist evergreen rainforest zone*** / *Végétation ouverte ouest africaine saxicole sur inselberg granitique de la zone des Forêts tropicales perhumides sempervirentes submontagnardes* (Senterre, Bruno nov.). Type: Guinea: Ziama, South; 8.17185; -9.43236; 1100; *Senterre, Bruno 20200812114629* (holo-, BIOID: 20200812114629).

Description: Poorly known. Not included in Porembski's studies, but we consider that the study of perhumid submontane inselbergs is needed to assess their identity as a specific ecosystem (see notes in [53]).

Distribution: Only found in the South of the Ziama (Guinea).

RLE status: DD, but possibly threatened due to restricted distribution (criterion B).

[59] ***West African Saxicolous open vegetation on granitic outcrop of the Montane tropical perhumid moist evergreen rainforest zone*** / *Végétation ouverte ouest africaine saxicole sur inselberg granitique de la zone des Forêts tropicales perhumides sempervirentes montagnardes* (Senterre, Bruno nov.). Type: Guinea: Ziama, South; 8.17602; -9.42485; 1290; *Senterre, Bruno 20200812113315* (holo-, BIOID: 20200812113314).

Same comments as for the previous ecosystem-type.

[60] ***West African Saxicolous open vegetation on granitic outcrop of the Lowland tropical humid moist seasonal semi-deciduous rainforest zone*** / *Végétation ouverte ouest africaine*

saxicole sur inselberg granitique de la zone des Forêts tropicales humides saisonnières semi-décidues de plaine (Senterre, Bruno nov.). Type: Guinea: Ziama, from Google Earth; 8.24583; -9.24974; 673; *Senterre, Bruno 20200811163826* (holo-, BIOID: 20200811163826).

Heterotypic synonyms:

Granite inselberg (Couch et al. 2019: 199). Type: Guinea: Mt. Wokou, near Macenta; 8.52329; -9.46166; 670; p.40 *Afrotrilepis pilosa*-mats; *Couch, Charlotte s.n.* (lecto-, designated here, BIOID: 20200812153547).

Afrotrilepis pilosa-mats of granite inselbergs (Porembski et al. 1994: 318). Type: Guinea: Study site 3: inselberg at Macenta; 8.5333; -9.4666; p.318: *Afrotrilepis pilosa* forming large patches. They are fringed with mosses like *Bryum arachnoideum* and ferns (*Asplenium stuhlmannii*, *Pellaea doniana*). Occasionally traces of fire are present; *Porembski, Stefan s.n.* (lecto-, designated here, BIOID: 20200909141453).

Description: Unlike Porembski et al. (1994), Couch et al. (2019: 15) consider that granitic inselbergs have many local endemics (a point of view although shared by Porembski et al., 1996). These authors have focused on lowland inselbergs (< 850 m altitude) of the humid bioclimatic zone (which represent the large majority of inselbergs of Guinea). Couch et al. (2019: 37) report 33 threatened species from granitic inselbergs, of which four are unique to granite alone: *Bryaspis humulariodes*, *Feliciadamia stenocarpa* (but on submontane rock cliffs: see [54]), *Loudetiopsis baldwinii*, *Osbeckia praviantha*.

Distribution: Widespread in West Africa (see [53]).

RLE status: DD, but likely to be considered LC, although Couch et al. (2019) consider this ecosystem as threatened. It seems likely that Couch et al.'s opinion is more guided by the presence of threatened species in taxonomic groups where they are leading new research. They evaluate the total area of inselbergs documented in Guinea to 317.15 km² (AOO). We estimate that it cannot trigger a threatened class based on criterion B (if calculated according to RLE methodology), and although there is a reduction in AOO described by Couch et al. (2019: 41), due to quarrying, this reduction cannot be quantified (and is likely inferior to 30% over any 50 years period).

[61] ***West African Saxicolous open vegetation on granitic outcrop of the Submontane tropical humid moist seasonal semi-deciduous rainforest zone*** / *Prairie ouest africaine saxicole sur inselberg granitique de la zone des Forêts tropicales humides saisonnières semi-décidues submontagnardes* (Senterre, Bruno nov.). Type: Guinea: Massif du Ziama, pentes du Mont Tambakula; 8.38082; -9.33196; 1012; *Senterre, Bruno & Konate, Lansana BS61-20190924-1353-4* (holo-, BIOID: BS61-20190924-1353-4).

Paratypic synonyms (p.p. synonyms):

Granite inselberg (Couch et al. 2019: 199). Type: Guinea: Ziama (coordinates and location hypothesized based on photo provided in the book TIPAS; most likely in the submontane belt, >850-900 m); 8.34849; -9.34606; 1150; *Couch, Charlotte s.n.* (para-, BIOID: 20200812150816).

High Altitude Lateritic Bowal (Couch et al. 2019: 163). Type: Guinea: Mont Béro, on the summit area; 1182; p.149: The grassland area on the flat tops includes small areas of high-altitude lateritic (ferralitic) bowal. This is much smaller than that at Simandou, and not as species-rich, but there are some threatened species present in the seasonally wet areas; *Couch, Charlotte s.n.* (para-, BIOID: 20200812180546).

Other virtual ecosystemic specimens:

Côte d'Ivoire: Massif des Dans, Mont Tonkoui; 7.44461; -7.64488; 1100; p.176: Prairie à *Afrotrilepis*; Les dômes rocheux et escarpements du sommet du Tonkoui (1240 m) portent une végétation pionnière: Lichens, et parfois herbes (*Afrotrilepis pilosa*, *Monocymbium*) et sous-arbrisseaux (*Hibiscus scotellii*); il arrive que l'Orchidée *Polystachya microbambusa* se trouve sur les touradons de l'*Afrotrilepis*. Au Mont Momy (qui atteint 1180 m) vit *Olea hochstetteri* qui se retrouve au Ziama (Guinée), au Bautchi (Nigeria) et sur les montagnes d'Afrique orientale (de l'Éthiopie à la Rhodèsie); *Schnell, Raymond s.n.* (BIOID: 20200813094800, in Schnell 1979).

Côte d'Ivoire: Massif des Dans, Mont Tonkoui; 7.44846; -7.64889; 990; p.176: Groupement à *Eugenia leonensis* et *Monocymbium*; et Peuplements d'*Hymenodictyon*: On passe finalement à une formation basse et rabougrie à *Hymenodictyon floribundum* sur un sol très mince recouvrant la dalle; à cette espèce peuvent s'ajouter des *Hibiscus*, *Dolichos tonkouiensis*, *Afrotrilepis pilosa*, quelques Graminées (*Monocymbium*), des épiphytes (Lichens, etc.), et parfois sur le sol quelques taches de *Rhodobryum pseudohomalobolax*; *Schnell, Raymond s.n.* (BIOID: 20200813094303, in Schnell 1979).

Description: This type of ecosystem differs from the lowland equivalent by the presence of a (sub)montane element, often with a wide geographic distribution. It is often predominantly herbaceous, eventually with sparse shrubs.

Distribution: Poorly known. Guinea (Ziama, Mt. Béro), Sierra Leone (Mt. Loma), Ivory Coast (Massif des Dans), and possibly further to the East.

RLE status: DD.

[62] ***West African Saxicolous open vegetation on granitic outcrop of the Montane tropical humid moist seasonal semi-deciduous rainforest zone*** / *Prairie ouest africaine saxicole sur inselberg granitique de la zone des Forêts tropicales humides saisonnières semi-décidues montagnardes* (Senterre, Bruno nov.). Type: Guinea: Ziama North; 8.34652; -9.35159; 1314; observed on Google Earth images; *Senterre, Bruno 20200811161854* (holo-, BIOID: 20200811161854).

Other virtual ecosystemic specimens:

Guinea: Massif du Ziama, proche du Macenta, du côté Est du massif; 8.346; -9.352; 1300; Là où le sol est encore plus mince et rocheux, la végétation se réduit à des peuplements arbustifs rabougris d'*Hymenodictyon floribundum*, auquel s'ajoutent *Eugenia leonensis*, *Memecylon fasciculare*, *Psychotria rufipilis*, *Dolichos tonkouiensis*, *Afrotrilepis pilosa*, etc. et quelques épiphytes : *Tridactyle tridactylites*, *Polystachya* spp., *Usnea speciosa*, *Usnea* spp., *Parmelia* spp., etc.; *Schnell, Raymond s.n.* (BIOID: 20200813101432, in Schnell 1979).

Description: Known mostly from the description given above by Schnell (1979).

Distribution: Possibly endemic to the North-Eastern part of the Ziama (Mt. Tambakula).

RLE status: DD. Although this would surely be a very rare ecosystem, its identity remains too poorly known, e.g. with respect to submontane inselbergs and other African montane inselbergs.

III.1.7.8 Saxicolous open vegetation on ironstone outcrops (Ge.)

[63] ***West African Saxicolous grassland on ironstone of the Lowland tropical rainforest zone*** / *Prairie ouest africaine saxicole sur cuirasse ferrugineuse de la zone des Forêts tropicales de plaine* (Senterre et al. 2019a: 54). Type: Guinea: Massif du Mont Nimba, entre

la vallée du Zougué et le Gba; 7.69421; -8.39912; *Senterre, Bruno & Bidault, Ehoarn BS61-26b* (holo-, BIOID: BS61-20191001-1601-26b).

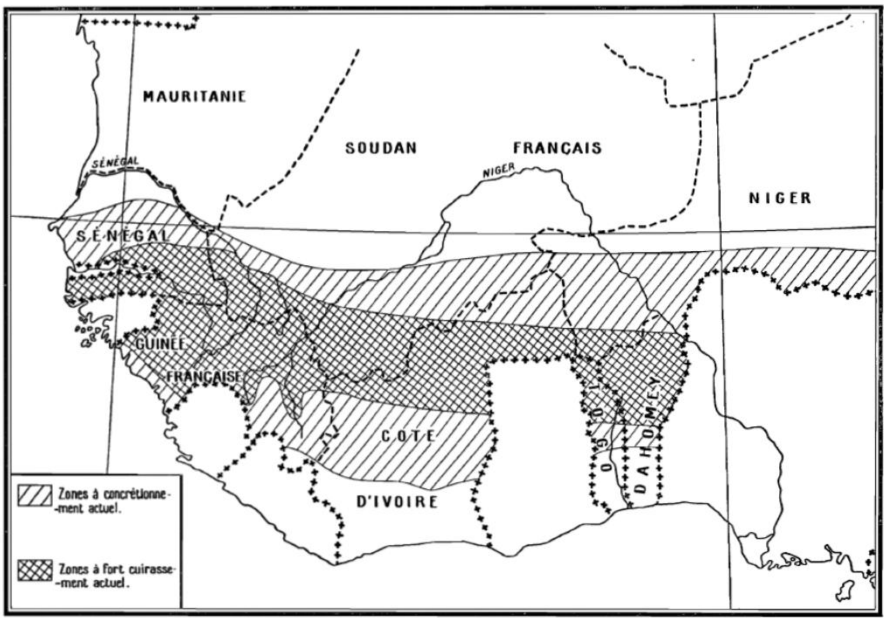


Figure 5. Current distribution of ironstone outcrops in West Africa, according to Maignien 1958: 14).

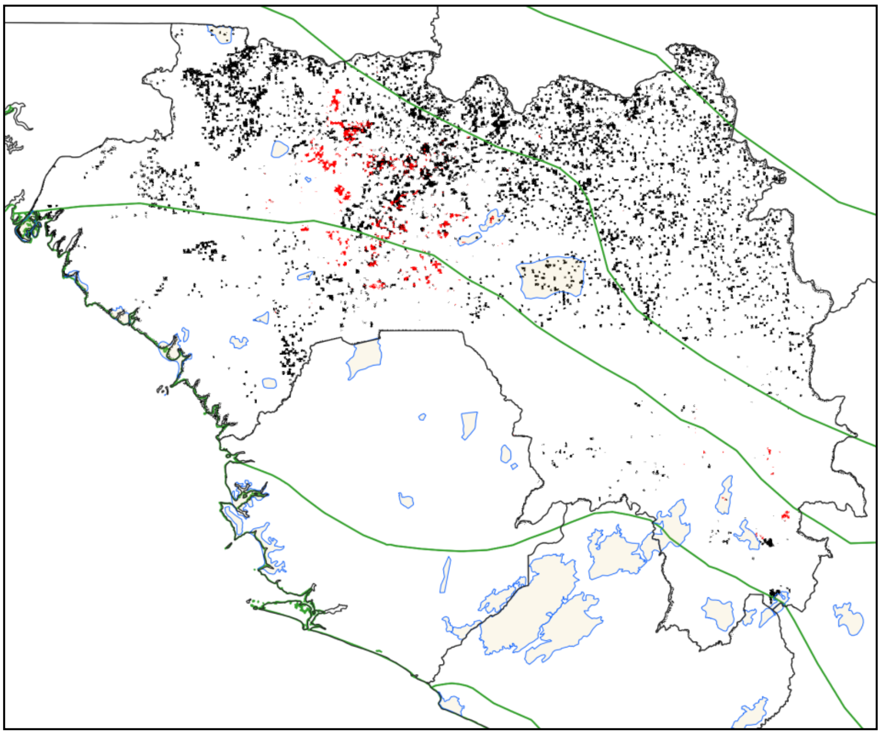


Figure 6. Distribution of bowe in Guinea (saxicolous herb savannas on ironstone), according to Couch et al. (2019: 33).

The green lines correspond to the life zone transitions as defined in the current study. Bowe located at more than 850 m of altitude are colored in red (submontane and montane belts).

Heterotypic synonyms:

Groupement à Loudetia arundinacea (Loudetietum arundinaceae) (Schnell 1952: 381). Type: Guinea: Mont Nimba; *Loudetia arundinacea* constitue la quasi-totalité du peuplement herbacé. Autres espèces: *Sopubia parviflora*, *Striga aequinoctialis*, *Antholyza Fleuryi*, *Phyllanthus alpestris*, … Ce groupement est celui des prairies basses sur cuirasse affleurante; *Schnell, Raymond s.n.* (holo-, BIOID: Schnell-19520101-2109-381).

Savane édaphique de basse terre / lowland edaphic savanna (Golder 2013: 11). Type: Guinea: Mount Nimba; *Golder s.n.* (holo-, BIOID: Golder-20130101-2213-11).

Lowland edaphic savanna (Astron 2019: 13). Type: Guinea: Mount Nimba; *Astron s.n.* (holo-, BIOID: Astron-20190101-1303-13).

High Altitude Lateritic Bowal (Couch et al. 2019: 163). Type: Guinea: Nimba, NE; 7.6965; -8.4041; 730; >500m; Couch, Charlotte s.n. (lecto-, designated here, BIOID: 20200812170349).

Low Altitude Lateritic Bowal (Couch et al. 2019: 31). Type: Guinea: n.b.: see map on page 31, 9.82371; -12.73343; 150; *Couch, Charlotte s.n.* (lecto-, designated here, BIOID: 20200812171900).

Végétation herbacée saxicole sur cuirasse ferralitique ou gravillonnaire (bowal) sèche de basse altitude (Aussel 2018: 32151). Type: Guinea: MG; petite quantité de terre meuble, en dessous de 500m d'altitude. *Loudetia* spp., *Sporobolus* spp., *Hyparrhenia* spp., *Ctenium newtonii*; *Aussel, Alexia s.n.* (holo-, BIOID: Aussel-20181211-0709-32151).

Description: See descriptions above. This type of ecosystem generally lacks shrubs or trees. It occurs often on horizontal or sub-horizontal surfaces. In degraded landscapes, it is often characterized by a narrow linear fringe of shrubs and small trees at the periphery, followed outwards by cultivated or fallow lands (see Senterre 2016b).

Distribution: Lowland bowe are widely distributed in Guinea (Couch et al. 2019; Figures 6) and in West Africa (Maignien 1958: 14, http://www.herbierguinee.org/habitats-menaces.html; Figure 5). They are mostly abundant in the humid and subhumid bioclimates, and occur more rarely towards the northern limit of the perhumid zone. Based on knowledge available, Senterre et al. (2019a) have suggested that only altitudinal gradients should be considered to distinguish bioclimatic types of bowe, regrouping therefore bowe from perhumid, humid and subhumid zones together (see name: "*of the Lowland tropical rainforest zone*").

RLE status: LC according to Senterre et al. (2019a).

[64] ***West African Saxicolous grassland on ironstone of the Submontane tropical rainforest zone*** / *Prairie ouest africaine saxicole sur cuirasse ferrugineuse de la zone des Forêts tropicales submontagnardes* (Senterre et al. 2019a: 55). Type: Guinea: Massif du Mont Nimba, Vallée de la Zouge; 7.67907; -8.38515; 993; Petit bowal, de bas de pente; *Senterre, Bruno & Bidault, Ehoarn BS61-14* (holo-, BIOID: BS61-20191001-0851-14).

Heterotypic synonyms:

Végétation herbacée saxicole sur cuirasse ferralitique ou gravillonnaire (bowal) sèche de haute altitude (Aussel 2018: 32153). Type: Guinea: MG; petite quantité de terre meuble, au dessus de 500m d'altitude; *Aussel, Alexia s.n.* (holo-, BIOID: Aussel-20181211-1506-32153).

Description: Although Shnell (1952) did not recognize altitudinal variants of bowe, he did with the pyrophilic disclimax savannas and others have distinguished high altitude bowe from lowland ones (Couch et al. 2019). According to Couch et al. (2019: 33): "Flat, well-drained surfaces [of the High-Altitude Lateritic Bowal Grassland], dominated by sparse grasses, such as *Schizachyrium djalonicum*, interspersed with rare, fire-resistant or pyrophytic, usually tuberous perennial herbs, such as *Vernonia djalonenis*, *Rhytachne glabra*, and *Eriosema triformum*.".

Distribution: If submontane bowe have to be recognized (i.e. on a bioclimatic basis), it seems to us that the threshold value for the minimum altitude should be the same as for other types of stands (including forests for which altitudinal belts are better characterized, when looking at plants). Therefore we reclassified the map proposed by Couch et al. (2019) using the 850 m altitude threshold (see Figure 6). Most of the submontane bowe of the Fouta Djalon are in the subhumid bioclimatic zone, and therefore humid submontane bowe might not be very common. In Mt. Nimba, we identified only one site, and none was cited from the literature (which might explain why Schnell did not recognize this ecosystem). A small outcrop is mentioned by Couch et al. (2019: 149) at Mont Béro, which we consider more likely to be an inselberg grassland rather than an ironstone one (see [61]). Therefore, we consider this type of ecosystem as rare (number of sites and AOO).

RLE status: DD according to Senterre et al. (2019a).

[65] ***West African Saxicolous grassland on ironstone of the Montane tropical rainforest zone*** */ Prairie ouest africaine saxicole sur cuirasse ferrugineuse de la zone des Forêts tropicales montagnardes* (Senterre et al. 2019a: 56). Type: Guinea: Massif du Mont Nimba, Haut Cavally; 7.6659; -8.39211; 1311; Petit affleurement de cuirasse ferralitique en rebord de cassure; *Senterre, Bruno & Bidault, Ehoarn BS61-52* (holo-, BIOID: BS61-20191005-0933-52).

Description: Poorly known. It seems localized on the largest ridges and just above the gently slopes, ironstone breaks. They probably replaced partly the subsaxicolous dwarf forest on ironstone that existed on some of the upper slopes and ridges of the summit of the Nimba and Pic de Fon.

Distribution: Only found in Mt. Nimba and at Pic de Fon.

RLE status: DD according to Senterre et al. (2019a).

III.1.7.9 Saxicolous open vegetation on ultramafic outcrop (Ge.)

[66] ***West African Saxicolous grassland on quartzite of the Montane tropical rainforest zone*** */ Prairie ouest africaine saxicole sur quartzite de la zone des Forêts tropicales montagnardes* (Senterre et al. 2019a: 57). Type: Guinea: Massif du Mont Nimba, haut de la vallée de Wolanda; 7.65758; -8.37744; 1562; alternance de poches de sol et de surfaces saxicoles; *Senterre, Bruno & Bidault, Ehoarn BS61-34* (holo-, BIOID: BS61-20191003-0944-34).

Heterotypic synonyms:

Groupement hélio-xérophile à Tridactyle tridactylites et Polystachya pobeguinii (Schnell 1952: 384). Type: Guinea: Mont Nimba; Ce groupement comporte, outre ces deux Orchidées, un *Parmelia* et des Lichens incrustants. Localisé sur le sommet de blocs rocheux très secs; *Schnell, Raymond s.n.* (holo-, BIOID: Schnell-19520101-2041-384).

Groupement à Eriospora pilosa et Osbeckia porteresii (Schnell 1952: 383). Type: Guinea: Mont Nimba; Localisé sur des seuils rocheux, où la flore prairiale typique ne peut s'installer. Les touffes d'*Eriospora* [=*Afrotrilepis pilosa*] engendrent un humus qui s'accumule dans le feutrage des touradons, ou sur la dalle rocheuse; *Schnell, Raymond s.n.* (holo-, BIOID: Schnell-19520101-1639-383).

Savane de haute altitude / high-altitude savanna (Golder 2013: 14). Type: Guinea: Mount Nimba; *Golder s.n.* (holo-, BIOID: Golder-20130101-1934-14).

Nimba mountain savanna (Astron 2019: 14). Type: Guinea: Mount Nimba; *Astron s.n.* (holo-, BIOID: Astron-20190101-0929-14).

Submontane grassland on leached ferralitic itabirite (Couch et al. 2019: 159). Type: Guinea: Nimba NE; 7.65879; -8.37475; 1570; The slopes of the mountains are forested and there is submontane grassland above this, on mainly ferralitic itabirites that have undergone various degrees of leaching of its alumina-silicate components. In an earlier report on TIPAS, the same authors called this "High altitude grassland with high species diversity"; *Couch, Charlotte s.n.* (holo-, BIOID: 20200812172738).

Description: Two endemic species are found: the viviparous toad (*Nimbaphrynoides occidentalis*) and *Polystachya orophila* (Orchidaceae).

Distribution: This ecosystem-type is endemic to Mount Nimba and is restricted to the uppermost rocky outcrops and the slopes directly beneath.

RLE status: VU according to Senterre et al. (2019a).

III.1.7.10 Subsaxicolous dwarf forest on granitic outcrop (Ge.)

[67] ***West African Saxicolous dwarf forest on granitic outcrop of the Lowland tropical perhumid moist evergreen rainforest zone*** / *Forêt ouest africaine naine saxicole sur inselberg granitique de la zone des Forêts tropicales perhumides sempervirentes de plaine* (Senterre, Bruno nov.). Type: Liberia: North Lorma National Forest, Lawa River; 8.01872; -9.74165; 440; Slightly uphill from the Lawa River, the vegetation quickly changed to lower forest with scattered huge trees which even harbored characteristic dry-forest species like *Gardenia nitida* and *Grewia pubescens*; *Jongkind, Carel s.n.* (holo-, BIOID: 20200807175827, in Jongkind 2007).

Description: Poorly known.

Distribution: Rare in West Africa, probably restricted to the South of the Ziama (Guinea) and to the Wonegizi-Wologizi (Liberia).

RLE status: DD.

[68] ***West African Saxicolous dwarf forest on granitic outcrop of the Submontane tropical perhumid moist evergreen rainforest zone*** / *Forêt ouest africaine naine saxicole sur inselberg granitique de la zone des Forêts tropicales perhumides sempervirentes submontagnardes* (Senterre, Bruno nov.). Type: Guinea: Ziama, South; 8.17075; -9.43284; 1050; based on Google Earth; *Senterre, Bruno 20200812114303* (holo-, BIOID: 20200812114303).

Description: Unexplored.

Distribution: Very rare in West Africa, probably restricted to the South of the Ziama (Guinea).

RLE status: DD.

[69] ***West African Saxicolous dwarf forest on granitic outcrop of the Montane tropical perhumid moist evergreen rainforest zone*** / *Forêt ouest africaine naine saxicole sur inselberg granitique de la zone des Forêts tropicales perhumides sempervirentes montagnardes* (Senterre, Bruno nov.). Type: Guinea: Ziama, South; 8.17769; -9.42539; 1330; based on Google Earth; *Senterre, Bruno 20200812113021* (holo-, BIOID: 20200812113021)

Other virtual ecosystemic specimens:

Guinea: Massif du Ziama, proche du Macenta, du côté Ouest du massif, exposé à la mousson; 8.17534; -9.42733; 1310; p.177: Les épiphytes sont surtout abondants dans celles de ces forêts qui, du côté Ouest, sont exposées à la mousson: *Xiphopteris* (*Polypodium*) *oosora*, *X. villosissima*, *X. serrulata* (trés petite espèce américaine), *Asplenium dregeanum* (abondant), *Hymenophyllum*, *Rhacopilum africanum*, *Plagiochila*, etc.; *Schnell, Raymond s.n.* (BIOID: 20200813101040, in Schnell 1979).

Description: Poorly known.

Distribution: Endemic to the South of the Ziama (Guinea).

RLE status: DD. Although we could assess criterion B, this ecosystem-type is too poorly known and lacks field data.

[70] ***West African Saxicolous dwarf forest on granitic outcrop of the Lowland tropical humid moist seasonal semi-deciduous rainforest zone*** / *Forêt ouest africaine naine saxicole sur inselberg granitique de la zone des Forêts tropicales humides saisonnières semi-décidues de plaine* (Senterre, Bruno nov.). Type: Guinea: Ziama, from Google Earth; 8.24653; -9.24955; 683; *Senterre, Bruno 20200811164012* (holo-, BIOID: 20200811164012).

Description: Poorly known. Inselberg studies have focused on open vegetation types. Dwarf saxicolous forests are only briefly mentioned by Porembski et al. (1994: 319) as "fringes of xerophytic forest".

Distribution: Widespread in West Africa (see [53]), although we have no information on the conservation state of the saxicolous forests on inselbergs (fires, deforestation).

RLE status: DD.

[71] ***West African Saxicolous dwarf forest on granitic outcrop of the Submontane tropical humid moist seasonal semi-deciduous rainforest zone*** / *Forêt ouest africaine naine saxicole sur inselberg granitique de la zone des Forêts tropicales humides saisonnières semi-décidues submontagnardes* (Senterre, Bruno nov.). Type: Guinea: Massif du Ziama, Pentes du Mont Tambacoula; 8.38095; -9.33207; 1009; forêt dense, 12 m de haut; *Senterre, Bruno & Bidault, Ehoarn BS61-10* (holo-, BIOID: BS61-20190927-1043-10).

Other virtual ecosystemic specimens:

Côte d'Ivoire: Massif des Dans, Mont Tonkoui; 7.44368; -7.64638; 1015; p.176: Forêt basse: Sur les pentes des dômes rocheux, à sol moins épais, la forêt devient plus basse, avec disparition des grands arbres au profit de petits arbres tels qu'*Eugenia leonensis*, *Maesa lanceolata*, *Harungana madagascariensis*, *Premna hispida*; *Schnell, Raymond s.n.* (BIOID: 20200813094013, in Schnell 1979).

Description: Poorly known, see description by Schnell above.

Distribution: Poorly known. Guinea (Ziama, Mont Béro?), Sierra Leone (Mt. Loma), Ivory Coast (Massif des Dans), and possibly further to the East (see [61]).

RLE status: DD.

[72] ***West African Saxicolous dwarf forest on granitic outcrop of the Montane tropical humid moist seasonal semi-deciduous rainforest zone*** / *Forêt ouest africaine naine saxicole sur inselberg granitique de la zone des Forêts tropicales humides saisonnières semi-décidues montagnardes* (Senterre, Bruno nov.). Type: Guinea: Ziama North; 8.34629; -9.35176; 1314; *Senterre, Bruno 20200811162136* (holo-, BIOID: 20200811162136).

Other virtual ecosystemic specimens:

Guinea: Massif du Ziama, proche du Macenta, du côté Est du massif; 8.34633; -9.35194; 1315; p.177: Sur le sol mince de certaines crêtes et sur le pourtour des bombements granitiques non boisés se trouvent des forêts basses édaphiques à *Parinari excelsa*, *Memecylon polyanthemos*, *Ochna membranacea*, *Garcinia polyantha*, *Afrosersalisia cerasifera*, avec des épiphytes nombreux (Fougères, Orchidées, Bryophytes, Lichens), Ces forêts basses, qui n'ont souvent que 4 à 10 m, en pourtour des clairières naturelles, sont l'habitat d'*Olea hochstetteri*. Ces forêts basses sont vulnérables aux feux en saison sèche; nous avons vu les traces d'un incendie qui avait parcouru le sous-bois de l'une d'elles sur des dizaines de mètres; *Schnell, Raymond s.n.* (BIOID: 20200813100055, in Schnell 1979: 177).

Description: Poorly known, see description by Schnell above.

Distribution: Possibly endemic to the North-Eastern part of the Ziama (Mt. Tambakula) (see [62]).

RLE status: DD (DD-EN). It is likely to be threatened due to criterion B, and possibly also criterion A (see notes by Schnell above). However, we have too few data from both GIS and field work.

III.1.7.11 Subsaxicolous dwarf forest on ironstone outcrop (Ge.)

[73] ***West African Saxicolous dwarf forest on ironstone of the Lowland tropical perhumid moist evergreen rainforest zone*** / *Forêt ouest africaine naine saxicole sur cuirasse ferrugineuse de la zone des Forêts tropicales perhumides sempervirentes de plaine* (Senterre et al. 2019a: 38). Type: Liberia: Massif du Wologizi; 8.1196; -9.97136; 603; *Senterre, Bruno & Bidault, Ehoarn BS61-100b* (holo-, BIOID: BS61-20191019-1108-100b).

Description: Within the lowland perhumid life zone, saxicolous dwarf forests on ironstone are particularly rare and found mostly towards the transition zone to the lowland humid life zone. The identity of this ecosystem is unclear (see Senterre et al. 2019a). Saxicolous forests seem to be mostly influenced (bioclimatically speaking) by altidudinal gradients (i.e. with a temperature gradient added to a climatic wetness gradient). It would therefore be possible (at least from a botanist perspective) to interpret the type of ecosystem discussed here simply as a marginal intrusion from the lowland humid life zone (i.e. as a synonym of the ecosystem species [76]).

Distribution: There is very little mention in the literature of saxicolous dwarf forests within the lowland perhumid life zone, but we also have to keep in mind that there is very few mentions of saxicolous dwarf forests in general. We have not found other records than the ones observed by ourselves in the Wologizi. It is also likely present in SW Nimba.

RLE status: DD according to Senterre et al. (2019a).

[74] ***West African Saxicolous dwarf forest on ironstone of the Submontane tropical perhumid moist evergreen rainforest zone*** / *Forêt ouest africaine naine saxicole sur cuirasse ferrugineuse de la zone des Forêts tropicales perhumides sempervirentes submontagnardes* (Senterre et al. 2019a: 40). Type: Guinea: Massif du Mont Nimba, Seringbara 2; 7.62948; -8.42192; 1123; Forêt naine subsaxicole sur cuirasse, naturelle, mature, 7 m de haut; *Senterre, Bruno & Bidault, Ehoarn BS61-70* (holo-, BIOID: BS61-20191009-0948-70).

Heterotypic synonyms:

Permanent secondary forest (Astron 2019: 3). Type: Guinea: Mount Nimba; *Astron s.n.* (holo-, BIOID: Astron-20190101-2134-3).

Other virtual ecosystemic specimens:

Liberia: Massif du Wologizi, Balagazi; 8.12217; -9.94845; 847; forêt dense, 23 m de haut, sur cuirasse ferrallitique en décomposition; *Senterre, Bruno & Bidault, Ehoarn BS61-96* (BIOID: BS61-20191017-1434-96).

Description: Poorly known. Briefly illustrated by Schnell (1948); see also Senterre et al. (2019: 92-94). The moister climate of the perhumid zone is responsible for a better stability of the forest and therefore for a more advanced regression of the ironstone shields (due to regressive erosion). The forest is typically less than 10 m high, with a high density of small, short trunks and an open understorey with regular stratification. The ground is sub-horizontal and remains of the ironstone shield are visible. We observed the same ecosystem type in the

Wologizi in Liberia (i.e. climatically moister than SW Nimba), but in a relatively taller form (ca. 20 m, within a landscape of mesic forests with much higher canopies).

Distribution: This type of ecosystem is probably very rare. Within the submontane belt we find it only towards the transition from the perhumid to the humid climatic wetness zones, in landscapes with a geology compatible with the formation of ironstone shields (during the Quaternary). To our knowledge, it is recorded only from the SW Nimba and the Wologizi.

RLE status: CR according to Senterre et al. (2019a).

[75] ***West African Saxicolous dwarf forest on ironstone of the Montane tropical perhumid moist evergreen rainforest zone*** / *Forêt ouest africaine naine saxicole sur cuirasse ferrugineuse de la zone des Forêts tropicales perhumides sempervirentes montagnardes* (Senterre et al. 2019a: 42). Type: Guinea: Massif du Mont Nimba, Seringbara; 7.5886; -8.43879; 1394; identifié sur Google Earth (image du 13/01/2018); *Senterre, Bruno & Bidault, Ehoarn BS61-64g* (holo-, BIOID: BS61-20191008-1303-64g).

Heterotypic synonyms:

Fourrés de haute altitude / high altitude thicket (Golder 2013: 10). Type: Guinea: Mount Nimba; *Golder s.n.* (holo-, BIOID: Golder-20130101-0614-10).

High altitude gallery forest or thickets (Astron 2019: 6). Type: Guinea: Mount Nimba; *Astron s.n.* (holo-, BIOID: Astron-20190101-0334-6).

High altitude low forest or thickets (Astron 2019: 7). Type: Guinea: Mount Nimba; *Astron s.n.* (holo-, BIOID: Astron-20190101-0120-7).

Forêt basse ombrophile à Parinari excelsa et Eugenia leonensis (Schnell 1952: 385). Type: Guinea: Mont Nimba; Ce second groupement correspond aux forêts basses vivant sur un sol meuble très mince recouvrant la dalle rocheuse. On le rencontre sur les crêtes Sud-Ouest du Nimba, à 1200-1400 m. C'est également à ce groupement qu'appartiennent les régions périphériques (généralement externes aux corniches rocheuses délimitant les vallées mineures) des forêts occupant le haut des ravins supérieurs du Nimba NE; le groupement y est alors généralement plus ou moins dégradé (intrusions d'espèces secondaires, en particulier *Canthium glabriflorum*). Nous pensons que ce groupement possédait à l'origine une extension beaucoup plus grande; c'est lui qui devait recouvrir, sur de vastes espaces, les pentes supérieures et une partie des crêtes. Ce même groupement se retrouve (avec des variantes de détail) dans les reliques forestières des pentes supérieures du massif de Fon. Schnell (1952: 387): Ce groupement paraît devoir être considéré comme une variante édaphique des forêts plus hautes à *Parinari* vivant sur des sols plus épais (ravins, etc.). Parmi les relevés suivants, le premier concerne la forêt intacte des crêtes SO du Nimba; les deux suivants correspondent à des vestiges de forêt basse sur la périphérie des têtes de galeries forestières (à 1500 et 1400 m.); le dernier a été établi dans un bosquet relique de forêt basse, vers 1520 m, sur un petit plateau. La présence locale de quelques espèces secondaires, telles que *Canthium glabriflorum* et *Haronga paniculata*, traduit l'altération de ces reliques. 1. Espèces communes avec les forêts de ravins: *Parinari excelsa*, *Uapaca togoensis*, *Eugenia Pobeguini*, *Memecylon polyanthemos*, *Garcinia polyantha*, *Schefflera Barteri*, *Gaertnera Cooperi*, *Urophyllum canthiiflorum*, *Salacia alpestris*, *Popowia af. nigritana*, *Peperomia Staudtii*, *Begonia rubromarginata*, *Tridactyle tridactylites*, *Bulbophyllum bifarium*, *B. af. Schimperianum*, *Arthropteris orientalis*, *Asplenium Dregeanum*, *Elaphoglossum sejunctum*, *Lycopodium Mildbraedii*, *Macromitrium levatum*, *Usnea speciosa*, 2. Espèces propres au groupement: *Homalium longistylum*, *Eugenia leonensis*, *Lachnopylis guinensis*, *Hymenodictyon floribundum*, *Habenaria macrandra*, *Disperis thomensis*. Le sol de ces forêts, épais de quelques décimètres au maximum, est très foncé. Nous donnons ci-après les caractéristiques de sols de diverses forêts montagnardes basses, et celles (no. 2) d'un sol de forêt demi-haute sur sol plus épais. Ces forêts basses, pendant toute la saison des pluies, sont noyées dans des brouillards persistants; le déficit de saturation y reste voisin de 0 mm de mars à septembre, sauf en de rares et brèves éclaircies. En saison sèche, ces forêts sont soumises à une dessiccation plus accentuée que les forêts des ravins; *Schnell, Raymond s.n.* (holo-, BIOID: Schnell-19520101-2312-385).

Description: See above, the description provided by Schnell. It is most probably quite similar with the ecosystem [74], except for non-vascular plants, vascular epiphytes and associate micro-fauna.

Distribution: Known only from the SW Nimba; possibly present in the highest parts of the Wologizi, but not observed there and possibly destroyed by fires.

RLE status: CR (EN-CR) according to Senterre et al. (2019a).

[76] ***West African Saxicolous dwarf forest on ironstone of the Lowland tropical humid moist seasonal semi-deciduous rainforest zone*** */ Forêt ouest africaine naine saxicole sur cuirasse ferrugineuse de la zone des Forêts tropicales humides saisonnières semi-décidues de plaine* (Senterre et al. 2019a: 45). Type: Guinea: Massif du Mont Nimba; 7.69119; -8.42651; 567; observé sur Google Earth (11/1/2012); *Senterre, Bruno & Bidault, Ehoarn BS61-26f* (holo-, BIOID: BS61-20191001-1557-26f).

Heterotypic synonyms:

Saxicolous dry forest (Senterre 2016b: 4). Type: Guinea: Bel Air, Alufer; 10.41893; -14.32533; 148; This land cover type comprises relatively low forests (ca. 20 m high) with smooth canopy, and is characterized by floristic elements from the Soudanian (mesic) woodlands such as *Parkia biglobosa* and *Piliostigma thonningii* (White 1983). Saxicolous dry forests typically occur as a narrow fringe (5 m wide) around bowe, followed by Mesic forest, which are now generally replaced by fallow lands within the study area. In some places the transition from bowal to Mesic forest is stretched, due to micro-topography and patterns of ironstone concretion, and the natural landscape might have been a Saxicolous dry forest-Saxicolous dry herb-savanna mosaic (see for example near MBGB-67). These can be distinguished from anthropic forest-savanna mosaic by the nature of the forest patches (combining aspects of soil surface and forest structure) and by their direct proximity to true bowe (a maximum of a few 10s or 100s of meters); *Senterre, Bruno & Bidault, Ehoarn MBGB-62* (lecto-, designated here, BIOID: 20200911094637).

Description: Throughout the lowland humid life zone, fires and deforestation has been intense and subsaxicolous forest fringes of bowe have disappeared in many places (see Senterre 2016b: Annexe 6, p. 40, photo PA242086.jpg). In 2016 (see description above), we had not made a distinction between subsaxicolous forests of ironstone outcrops (bowe) and other rocky outcrops (see Senterre 2016: Annexe 6, p.39, photo PA242026.jpg), the flora of these being a priori similar. Here, we make such distinction, tentatively. More studies are needed to evaluate the biotic differentiation of subsaxicolous dwarf forests of the lowland humid life zone depending on various lithologies.

Distribution: Poorly known; This ecosystem has been destroyed in many locations (by fires and deforestation), and has therefore a current distribution reduced compared to the non-woody ecosystem types of bowe landscapes (see [63]).

RLE status: EN (DD-EN). The criterion A is certainly the one that could trigger a threatened status. Although data do not exist, we estimate that it is likely that the reduction in distribution is >50% over any 50 years period (A2b). We considered this ecosystem as DD earlier (Senterre et al. 2019a).

[77] ***West African Saxicolous dwarf forest on ironstone of the Submontane tropical humid moist seasonal semi-deciduous rainforest zone*** / *Forêt ouest africaine naine saxicole sur cuirasse ferrugineuse de la zone des Forêts tropicales humides saisonnières semi-décidues submontagnardes* (Senterre et al. 2019a: 49). Type: Guinea: Massif du Mont Nimba, NE; non-observé directement mais probablement présent; *Senterre, Bruno & Bidault, Ehoarn BS61-26c* (holo-, BIOID: BS61-20191001-1558-26c).

Heterotypic synonyms:

Variante édaphique du groupement à Parinari excelsa et Carapa procera (Schnell 1952: 372). Type: Guinea: Nimba N.E.; Là où ce groupement vit sur une cuirasse subaffleurante, la hauteur de ses arbres diminue, les espèces de première grandeur font défaut, et la strate supérieure est essentiellement constituée par *Carapa procera* et *Sersalisia djalonensis*; simultanément, les Fougères abondent dans le sous-bois, où les affleurements rocheux sont nombreux. Il s'agit là d'une variante édaphique du groupement. Dans ces forêts mésophiles submontagnardes, le déficit de saturation, en juin, varie de 0 à 5 mm (exceptionnellement 7 ou 9 mm). Le pH des sols y est de l'ordre de 5,4, soit un peu plus élevé que dans les forêts de ravins; *Schnell, Raymond s.n.* (holo-, BIOID: Schnell-19520101-0628-372).

Description: Known only from Schnell's description (see above).

Distribution: Recorded by Schnell (1952) in the NE Nimba, but no explicit locality is given, and no site is currently known for this ecosystem type. Small relicts could also be searched for in the Pic de Fon.

RLE status: CR according to Senterre et al. (2019a).

[78] ***West African Saxicolous dwarf forest on ironstone of the Montane tropical humid moist seasonal semi-deciduous rainforest zone*** / *Forêt ouest africaine naine saxicole sur cuirasse ferrugineuse de la zone des Forêts tropicales humides saisonnières semi-décidues montagnardes* (Senterre et al. 2019a: 51). Type: Guinea: Pic de Fon; 8.55767; -8.90707; 1518; Non-observé directement mais sur Google Earth image du 1/2/2015; *Senterre, Bruno & Bidault, Ehoarn BS61-26e* (holo-, BIOID: BS61-20191001-1600-26e).

Description: Poorly known.

Distribution: Schnell (1948: 216): "L'existence de reliques forestières primaires sur les pentes supérieures à carapace et même sur certaines crêtes, dans le massif de Fon (identique au Nimba par sa constitution géologique, son modelé et son sol), montre que la forêt montagnarde devait jadis atteindre les régions supérieures de ces montagnes. Les reliques forestières du haut Nimba, moins étendues, le confirment.". This type of ecosystem is restricted to the Mont Nimba and Pic de Fon, but seems to have now disappeared from the Mont Nimba (based on our study of Google Earth images and GIS data).

RLE status: CR (CR-EN) according to Senterre et al. (2019a).

III.1.7.12 Saxicolous ravine grassland on ironstone (Ge.)

[79] ***West African Saxicolous periodically moist grassland on ironstone of the Lowland tropical rainforest zone*** / *Prairie ouest africaine périodiquement humide saxicole sur cuirasse ferrugineuse de la zone des Forêts tropicales de plaine* (Senterre et al. 2019a: 54). Type: Guinea: Massif du Mont Nimba, entre la Zougoue et le Gba; 7.69408; -8.39893; 784; Bowal humide, cuirasse ferralitique de bas de pente subhorizontale; *Senterre, Bruno & Bidault, Ehoarn BS61-26* (holo-, BIOID: BS61-20191001-1556-26).

Heterotypic synonyms:

Groupement à Loudetia arundinacea et Polygala clarkeana (Schnell 1952: 381). Type: Guinea: Mont Nimba; Le *Loudetietum* s'y enrichit par la présence d'espèces méso-hygrophiles. Il s'agit vraisemblablement d'une sous-association du groupement précédent (see [63] in this report). Principales espèces: *Loudetia arundinacea* (dominant), *Cyperus auricomus*, *Cyanotia Deightonii*, *Habenaria ichneumonea*, *Polygala Clarkeana*, *Sopubia parviflora*, *Striga aequinoctialis*, et parfois *Genlisea africana* et *Utricularia peltatifolia*. Ce groupement correspond à des prairies sur cuirasse affleurante temporairement humide lors des pluies; *Schnell, Raymond s.n.* (holo-, BIOID: Schnell-19520101-0619-381).

Végétation herbacée saxicole sur cuirasse ferralitique ou gravillonnaire (bowal) dans dépression humide de basse altitude (Aussel 2018: 32152). Type: Guinea: MG; Bowal temporairement humide, végétation hydrophile, floristiquement riche en dessous de 500 m d'altitude. *Rhytachne rottboellioides*, *Bryaspis lupulina*, *Loudetiopsis tristachyoides*, *Nemum spadiceum*, *Anadelphia macrochaeta*, *Adelostigma senegalensis*, *Drosera indica*, *Nerophila gentianoides*, *Scleria* spp., *Burmannia madagascariensis*, *Utricularia spiralis*, *Eriocaulon* spp., *Xyris* spp; *Aussel, Alexia s.n.* (holo-, BIOID: Aussel-20181211-1718-32152).

Description: See descriptions by other authors above.

Distribution: Widely distributed in Guinea and in West Africa. Extent Of Occurrence (EOO) similar to that of the ecosystem-type [63], but present on a smaller number of sites and more localized.

RLE status: LC according to Senterre et al. (2019a).

[80] ***West African Saxicolous periodically moist grassland on ironstone of the Montane tropical rainforest zone*** / *Prairie ouest africaine périodiquement humide saxicole sur cuirasse ferrugineuse de la zone des Forêts tropicales montagnardes* (Senterre et al. 2019a: 56). Type: Guinea: Massif du Mont Nimba, Mare d'hivernage; 7.66082; -8.37971; 1602; *Senterre, Bruno & Bidault, Ehoarn BS61-63* (holo-, BIOID: BS61-20191007-1452-63).

Heterotypic synonyms:

Groupement à Mesanthemum prescottianum et Genlisea africana (Schnell 1952: 384). Type: Guinea: Mont Nimba; Caractéristique: *Mesanthemum Prescottianum*. Electives et préférantes: *Genlisea africana*, *Cyanotis rupicola*, *Fimbristylis exilis*, *Bulbostylis trichobasis*, *B. filamentosa*, *Eriospora pilosa*. Quelques espèces prairiales sont parfois intrusives, surtout sur la périphérie. Sur des dalles rocheuses légèrement inclinées, humides en saison des pluies; *Schnell, Raymond s.n.* (holo-, BIOID: Schnell-19520101-0805-384).

Description: See above, the description by Schnell.

Distribution: To our knowledge, this type of ecosystem is only found at the Mare d'Hivernage (Mount Nimba), on the margin of the saxicolous marsh (see [26]).

RLE status: CR according to Senterre et al. (2019a).

III.1.7.13 Ravine forest (Ge.)

Ravine forests are rarely recognized as distinct types of ecosystem in the literature. Nevertheless, several authors have provided good evidences to consider Ravine forests as an important ecosystem, especially for small plants or animals (Leaché *et al.* 2006; Senterre *et al.* 2009; Senterre *et al.* 2013; Senterre *et al.* 2014), but also for trees (Gerlach *et al.* 2013).

[81] ***West African Ravine forest of the Tropical lowland superhumid evergreen rainforest zone*** / *Forêt ouest africaine de ravin de la zone des Forêts tropicales superhumides*

sempervirentes de plaine (Senterre, Bruno nov.). Type: Liberia: Dugbe HummingBird site (Sinoe County, ca. 20 km South of Sapo National Park, ca. 50 km East of Greenville), south slopes of Killer Mountain; 5.07051; -8.57287; 137m; *Senterre, Bruno HB-11* (holo-, BIOID: ae899a1a-7b78-4919-82da-3792023f08da).

Homotypic synonyms:

Ravine forests of the wet evergreen littoral rain forest zone (Senterre 2014: 19).

Description: Ravine forests are upwardly concave landforms along slopes of hills and in narrow valleys. They are characterized by a large diversity of micro-habitats, including some that are free of leaf litter (which distinguishes them from the understorey of most mesic forests) such as bare rock, bare soil on lateral slopes, trunks and leaves of other plants (more easily accessible for epiphytes and epiphylls, etc.). The ravine forests observed in the Dugbe HummingBird site were often characterized by rupicolous species of *Bolbitis* and *Asplenium*, as well as by a species of *Ptisana* (Possibly *P. senterreana*).

Distribution: Regularly occurring within the lowland superhumid life zone (Figure 7a), especially in mountainous and hilly landscapes. Likely present at Cape Mount (Lake Piso).

RLE status: EN. Based on the evaluation of the ecosystem [39], we consider the currently discussed ecosystem species as EN due to a potential diminution in distribution >50% (using Absolute Rate of Decline, ARD: Table 1).

[82] ***West African Ravine forest of the Lowland tropical perhumid moist evergreen rainforest zone** / Forêt ouest africaine de ravin de la zone des Forêts tropicales perhumides sempervirentes de plaine* (Senterre et al. 2019a: 36). Type: Liberia: Massif de Wologizi, Malsaw river; 8.12786; -9.94923; 655; *Senterre, Bruno & Bidault, Ehoarn BS61-82* (holo-, BIOID: BS61-20191015-1225-82).

Heterotypic synonyms:

Variante vallicole du groupement à Tarrietia utilis et Lophira procera (Schnell 1952: 366). Type: Guinea: Nimba S.O; Localisé dans les thalwegs humides (mais non marécageux) du Nimba S.O., ce groupement apparaît comme une variante (sous-association) de Forêt ombrophile de l'étage inférieur à *Tarrietia utilis* et *Lophira procera*. Dans l'ensemble, sa composition est celle de ce dernier, mais il s'y ajoute un certain nombre d'espèces différentielles hygrophiles: *Endosiphon primuloides*, *Chidlovia sanguinea* (très abondant), *Trichomanes mandioceanum*, *Coleus repens* (association dépendante des affleurements rocheux), *Stenochlaena guineensis*. On note de plus l'abondance considérable des espèces hygrophiles: *Mapania*, *Uapaca guineensis*, *U. esculenta*, … Le microclimat de ce groupement se caractérise par son humidité élevée et constante. Dans l'une de ces forêts, en juin 1945, le déficit de saturation restait compris entre 0 et 1, même par temps ensoleillé. En septembre 1947, dans la même forêt, la température quotidienne variait de 20° (minimum) à 23° (maximum); *Schnell, Raymond s.n.* (holo-, BIOID: Schnell-19520101-2217-366).

Groupement à Lophira et Chidlovia sanguinea (Schnell 1952: 369). Type: Guinea: Nimba S.O.; *Schnell, Raymond s.n.* (holo-, BIOID: Schnell-19520101-1113-369).

Valley Bottom (Hawthorne et al. 2010: 10, 39). Type: Liberia: West Nimba, Gangra, site EPVB05; 7.55405; -8.62128; 550; p.10: Valley Bottom (VB), small seasonal streams and lower slopes; Nuveg 4 is the common forest type on the ridges and upper slopes of Tokadeh, and on the western slopes of Yuelliton, but also has been sampled at lower altitudes including the valley between Gangra and Yuellton, at 440-840 m. Many of these samples were in steep river valleys where some riverine specialists were intermingled with more generalist forest species. They most closely match Guinea-Nimba Upland evergreen forest (Guinean type 6), and (in more riverine strips) Lowland moist riverine or groundwater forest (Guinean type 4).

As they are so closely intermingled, it would be hard to differentiate these types on a map, except by arbitrarily marking strips along rivers as the latter type. Typical trees are *Chidlowia sanguinea* (96%), *Bussea occidentalis* (86%), *Diospyros mannii* (69%). *Lophira alata*, *Piptadeniastrum*, *Parkia bicolor* and *Heritiera utilis* are common, as they are in other lowland forest type (Nuveg 6). Other characteristic species are *Drypetes chevalieri* (81%), *Whitfieldia lateritia* (72%), and *Rinorea welwitschii* (56%); *Hawthorne, William D. EPVB05* (lecto-, designated here, BIOID: 20200813154812).

Other virtual ecosystemic specimens:

Liberia: Gola National Forest; 7.452; -10.692; Waterside vegetation and streams: Along the streams the damage to the vegetation caused by rapidly changing water levels was clearly visible. Several species were adapted to this condition; usually shrubs with flexible twigs and narrow leaves like *Rinorea breviracemosa* were collected along fast-flowing parts of the streams; *Jongkind, Carel s.n.* (BIOID: 20200810093857, in Jongkind 2007).

Sierra Leone: Gola North, site 1, Mogbai; 7.65; -10.8667; 300; Primary evergreen forest, valley running through rolling hills, moderately well drained. *Cynometra leonensis* generally of moist sites, in association with *Heritiera*, and absence of *Didelotia idae* (pp.25, 39); *Davies, A. Glyn s.n.* (BIOID: 20200810173857, in Davies 1987).

Description: See descriptions provided above.

Distribution: Widespread within the lowland perhumid life zone (Figure 7b).

RLE status: VU according to Senterre et al. (2019a).

[83] ***West African Ravine forest of the Submontane tropical perhumid moist evergreen rainforest zone*** / *Forêt ouest africaine de ravin de la zone des Forêts tropicales perhumides sempervirentes submontagnardes* (Senterre et al. 2019a: 40). Type: Guinea: Massif du Mont Nimba, Seringbara; 7.63843; -8.42357; 900; identifié sur Google Earth; *Senterre, Bruno & Bidault, Ehoarn BS61-64c* (holo-, BIOID: BS61-20191008-1307-64c).

Description: Poorly known. This type of ecosystem is likely to host micro-endemic species, and it is at the same time under-explored.

Distribution: Rare, found in the Wologizi, SW Ziama, SW Nimba and in the Western Area Peninsula Non-Hunting Forest Reserve (Sierra Leone) (Figure 7d).

RLE status: VU(LC-VU) according to Senterre et al. (2019a).

[84] ***West African Ravine forest of the Montane tropical perhumid moist evergreen rainforest zone*** / *Forêt ouest africaine de ravin de la zone des Forêts tropicales perhumides sempervirentes montagnardes* (Senterre et al. 2019a: 41). Type: Guinea: Massif du Mont Nimba, Seringbara; 7.61497; -8.41855; identifié sur Google Earth (image du 13/01/2018); *Senterre, Bruno & Bidault, Ehoarn BS61-64f* (holo-, BIOID: BS61-20191008-1304-64f).

Description: Poorly known.

Distribution: SW Nimba, South Ziama, Massif de Wologizi (see Figure 7e).

RLE status: EN according to Senterre et al. (2019a).

[85] ***West African Ravine forest of the Lowland tropical humid moist seasonal semi-deciduous rainforest zone*** / *Forêt ouest africaine de ravin de la zone des Forêts tropicales humides saisonnières semi-décidues de plaine* (Senterre et al. 2019a: 44). Type: Guinea: Massif du Mont Nimba, Monts des Génies; 7.70583; -8.3642; 616; Forêt de ravin; *Senterre, Bruno & Bidault, Ehoarn BS61-44* (holo-, BIOID: BS61-20191004-1426-44).

Heterotypic synonyms:

Forêt mésophile vallicole à Chidlovia sanguinea (Schnell 1952: 371). Type: Guinea: Nimba N.E.; A la flore mésophile typique du groupement précédent s'y ajoutent, principalement dans les strates inférieures, un certain nombre d'espèces hygrophiles, communes avec les forêts ombrophiles vallicoles: *Chidlovia sanguinea* (abondant), *Pentaclethra macrophylla*, *Cleistopholis patens*, *Uapaca guineensis*, *U. esculenta*, *Rinorea ilicifolia*, *Selaginella Vogelii*. Plus rarement s'observent quelques jeunes individus de *Lophira procera*, qui n'effectueront pas dans ces forêts leur développement complet. On note enfin, dans les sous-bois, comme dans les forêts ombrophiles de vallées, l'abondance des Fougères, des épiphytes, et la présence d'Hépatiques épiphylles (*Leptolejeunea*, *Ceratolejeunea*) et d'Algue, d'épiphylles (*Trentepohlia*). Ce groupement (forêts hygro-mésophiles) est localisé dans les vallées. Le déficit de saturation, dans le sous-bois, est faible; en octobre, par temps ensoleillé, son maximum, au milieu de la journée, n'est que de 5.5 mm. Le pH du sol est de l'ordre de 5,0; *Schnell, Raymond s.n.* (holo-, BIOID: Schnell-19520101-1022-371).

Other virtual ecosystemic specimens:

Guinea: Massif du Ziama, Balassou; 8.3922; -9.32754; 713; forêt dense, 35 m de haut; *Senterre, Bruno & Bidault, Ehoarn BS61-20190923-1435-4* (BIOID: BS61-20190923-1435-4).

Description: see above (notes by Schnell).

Distribution: Widespread in West Africa (see Figure 7b); more frequent in mountainous and hilly landscapes (see landform categories 1 and 2 in Sayre et al. 2014).

RLE status: EN (EN-CR) according to Senterre et al. (2019a).

[86] ***West African Ravine forest of the Submontane tropical humid moist seasonal semi-deciduous rainforest zone*** / *Forêt ouest africaine de ravin de la zone des Forêts tropicales humides saisonnières semi-décidues submontagnardes* (Senterre et al. 2019a: 48). Type: Guinea: Massif du Mont Nimba, Haut Cavally; 7.6615; -8.39068; 1078; *Senterre, Bruno & Bidault, Ehoarn BS61-56* (holo-, BIOID: BS61-20191005-1054-56).

Heterotypic synonyms:

Forêt mésophile à Parinari excelsa, Chidlovia sanguinea et Carapa procera (Schnell 1952: 371). Type: Guinea: Nimba N.E.; Ce groupement s'apparente floristiquement au précédent [see type [82] in this report], dont il se distingue par la présence de quelques espèces de l'étage montagnard, encore disséminées. Caractéristiques différentielles: *Parinari excelsa*, *Chidlovia sanguinea*, *Carapa procera*, *Asplenium dregeanum*. Ce groupement occupe les fonds de vallées des altitudes moyennes, vers 800 mètres. […] pH du sol: 5,0.; *Schnell, Raymond s.n.* (holo-, BIOID: Schnell-19520101-2309-371).

Forêt galerie marécageuse sur sol hydromorphe de montagne (Aussel 2018: 3133). Type: Guinea: GF; Dans les ravins humides de l'étage montagnard (au-delà de 950 m d'altitude). Forêt dominée par des fougères arborescentes. *Cyathea manniana*, *Cyathea dregei*, *Macaranga* spp.; *Aussel, Alexia s.n.* (holo-, BIOID: Aussel-20181211-2246-3133).

Description: see above (notes by Schnell).

Distribution: Widespread in West Africa (see notes for type [44]; Figure 7f).

RLE status: VU according to Senterre et al. (2019a).

[87] ***West African Ravine forest of the Montane tropical humid moist seasonal semi-deciduous rainforest zone*** / *Forêt ouest africaine de ravin de la zone des Forêts tropicales humides saisonnières semi-décidues montagnardes* (Senterre et al. 2019a: 50). Type: Guinea: Massif du Mont Nimba, haut de la vallée de Wolanda; 7.65533; -8.37421; 1404; *Senterre, Bruno & Bidault, Ehoarn BS61-37* (holo-, BIOID: BS61-20191003-1046-37).

Heterotypic synonyms:

Forêt montagnarde à Parinari excelsa des ravins supérieurs (=forêts hautes des thalwegs) (Schnell 1952: 384). Type: Guinea: Nimba N.E., vallée du Zié, vers 1600 m d'altitude; *Parinari excelsa*, *Uapaca togoensis*, *Eugenia Pobeguini*, *Memecylon polyanthemos*, *Garcinia polyantha*, *Schefflera Barteri*, *Gaertnera Cooperi*, *Urophyllum canthiiflorum*, *Salacia alpestris*, *Popowia af. nigritana*, *Peperomia Staudtii*, *Begonia rubromarginata*, *Tridactyle tridactylites*, *Bulbophyllum bifarium*, *B. af. Schimperianum*, *Arthropteris orientalis*, *Asplenium Dregeanum*, *Elaphoglossum sejunctum*, *Lycopodium Mildbraedii*, *Macromitrium levatum*, *Usnea speciosa*, ... Le sol meuble, dans ces forêts, est épais (jusqu'à 2 m.), parsemé de blocs rocheux, avec un pH de l'ordre de 4,8 en surface, et une haute teneur en matière organique. Pour l'un d'eux, prélevé en surface, à 1600 mètres, les caractéristiques étaient les suivantes: En saison des pluies, la température du sous-bois varie entre 14° et 19 ° par temps de brouillard, l'hygrométrie y varie de 95 à 100 %, et le déficit de saturation de 0 à 0,5 mm., pour s'élever à 1,0 mm lors des éclaircies. En saison sèche, la température du sous-bois varie de 14° à 23° et le degré hygrométrique s'abaisse dans la journée jusqu'à 45-50 % (et même 40 % lorsque souffle l'harmattan), avec un déficit de saturation atteignant un maximum de 9 mm. par temps d'harmattan (observations faites dans le thalweg supérieur du Zié, vers 1600 m.); *Schnell, Raymond s.n.* (holo-, BIOID: Schnell-19520101-0058-384).

Forêt dense guinéenne mi-haute de haute montagne des ravins (Aussel 2018: 31132). Type: Guinea: Ziama (et Hauts plateaux de la dorsale Loma-Man: Nimba, Fon); Forêt haute et mi-haute (20-30 m maximum) située dans les ravins entre 1300 et 1600 m d'altitude. *Parinari excelsa* est souvent le seul grand arbre et les espèces d'arbres de plaine sont rares ou absentes. Forêt de transition entre la forêt basse à *Parinari excelsa* et les forêts denses guinéennes hautes de haute montagne; *Aussel, Alexia s.n.* (holo-, BIOID: Aussel-20181211-1511-31132).

Description: see above (notes by Schnell).

Distribution: Rare and localized in West Africa (Figure 7g). It represents most of the so called "forêts galleries" seen at elevations above 1250 m, e.g. high mountains near Dalaba (Guinea), Mt. Loma (Sierra Leone), NE Ziama, NE Nimba, and Pic de Fon (Guinea).

RLE status: VU (VU-EN) according to Senterre et al. (2019a).

III.2 Ecosystem mapping and preliminary red listing assessment

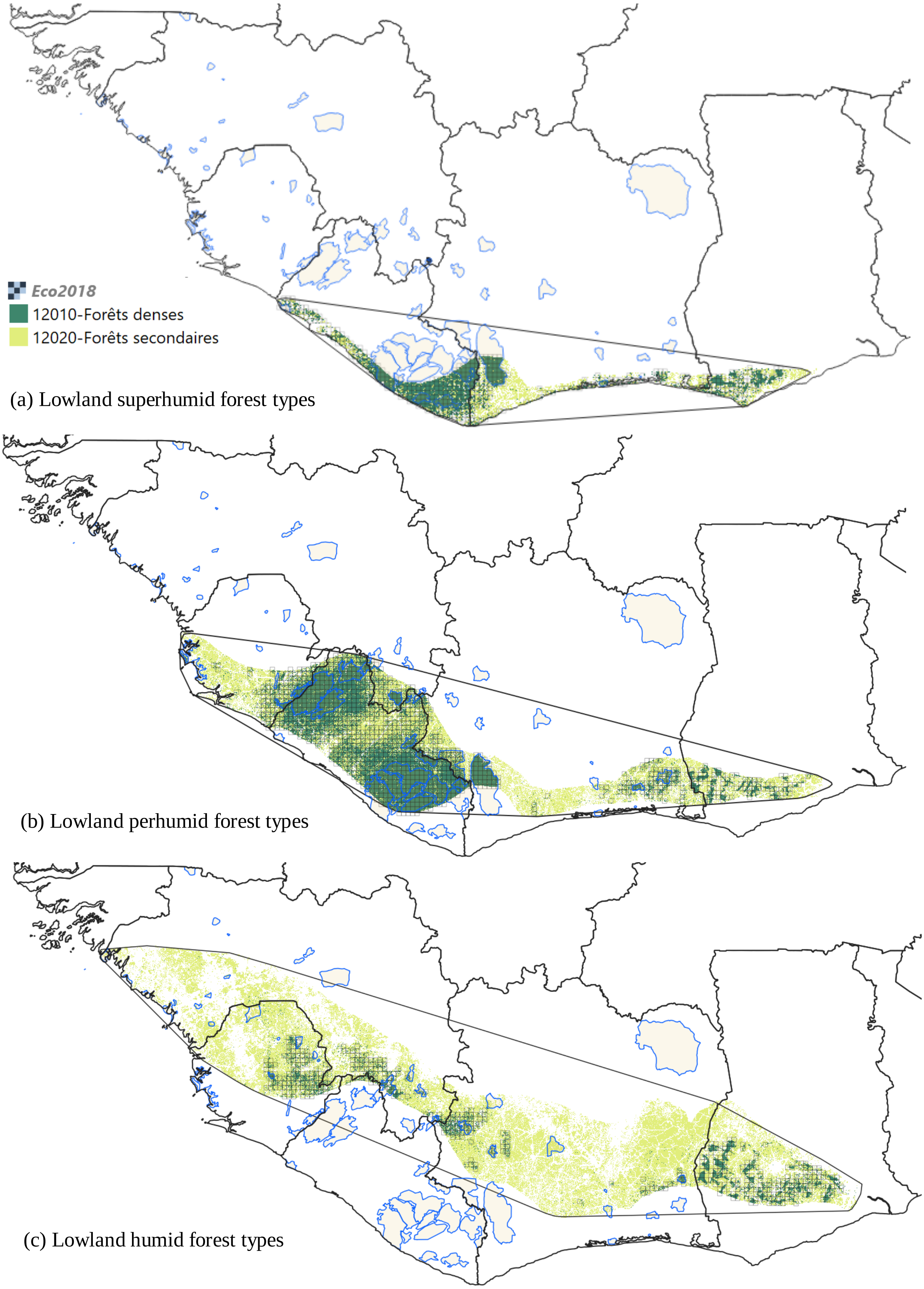
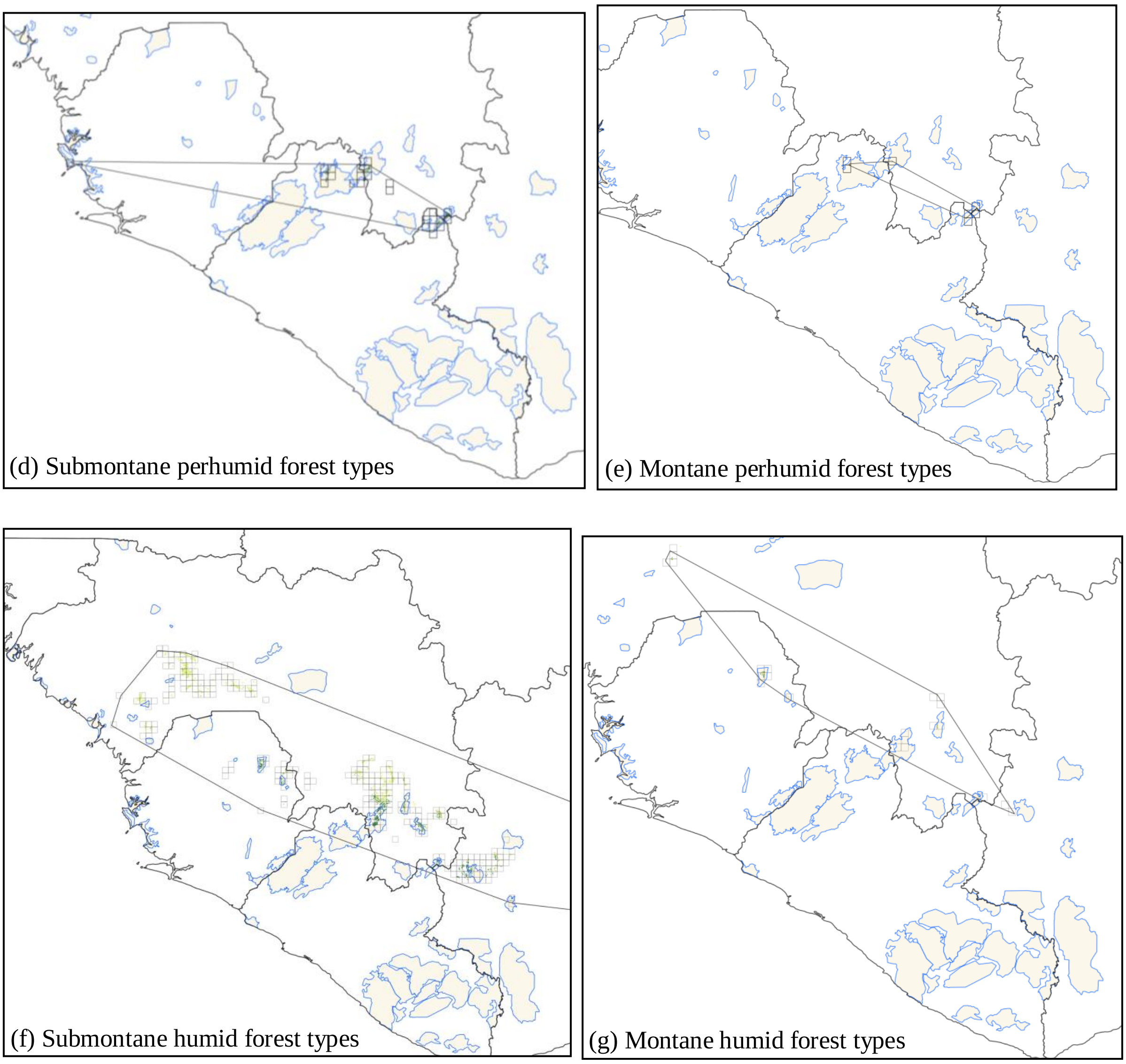


Figure 7. Distribution maps, AOO and EOO for the main forest ecosystem groups (as mapping units, incl. mesic, ravine, riparian, swamp, overdrained and saxicolous types) of West Africa. The lighter green areas represent secondary forests (Senterre et al. 2019a).



(d) Submontane perhumid forest types

(e) Montane perhumid forest types

(f) Submontane humid forest types

(g) Montane humid forest types

Figure 7. (continued).

Table 1. Main parameters used for RLE assessment of "ecosystem groups" present in the study area (calculated with "Redlistr" R package). Values that trigger a threat status according to IUCN are highlighted in green (VU), orange (EN) and red (CR) (see Bland et al. 2016: 43, 49). AOO=Area Of Occupancy (number of grid cells of 10 x 10km); EOO=Extent Of Occurrence (km²); ARD=Absolute Rate of Decline; PRD=Proportional Rate of Decline.

			Km² (2000)	Km² (2018)	AOO (2018)	EOO (2018)	Km² (2050, PRD)	Km² (2050, ARD)	Réduction (PRD)	Réduction (ARD)
Superhumid-Lowland		Forest	27057.5	22452.8	444	172136.0	16115.3	14266.6	-0.40	-0.47
Perhumid	Lowland	Forest	81480.5	67368.8	1166	296462.6	48042.3	42281.4	-0.41	-0.48
	Submontane	Forest	135.0	132.1	25	21427.5	127.0	126.9	-0.06	-0.06
		Savanna	5.7	5.7	15	19947.3	5.7	5.7	0.00	0.00
	Montane	Forest	5.9	5.6	7	3706.2	5.0	4.9	-0.16	-0.17
		Savanna	2.9	3.0	5	1330.7	3.2	3.2	0.11	0.11
Humid	Lowland	Forest	22794.7	17029.9	479	435025.3	10141.6	6781.3	-0.56	-0.70
	Submontane	Forest	802.1	687.4	249	219795.9	522.4	483.4	-0.35	-0.40
		Savanna	2386.9	2336.9	343	102959.3	2250.5	2247.9	-0.06	-0.06
	Montane	Forest	24.7	24.2	23	43675.3	23.3	23.3	-0.05	-0.06
		Savanna	49.3	49.5	26	47733.6	49.8	49.8	0.01	0.01

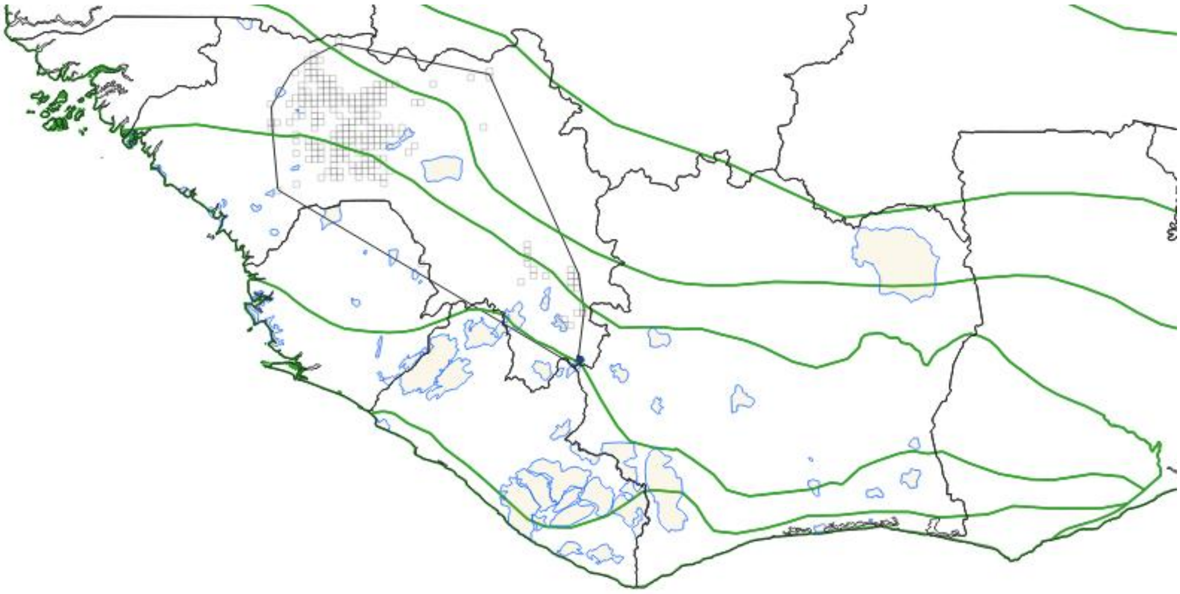


Figure 8. Distribution map, AOO (215 grid cells) and EOO (145,252 km²) for submontane bowe of Guinea, based on our reclassification of the map proposed by Couch et al. (2019; see Figure 6). The climatic wetness zones transitions (see Figure 3) are indicated by the green lines.

In this chapter, we compiled all maps and statistics produced for the RLE assessment. Most of the analysis were done in Senterre et al. (2019a) and we have added analysis for the superhumid bioclimatic zone and for submontane bowe.

III.3 KBAs of the Lofa-Gola-Mano-Nimba complexes and their ecosystems

Here, we present each KBA individually in a sequence that we intend to be more or less geographic and ecologic (not according to their KBA code or alphabetically). In addition, KBAs of Mount Nimba (4 individual KBAs) and KBAs of the St. Paul River (3 individual KBAs) are treated as aggregated KBAs.

In Table 2, we compile in a synthetic table all ecosystem species (identified by their code [xx] and labeled shortly based on their eco-genus and life zone) and their occurrence within each of the KBAs covered by this study.

In Table 3, we compile the main statistics used to evaluate the status of "global KBA" according to the international guidelines (KBA Standards and Appeals Committee 2019). Those assessments are based on the concept of "ecosystem group", i.e. mapping units that include several ecosystem species having a similar general distribution (AOO and EOO) but that cannot be mapped individually over their global distribution scale.

In this chapter, we provide a series of maps that are complementary to the maps presented in the chapter III.2, providing here a view of ecosystems mapped at the stand scale and the landscapes they form. Those maps are mostly made for visualization at a local scale and can therefore be difficult to read at a scale that shows the complete KBA extent. Therefore, we also attach to this report a folder corresponding to the QGIS project used, in a format that is not sensitive to paths and compatible with Smartphones (using QField, free app for Android). These can also be particularly useful for future field work.

Table 2. Synthetic table of ecosystem species (codes in [x] refer to the chapter III.1) and their occurrence among the different KBAs included in the current study. "DD!" indicate ecosystem types that are DD and that require more attention for KBA assessment.

eco-sp	eco-genus	life zone	RLE	SLE1-Gola	SLE2-Kambui	SLE7-Tiwai	LBR8-Kpelle	LBR10-Piso	LBR11-Mano	LBR16-Wologizi	LBR17-Wonegizi	GIN4-Béro	GIN8-Ziama	GIN10-Fon	fw4-StPaul	fw5-StPaul	fw7-StPaul	fw11-StPaul	GIN2-Diécké	Gin9-Nimba	LBR12-Nimba	CIV8-14-Nimba	LBR15-W.Nimba	CIV7-Dans
[1]	Coastal backshore hyperhaline dwarf mangrove forest	T.low.superh.	DD					X																
[2]	Coastal backshore hyperhaline grassland on muddy soil (back of mangrove)	T.low.superh.	DD					X																
[3]	Coastal backshore tidal estuarine backshore/sheltered mangrove forest	T.low.superh.	DD					X																
[4]	Coastal backshore tidal freshwater lake	T.low.superh.	DD					X																
[5]	Coastal frontshore sandy beach	T.low.superh.	DD					X																
[6]	Coastal frontshore sandy beach open vegetation	T.low.superh.	DD					X																
[7]	Coastal backshore dunes shrubland	T.low.superh.	DD!					X																
[8]	Coastal backshore dunes grassland	T.low.superh.	DD					X																
[9]	Coastal backshore forest fringe on sandy beach	T.low.superh.	DD!!					X																
	Inland stream	T.low.superh.																						
[10]	Inland stream	T.low.perh.	DD	X	X		X		X	X	X		X		X	X	X	X	X	X	X	X	X	
[11]	Inland stream	T.subm.perh.	DD							X			X							X	X	X		
[12]	Inland stream	T.low.h.	DD									X	X	X						X				X
[13]	Inland stream	T.subm.h.	DD									X	X	X						X				X
[14]	Inland stream	T.mont.h.	VU (VU-EN)										X							X				
[15]	Inland river	T.low.superh.	DD					X							X	X								
[16]	Inland river	T.low.perh.	DD	X	X	X	X		X	X	X		X		X	X	X	X	X	X	X		X	
[17]	Inland river	T.low.h.	DD										X							X				
[18]	Inland waterfall	T.low.perh.	DD	X	X		X		X	X	X		X		X	X	X	X		X	X			
[19]	Inland waterfall	T.subm.h.	DD-VU										X							X				X
[20]	Inland waterfall	T.mont.h.	CR(DD-CR)																	X				
[21]	Inland pool	T.low.superh.	DD					X																

eco-sp	eco-genus	life zone	RLE	SLE1-Gola	SLE2-Kambui	SLE7-Tiwai	LBR8-Kpelle	LBR10-Piso	LBR11-Mano	LBR16-Wologizi	LBR17-Wonegizi	GIN4-Béro	GIN8-Ziama	GIN10-Fon	fw4-StPaul	fw5-StPaul	fw7-StPaul	fw11-StPaul	GIN2-Diécké	Gin9-Nimba	LBR12-Nimba	CIV8-14-Nimba	LBR15-W.Nimba	CIV7-Dans
[22]	Freshwater marsh	T.low.superh.	DD					X																
[23]	Freshwater marsh	T.low.perh.	DD			X									X	X								
[24]	Seasonal marsh on ironstone rock sheet	T.low.h.	DD											X						X				
[25]	Seasonal marsh on ironstone rock sheet	T.subm.h.	EN (DD-EN)											X										
[26]	Seasonal marsh on ironstone rock sheet	T.mont.h.	CR																	X				
[27]	Freshwater swamps	T.low.superh.	DD (DD-EN)					X							X	X								
[28]	Freshwater swamps	T.low.perh.	EN (DD-EN)	X		X	X		X	X	X		X		X	X	X	X	X	X	X	X	X	
[29]	Freshwater swamps	T.subm.perh.	EN										X							X	X	X		
[30]	Freshwater swamps	T.low.h.	CR (EN-CR)									X	X							X				X
[31]	Freshwater swamps	T.subm.h.	EN (VU-EN)									X	X							X				X
[32]	Seasonal swamp on ironstone rock sheet	T.mont.h.	CR																	X				
[33]	Riparian forest on alluvial soil	T.low.superh.	DD					X							X	X								
[34]	Riparian forest on alluvial soil	T.low.perh.	VU	X	X	X	X		X	X	X		X		X	X	X	X	X	X	X	X	X	
[35]	Riparian forest on alluvial soil	T.low.h.	EN (DD-EN)									X	X							X				X
[36]	Pyrophilic disclimax herb-savanna on mesic landform	T.low.h.	LC									X		X						X		X		X
[37]	Pyrophilic disclimax herb-savanna on mesic landform	T.subm.h.	LC									X		X						X		X		X
[38]	Pyrophilic disclimax herb-savanna on mesic landform	T.mont.h.	LC											X						X		X		
[39]	Mesic forest	T.low.superh.	EN					X							X	X								
[40]	Mesic forest	T.low.perh.	VU (VU-EN)	X	X		X		X	X	X		X		X	X	X	X	X	X	X	X	X	
[41]	Mesic forest	T.subm.perh.	EN							X	X		X							X	X	X	X	
[42]	Mesic forest	T.mont.perh.	EN							X			X							X	X	X		
[43]	Mesic forest	T.low.h.	EN (EN-									X	X	X						X				X

eco-sp	eco-genus	life zone	RLE	SLE1-Gola	SLE2-Kambui	SLE7-Tiwai	LBR8-Kpelle	LBR10-Piso	LBR11-Mano	LBR16-Wologizi	LBR17-Wonegizi	GIN4-Béro	GIN8-Ziama	GIN10-Fon	fw4-StPaul	fw5-StPaul	fw7-StPaul	fw11-StPaul	GIN2-Diécké	Gin9-Nimba	LBR12-Nimba	CIV8-14-Nimba	LBR15-W.Nimba	CIV7-Dans
			CR)																					
[44]	Mesic forest	T.subm.h.	VU (VU-EN)									X	X	X						X				X
[45]	Mesic forest	T.mont.h.	VU (VU-EN)										X							X				X
[46]	Overdrained forest	T.low.superh.	DD					X																
[47]	Overdrained forest	T.low.perh.	DD	X	X		X		X	X	X		X						X	X	X		X	
[48]	Overdrained forest	T.subm.perh.	DD							X	X		X							X	X			
[49]	Overdrained forest	T.mont.perh.	DD-NE							X			X							X	X			
[50]	Overdrained forest	T.low.h.	DD																	X				
[51]	Overdrained forest	T.subm.h.	CR										X	X						X				
[52]	Overdrained forest	T.mont.h.	CR (CR-EN)										X							X				
[53]	Granite rock	T.low.h.	DD									X	X											X
[54]	Granite rock	T.subm.h.	DD?									X	X											X
[55]	Ironstone rock	T.mont.h.	DD											X						X				
[56]	Ultramafic rock	T.mont.h.	DD																	X				
[57]	Saxicolous open vegetation on granitic outcrops	T.low.perh.	DD	X						X	X		X											
[58]	Saxicolous open vegetation on granitic outcrops	T.subm.perh.	DD?								X		X											
[59]	Saxicolous open vegetation on granitic outcrops	T.mont.perh.	CR?										X											
[60]	Saxicolous open vegetation on granitic outcrops	T.low.h.	DD-LC									X	X											X
[61]	Saxicolous open vegetation on granitic outcrops	T.subm.h.	DD									X	X											X
[62]	Saxicolous open vegetation on granitic outcrops	T.mont.h.	DD?										X											
[63]	Saxicolous open vegetation on ironstone outcrops	T.low.h.	LC											X						X		X		
[64]	Saxicolous open vegetation on ironstone outcrops	T.subm.h.	DD											X						X				
[65]	Saxicolous open vegetation on ironstone outcrops	T.mont.h.	DD											X						X				
[66]	Saxicolous open vegetation on ultramafic outcrop	T.mont.h.	VU																	X				
[67]	Subsaxicolous dwarf forest on granitic outcrop	T.low.perh.	DD							X	X		X											
[68]	Subsaxicolous dwarf forest on granitic outcrop	T.subm.perh.	DD								X		X											
[69]	Subsaxicolous dwarf forest on granitic outcrop	T.mont.perh.	DD?										X											

eco-sp	eco-genus	life zone	RLE	SLE1-Gola	SLE2-Kambui	SLE7-Tiwai	LBR8-Kpelle	LBR10-Piso	LBR11-Mano	LBR16-Wologizi	LBR17-Wonegizi	GIN4-Béro	GIN8-Ziama	GIN10-Fon	fw4-StPaul	fw5-StPaul	fw7-StPaul	fw11-StPaul	GIN2-Diécké	Gin9-Nimba	LBR12-Nimba	CIV8-14-Nimba	LBR15-W.Nimba	CIV7-Dans
[70]	Subsaxicolous dwarf forest on granitic outcrop	T.low.h.	DD									?	X											X
[71]	Subsaxicolous dwarf forest on granitic outcrop	T.subm.h.	DD									?	X											X
[72]	Subsaxicolous dwarf forest on granitic outcrop	T.mont.h.	DD(DD-EN)										X											
[73]	Subsaxicolous dwarf forest on ironstone outcrop	T.low.perh.	DD							X										X	X	X		
[74]	Subsaxicolous dwarf forest on ironstone outcrop	T.subm.perh.	CR							X										X	X	X		
[75]	Subsaxicolous dwarf forest on ironstone outcrop	T.mont.perh.	CR (EN-CR)							?										X	X	X		
[76]	Subsaxicolous dwarf forest on ironstone outcrop	T.low.h.	EN (DD-EN)											X						X				
[77]	Subsaxicolous dwarf forest on ironstone outcrop	T.subm.h.	CR											X						?				
[78]	Subsaxicolous dwarf forest on ironstone outcrop	T.mont.h.	CR (CR-EN)											X						?				
[79]	Saxicolous ravine grassland on ironstone	T.low.h.	LC											X						X				
[80]	Saxicolous ravine grassland on ironstone	T.mont.h.	CR																	X				
[81]	Ravine forest	T.low.superh.	EN					X																
[82]	Ravine forest	T.low.perh.	VU	X	X		X		X	X	X		X						X	X	X	X	X	
[83]	Ravine forest	T.subm.perh.	VU (LC-VU)							X	X		X							X	X	X	X	
[84]	Ravine forest	T.mont.perh.	EN							X			X							X	X	X		
[85]	Ravine forest	T.low.h.	EN (EN-CR)									X	X	X						X				X
[86]	Ravine forest	T.subm.h.	VU									X	X	X						X				X
[87]	Ravine forest	T.mont.h.	VU (VU-EN)										X	X						X				

Table 3. Evaluation of the percentage found in each KBA of the global distribution of each ecosystem group (mapping unit). The range of ecosystem threat levels observed within each group is mentioned; percentage values superior to 5% (threshold for VU ecosystems), superior to 10% (threshold for EN-CR ecosystems) and superior to 20% (threshold for ecosystems of any threat level) are highlighted in green, orange and red, respectively. The numbers in parenthesis (11010, 12010, 22010, etc.) indicates the code of the ecosystem group in the geotiff data file.

KBA Code	KBA Name	Lowland superhumid (11010): EN		Lowland perhumid (12010): VU-EN		Submontane perhumid (22010): EN		Montane perhumid (32010): EN		Lowland humid (13010): EN (EN-CR)		Submontane humid (23010): VU (VU-EN)		Montane humid (33010): VU (VU-EN)	
		km²	% Global	km²	% Global	km²	% Global	km²	% Global	km²	% Global	km²	% Global	km²	% Global
SLE2	Kambui	0	0	204.4	0.3	0	0	0	0	0.2	0.0	0	0	0	0
SLE7	Tiwai	0	0	11.4	0	0	0	0	0	0	0	0	0	0	0
SLE1	Gola	0	0	721.2	1.1	0	0	0	0	0	0	0	0	0	0
LIB10	Piso	42.1	0.2	0	0	0	0	0	0	0	0	0	0	0	0
LIB11	Lofa-Gola-Mano	0	0	4251.6	6.3	0	0	0	0	0	0	0	0	0	0
LIB8	Kpelle	0	0	2089.6	3.1	0	0	0	0	0	0	0	0	0	0
LIB16	Wologizi	0	0	1513.6	2.2	42.4	32.1	0.4	7.4	0	0	0	0	0	0
LIB17	Wonegizi	0	0	242.5	0.4	6.9	5.2	0	0	0	0	0	0	0	0
fw4		83.1	0.4	1049.3	1.6	0	0	0	0	0	0	0	0	0	0
fw5		123.8	0.6	1814.1	2.7	0	0	0	0	0	0	0	0	0	0
fw11		0	0	2424.8	3.6	0	0	0	0	0	0	0	0	0	0
GIN8	Ziama	0	0	139.2	0.2	34.8	26.3	1.0	17.8	451.3	2.6	155.2	22.6	0.8	3.4
GIN2	Diéké	0	0	548.1	0.8	0	0	0	0	0	0	0	0	0	0
LIB15	West Nimba	0	0	92.7	0.1	2.1	1.6	0	0	0	0	0	0	0	0
LIB12	Nimba	0	0	93.1	0.1	19.7	14.9	0.9	16.0	0	0	0	0	0	0
CIV8	Nimba transboundary	0	0	106.4	0.2	0	0	0	0	31.4	0.2	0	0	0	0
CIV14	Nimba integrale	0	0	44.2	0.1	9.7	7.4	1.4	25.4	0	0	0	0	0	0
GIN9	Nimba	0	0	23.1	0	13.6	10.3	1.8	32.9	48.6	0.3	14.6	2.1	2.0	8.2
GIN4	Bero	0	0	0	0	0	0	0	0	66.6	0.4	40.6	5.9	0	0
GIN10	Fon	0	0	0	0	0	0	0	0	46.8	0.3	26.4	3.8	2.1	8.7
CIV7	Man	0	0	0	0	0	0	0	0	194.0	1.1	42.7	6.2	0	0
	TOT KBA	249.1	1.1	15369.3	22.8	129.1	97.8	5.5	99.5	838.9	4.9	279.5	40.7	4.9	20.4
	TOT West Africa	22453	100	67369	100	132	100	6	100	17030	100	687	100	24	100

III.3.1 LBR10 Lake Piso

Bibliography: Kollie (2007); Siaffa Sambolah (2007)

Life zones: Tropical lowland superhumid; 0-321 m a.s.l. (mean: 13 m). The area falls within Liberia's maximum rainfall zone receiving up to 6000 mm, annually (Kollie 2007).

Eco-genera/species: Coastal backshore hyperhaline dwarf mangrove forest ([1]: DD) and grassland ([2]: DD), Coastal backshore tidal estuarine backshore/sheltered mangrove forest ([3]: DD), Coastal backshore tidal freshwater lake ([4]: DD), Coastal frontshore sandy beach ([5]: DD) and sandy beach open vegetation ([6]: DD), Coastal backshore dunes shrubland ([7]: DD!) and grasslands ([8]: DD), Coastal backshore forest fringe on sandy beach ([9]: DD!); Coastal streams, rivers and pools?, Inland streams?, rivers ([15]: DD), pools ([21]: DD), freshwater marshes ([22]: DD) and swamps ([27]: DD-EN), Riparian forest on alluvial soil ([33]: DD), Mesic ([39]: EN), Overdrained ([46]: DD), Ravine forests ([81]: EN).

Description: The Lake Piso KBA is a relatively small area of just 248 km² but with an extraordinary diversity of ecosystems, including some very rare ones and a general landscape still containing relatively preserved areas. The Cape Mount Mountain is a three-ranged mountain with rough and steep terrain. It is remarkable for being still in a good state of conservation all the way from its core hilly landscape down to the rocky shores on the Atlantic, westward. Although much larger areas of the lowland superhumid rain forests remain, for example, in the areas of Cestos-Sehnkwen and Krahn-Bassa (Van Rompaey 2002), those areas have most often a flat topography, and therefore with fewer ravine forests (evaluated as EN), and probably fewer understorey rocks and associate rupicolous species.

In addition to the uniqueness of the Cape Mount, Lake Piso is the only site in West Africa with extensive coastal lagunes, delta and associated wetlands (including possibly peat swamp forests so far undiscovered) located within the superhumid life zone and still in a good conservation state. The lake itself (100 km², 4-5 m deep, brackish up to about 10 km landward) is known to be an important site for migratory birds and mammals (Kollie 2007). It is surrounded by rivers, creeks/streams, lakelets and lagoons. Swamp forests are poorly known and probably include a diversity of distinct types of ecosystems such as backshore coastal swamps, peat swamps (Senterre et al. 2017) as well as more usual swamp forests (associated with the rivers Mano, Maffa, Mawua, Manii, Moffe, Maa and Lofa). The coastal backshore dunes, savannas and forests (see [7], [8] and [9]), associated with primary series on highly dynamic coastal landscapes and with coastal aridity, are also completely unexplored and should be distinguished from anthropic savannas that are also common in the area. Other eco-species of Coastal backshore dunes, savannas and forests have revealed the presence of rare endemic plant species at the southern edge of the Guineo-Congolian region (see Senterre et al. 2017). Finally, the rocky shore on the western slopes of Cape Mount, if present, would also represent a very rare ecosystem with the possible presence of coastal rupicolous endemic species.

KBA assessment: Global KBA under criterion B4([7],[8],[9]). Although most of the coastal ecosystem types are considered DD (and therefore the criterion A2 cannot be used), the rarity of coastal lagoons and deltas within the superhumid life zone is in itself enough to consider that Lake Piso holds more than 20% of their global distribution. This is certainly the case for the coastal backshore dunes, savannas and forests (see [7], [8] and [9]). Coastal lagoons of Ivory Coast such as Parc National des Iles Ehotilés are either climatically dryer or anthropically more disturbed. Ravine and Mesic forests (EN) found in the Lake Piso KBA represent only a small proportion of their global distribution (0.2%: Table 3). Therefore, the criterion A2 cannot be used for those ecosystems.

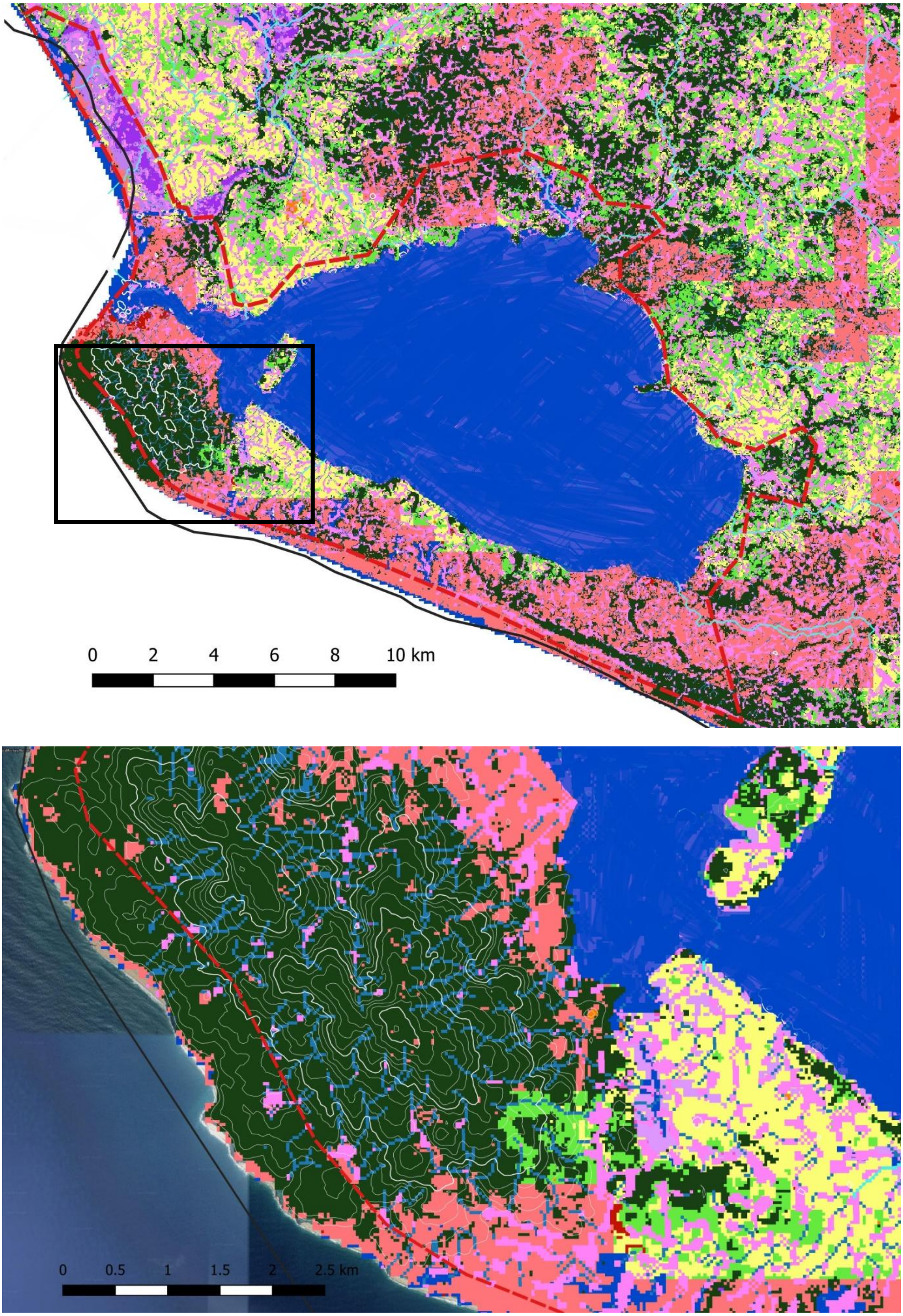


Figure 9. Vegetation of Lake Piso and detailed view of Cape Mount. Anthropic areas are approximate. Savannas are either anthropic disclimaxes or natural coastal savannas corresponding to primary series, both mixed as a mosaic.

Figure 9. Legend; Maps are produced by the overlay of three layers, in order to display a maximum of information from various sources. The top layer consists in the result of the landform analysis (topographic wetness), where 'mesic' landforms are uncolored (transparent). The second layer is based on the land cover class "Dense forest" (from EcoStand2018_30m.tif: Senterre et al. 2019a) but colored according to the climatic wetness zone (from superhumid to humid). Finally, the bottom layer shows the remaining information (not overlaid by the first two layers) on land cover types (from EcoStand2018_30m.tif).

Top layer: Landform analysis

- 1-Swamp
- 2-Riparian
- 3-Ravine
- 4-Mesic landform (transparent)
- 5-Overdrained
- 6-Cliff
- 7-Waterfall

- Countries
- KBAs
- Altitudinal belt transitions
- Contour lines (100m)
- Contour lines (10m)

Second layer: Dense forests in climax mesic stands under different climatic wetness zones

- 1-Superhumid (Wet sempervirent rainforest)
- 2-Perhumid (Moist sempervirent rainforest)
- 3-Humid (Seasonal/Monsoon moist semi-deciduous rainforest)

Third layer: Land cover class (from EcoStand2018_30m.tif: Senterre et al. 2019a)

- 20-Secondary forest (ESA tree + GLC forest)
- 30-Woodlands, Dry forests (ESA tree + GLC woodlands)
- 40-Shrublands (ESA tree + GLC shrublands OR ESA shrubs)
- 50-Savannas (ESA savannas)
- 81-Swamp forest (ESA wetland + Giri not mangrove + Hansen >=60%)
- 82-Marsh (ESA wetland + Giri not mangrove + Hansen < 60%)
- 91-Mangrove forest (Giri mangrove + Hansen >=60%)
- 92-Mangrove open vegetation (Giri mangrove + Hansen < 60%)
- 100-Water (=ESA + added inland estuaries)
- 111-Anthropic cropland (ESA cropland + HFootprint >12)
- 112-Anthropic land (HFootprint >12)
- 113-Built-up (=ESA)

III.3.2 SLE2 Kambui Hills Forest Reserve

Bibliography: Fayiah et al. (2018); Gordon et al. (1979); Hiemstra-van der Horst and Munro (2012) http://www.birdlife.org

Life zones: Tropical lowland perhumid (but possibly in the transition to the tropical lowland humid zone); 135-668 m a.s.l. (mean: 382 m).

Eco-genera/species: Inland streams ([10]: DD), rivers ([16]: DD), waterfalls ([18]: DD), freshwater swamps ([28]: EN), Riparian forest on alluvial soil ([34]: VU), Mesic ([40]: VU), Overdrained ([47]: DD), Ravine forests ([82]: VU).

Description: The Kambui hills cover an area of 270 km² and consist of steep hilly outcrops of metamorphic rocks known locally as the "Kambui schists", scattered in a predominantly granitic landscape which covers approximately two-thirds of Sierra Leone (Poorter et al. 2004: 8). This lithology is therefore rare and found also in the Kangari Hills towards Lake Sonfon and in the Nimini and Gori Hills (Savill and Fox 1967). According to Gordon et al. (1979: 1-2, 5-6, 36-38), it is covered by "moist evergreen forest" and "moist semi-deciduous forests". These two variations might be explained by topographic wetness effects: "moist evergreen forest" corresponding to mesic landforms of the lowland perhumid life zone and "moist semi-deciduous forests" possibly corresponding to dryer topographic or edaphic conditions (see Figure 2).

KBA assessment: Not a global KBA under ecosystem criteria A2 and B4. All ecosystem types recognized in the Kambui hills as potentially threatened are part of the lowland perhumid rain forest ecosystem group (Figure 7b), in proportions that are probably similar for all KBAs (i.e. mostly mesic stands combined with smaller proportions of "azonal" types). In the Kambui hills, the situation is similar to that of the Gola forests. Lowland perhumid rain forests of the Kambui Hills represent only 0.3% of all remaining lowland perhumid rain forests of West Africa. Therefore, using the ecosystem criterion, the Kambui hills do not qualify as a global KBA. Nevertheless, at the National scale, they represent an important conservation area, being one of few areas of Sierra Leone with remaining rain forest. In addition, it is important to note that the geology of the Kambui hills (schist) is different from that of most other areas of lowland perhumid rain forests in West Africa. More studies, especially including rupicolous plant species in dwarf subsaxicolous forests, would be useful to investigate the possibility of local endemism related to lithology.

III.3.3 SLE1 Gola Rainforest National Park

Bibliography: Cole (1980); Davies (1987); Fox (1968); Klop et al. (2008); Voorhoeve (1965)

Life zones: Tropical lowland perhumid; 68-506 m a.s.l. (mean: 239 m); Gola West (68-221 m; mean: 131 m); Gola East (74-421 m, mean 148 m); Gola North (106-506 m; mean 298 m); Gola North block (146-418 m; mean 260 m).

Eco-genera/species: Inland streams ([10]: DD), rivers ([16]: DD), waterfalls ([18]: DD), freshwater swamps ([28]: EN), Riparian forest on alluvial soil ([34]: VU), Mesic ([40]: VU), Overdrained ([47]: DD), Ravine forests ([82]: VU) and Saxicolous open vegetation on granitic outcrops ([57]: DD).

Description: The eastern boundary of Gola Forest follows the Moro and Mano Rivers, which form the border between Sierra Leone and Liberia (Klop et al. 2008: 12). This KBA (746 km²) consists of four separate forest blocks, namely Gola West (67 km²), Gola East (205 km²), Gola North (417 km²) and its extension further North (61 km²). The lithology is mostly derived from granite with varying proportions of lateritic gravel (Klop et al. 2008). The landforms are mostly hilly with some abrupt breaks caused by steep-sided valleys especially to the North (Davies 1987: 17). The well-drained hills of Gola North represent the eastern limit in the distribution of the Caesalp forests, characterized by *Didelotia idea* and *Brachystegia leonensis* (Klop et al. 2008: 39). In most of Gola East and West, moister landforms dominate and are characterized by the mixed *Heritiera-Lophira* community (Klop et al. 2008), including elements of the superhumid bioclimate zone (e.g. *Protomegabaria stapfiana*, *Sacoglottis gabonensis*: Cole 1980).

KBA assessment: Not a global KBA under ecosystem criteria A2 and B4. The Gola KBA contains only 1.1% of the lowland perhumid rain forests remaining in 2018 (Table 3) and therefore none of the types of ecosystems contained in this ecosystem group can be considered as a global KBA trigger. Nevertheless, at the scale of Sierra Leone, the Gola forest represents an important fraction of the remaining rain forests of that particular country.

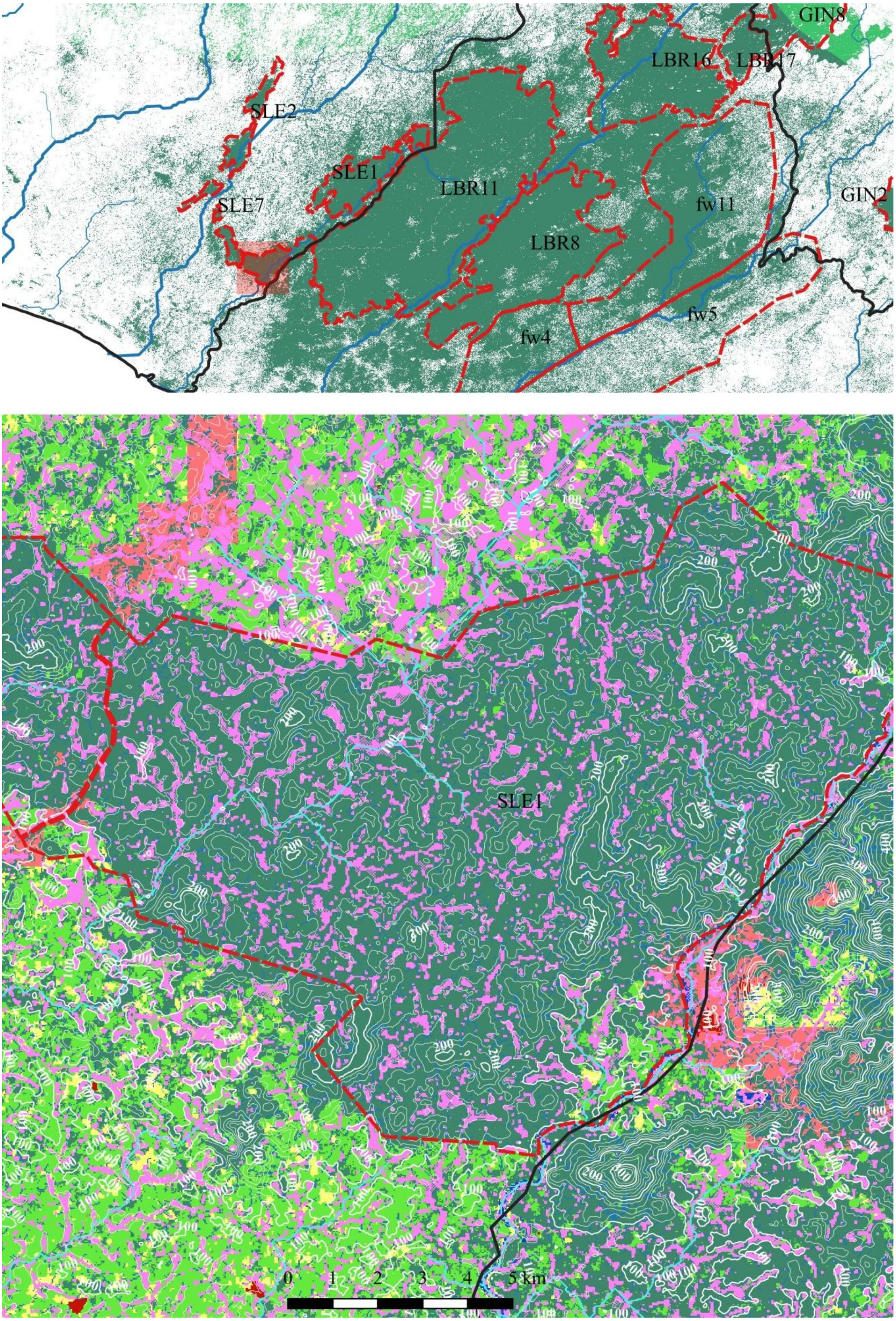


Figure 10. Overview of the stand scale ecosystems mapped for the Gola East KBA (SLE1, Sierra Leone). The complete legend is provided with Figure 9. The topography is not as rugged as in Lofa-Mano and ravines are less represented.

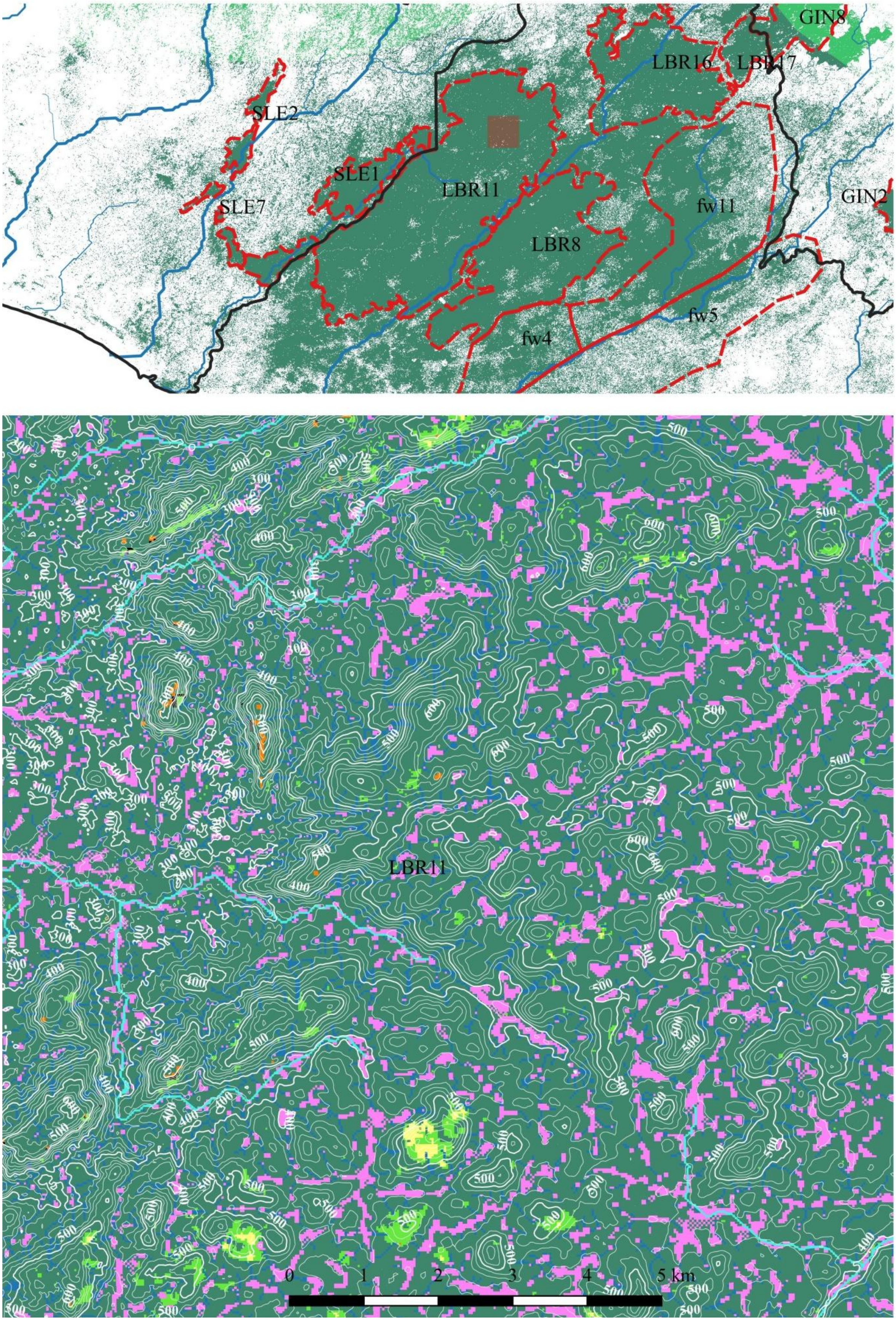


Figure 11. Overview of the stand scale ecosystems mapped for the Lofa-Mano KBA (LBR11, Liberia). The complete legend is provided with Figure 9. The topography is rugged with abundant ravines and some overdrained ridges. Some granite inselbergs appear with areas of grasslands and subsaxicolous dwarf forests (mapped as "secondary forests").

III.3.4 SLE7 Tiwai Island Wildlife Sanctuary

Bibliography: Davies (1987)

Life zones: Tropical lowland perhumid; 88-100 m a.s.l.

Eco-genera/species: Inland rivers ([16]: DD), freshwater marshes ([23]: DD) and swamps ([28]: EN), Riparian forest on alluvial soil ([34]: VU).

Description: The Tiwai Island Wildlife Sanctuary (or Tiwai Island Game Sanctuary / Non-hunting Forest Reserve) covers an area of 12 km². It is dominated by riverine vegetation and other wetlands, with a few patches of secondary mesic forests (Davies 1987).

KBA assessment: Due to its very small size and the absence of endemic or rare ecosystem type, the Tiwai Island Wildlife Sanctuary cannot qualify as global KBA using the ecosystem criteria. Even if we regrouped the three nearby KBAs of Sierra Leone (SLE1,2,7), those would only account for a total of 936 km² of lowland perhumid rain forest ecosystems, i.e. about 1.4% of their global distribution.

III.3.5 LBR11 Lofa-Mano Complex

Bibliography: Jongkind (2007); Van Rompaey (2002); Verschuren (1983), http://www.birdlife.org

Life zones: Tropical lowland perhumid; 89-713 m a.s.l. (mean: 320 m)

Eco-genera/species: Inland streams ([10]: DD), rivers ([16]: DD), waterfalls ([18]: DD), freshwater swamps ([28]: EN), Riparian forest on alluvial soil ([34]: VU), Mesic ([40]: VU), Overdrained ([47]: DD), Ravine forests ([82]: VU).

Description: The Lofa-Mano KBA covers 4378 km² and is adjacent to the Kpelle KBA and the border with Sierra Leone (Gola Forest). It presents a lot of similarity with those two KBAs but presents a more rugged topography. Steep bare rocky slopes, subsaxicolous and overdrained dwarf forests are present (although rare) on the ridges and slopes of lowland inselbergs and other forested high hills. Rivers and riparian forests are particularly well preserved and, on the slopes, rapids and waterfalls are common and often spectacular (Verschuren 1983). According to Jongkind (2007), the southern part of the Lofa-Mano forests are not yet in what he called the "hyperwet evergreen forest area" (i.e. our lowland superhumid life zone) but are not far from it. Upper Guinea endemic plants are not as common as in the superhumid zone (Jongkind 2007; Van Rompaey 2002).

KBA assessment: Global KBA under criterion A2a ([28]). The Lofa-Mano KBA is a large KBA, mostly in a 'pristine' forested state. It contains 6.3 % of the global distribution for the various ecosystem types belonging to the ecosystem group of the lowland perhumid rain forests, including at least one ecosystem type considered as EN (swamp forests). Therefore, this area qualifies to the status of global KBA under the criterion A2a.

III.3.6 LBR8 Kpelle Forest

Bibliography: Van Rompaey (2002); Voorhoeve (1965), http://datazone.birdlife.org
Life zones: Tropical lowland perhumid; 123-768 m a.s.l. (mean: 375 m).

Eco-genera/species: Inland streams ([10]: DD), rivers ([16]: DD), waterfalls ([18]: DD), freshwater swamps ([28]: EN), Riparian forest on alluvial soil ([34]: VU), Mesic ([40]: VU), Overdrained ([47]: DD), Ravine forests ([82]: VU).

Description: The Kpelle Forest area covers 2169 km² and is located directly east of the Lofa-Mano KBA. According to Van Rompaey (2002), Gola-Kpelle massif does not hold many rare species. It forms part of the lowland perhumid life zone, as is confirmed by Jongkind (2007). The mesic forests seem to be the typical Caesalp forest of the perhumid type ([40]), with the same transgression of superhumid elements into the wetter topographic landforms (ravines, riparian) as described for the Gola Forest (SLE1: see Figure 10). A few lowland perhumid inselbergs are present in the north (e.g. 7.5834°N; -10.2701°W), but those are undocumented (see also maps in Gunn 2018).

KBA assessment: Not a global KBA under ecosystem criteria A2 and B4. Kpelle Forest KBA (LBR8) contains only 3.1% of the global distribution of remaining lowland perhumid rain forest ecosystems, which include one EN ecosystem type (swamps) and several ecosystems classified as VU (see above). Therefore, none of these types of ecosystem can trigger a global KBA status. If we could regroup the KBAs of Gola (in Sierra Leone) and Lofa-Mano and Kpelle (in Liberia), or even just Lofa-Mano and Kpelle, into a single KBA (made of respectively three or two subdivisions), that KBA would include more than 5% (respectively 10.5 or 9.4%) of the remaining lowland perhumid swamp forests (considered as EN). It would then qualify as a global KBA under the criterion A2a. If that ecosystem type had to be revised as VU rather than EN, that KBA would still qualify as a global KBA under the criterion A2b (more than 10 % of an ecosystem type considered VU).

III.3.7 LBR16 Wologizi mountains

Bibliography: (Diabaté et al., 2019a; Jongkind, 2007)
Life zones: Tropical perhumid lowland, submontane and montane; 336-1445 m a.s.l. (mean: 513 m)

Eco-genera/species: Inland streams ([10]: DD; [11]: DD), rivers ([16]: DD), waterfalls ([18]: DD), freshwater swamps ([28]: EN), Riparian forest on alluvial soil ([34]: VU), Mesic ([40]: VU; [41]: EN; [42]: EN), Overdrained ([47]: DD; [48]: DD; [49]: DD), Ravine forests ([82]: VU; [83]: VU; [84]: EN), Saxicolous open vegetation ([57]: DD) and subsaxicolous dwarf forest on granitic outcrops ([67]: DD), subsaxicolous dwarf forest on ironstone outcrops of the lowland ([73]: DD) and submontane belts ([74]: CR).

Description: The Wologizi KBA covers an area of 1680 km². It is located close to the transition toward the lowland humid life zone, has a diverse geology (Gunn 2018) mixing metamorphic rocks and isolated granitic inselbergs. The main mountain range reaches the submontane and montane belts, on metamorphic rocks (schists), while the granitic inselbergs are mostly in the lowland belt, especially spread to the north-east. On the north-western side of the highest mountain range, on the plateau near the foothill, saxicolous savannas on ironstone outcrops (bowe) are found occasionally, mixed with nearby anthropic savannas resulting from deforestation and repeated fires. Subsaxicolous dwarf forests are also exceptionally observed in the hills and submontane ridges, showing regressive ironstone outcrops in the understorey.

KBA assessment: Global KBA under criteria A2a ([41],[42],[74]), B4 ([41]). Of all the KBAs studied here, the Wologizi is the one holding the largest percentage of the submontane perhumid forests (mostly [41]), i.e. 32% of the global distribution. This ecosystem type therefore qualifies Wologizi as a global KBA under the criterion A2a. Montane perhumid forests (mostly [42]) are also represented in the Wologizi by a percentage of their global distribution (7.4%) that is enough to qualify as global KBA, even though those forests have been affected by fires and are still in a process of recovery. On the contrary the ecosystem types included in the groups of the lowland perhumid rain forests (e.g. swamp forests: EN) represent in the Wologizi only 2.2% of their global distribution and are not triggers for the global KBA status. Finally, subsaxicolous dwarf forest on ironstone outcrops of the submontane perhumid life zone ([74]: CR) are known in West Africa only in the Wologizi and in the southern part of the Mount Nimba. Although a detailed global distribution map is not available, it is clear that the stands found in the Wologizi represent more than 5% (likely more than 20%) of the global distribution of that ecosystem species.

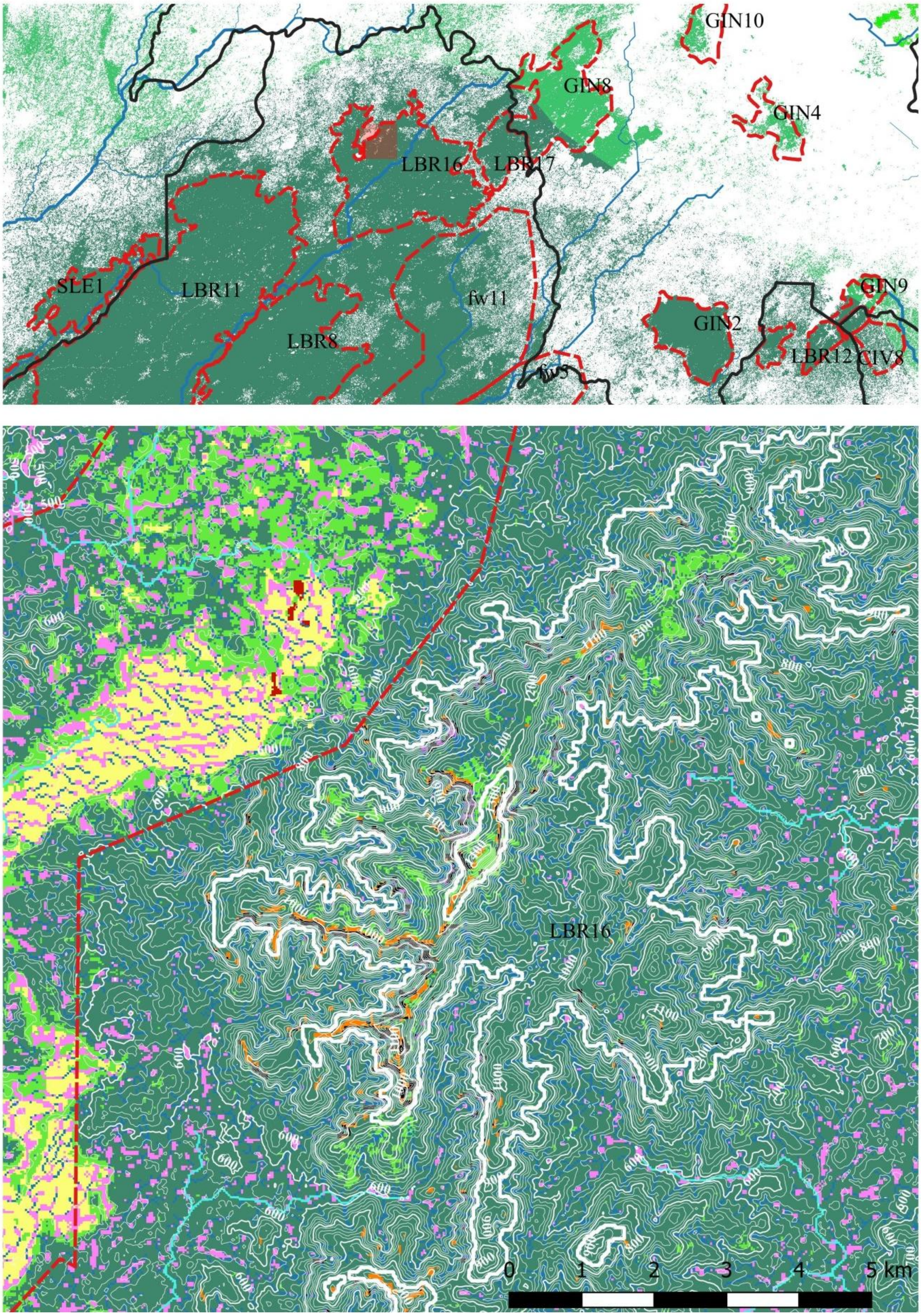


Figure 12. Overview of the stand scale ecosystems mapped for the Wologizi KBA (LBR16, Liberia). The complete legend is provided with Figure 9. The zoom area corresponds to the Mount Wuteve, with frequent overdrained ridges and cliffs, here mostly on schist. Submontane and montane ridges mapped as "secondary forests" correspond to areas having been affected by forest fires possibly partly of natural origin.

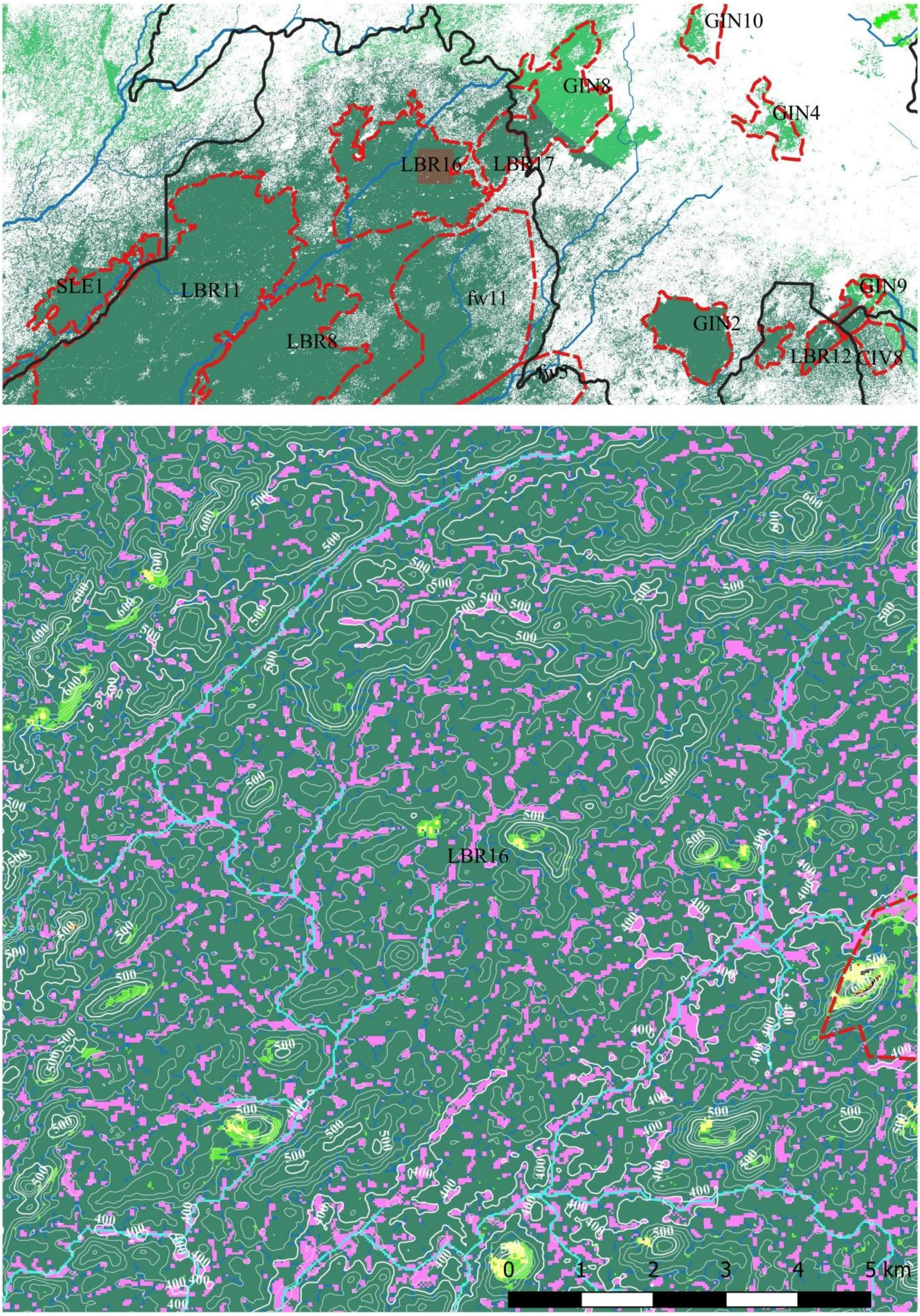


Figure 13. Overview of the stand scale ecosystems mapped for the Wologizi KBA (LBR16, Liberia). The complete legend is provided with Figure 9. The zoom area corresponds to the north-eastern part, with frequent granite hills and inselbergs. Here areas mapped as "secondary forests" correspond mostly to subsaxicolous dwarf forests on inselbergs ([67]).

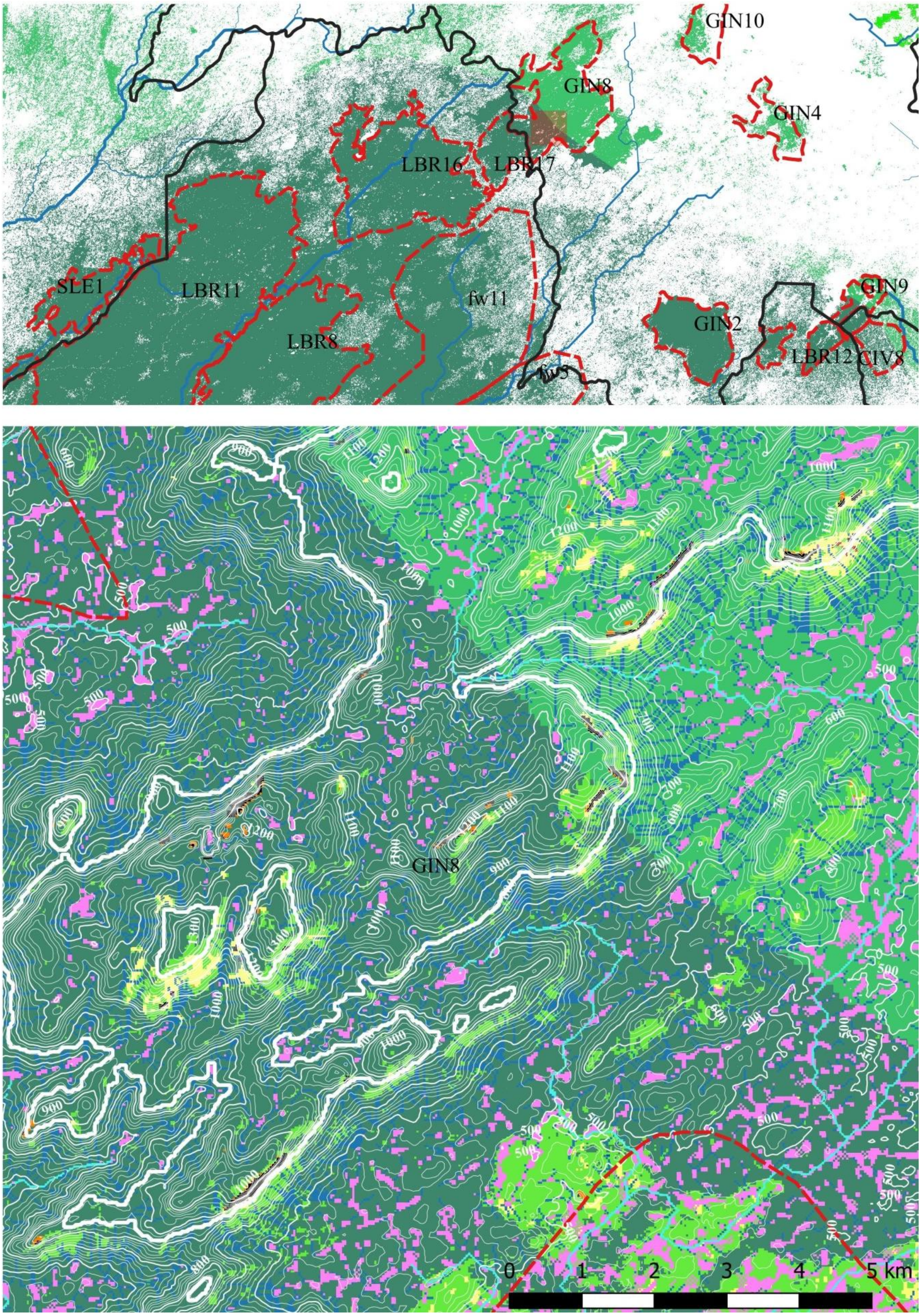


Figure 14. Overview of the stand scale ecosystems mapped for the Ziama (GIN8, Guinea). The complete legend is provided with Figure 9. The zoom area corresponds to the transition zone between the perhumid and humid climatic wetness zones. Granite outcrops are found at all altitudes. Areas mapped as "secondary forests" are either anthropic sites (e.g. in the south-eastern corner) or subsaxicolous dwarf forests (on inselbergs). Our landform analysis even suggests the presence of submontane riparian forests, which would be unique to this site.

III.3.8 LBR17 Wonegizi mountains

Bibliography: Van Rompaey (2002); Bongers et al. (2004); Jans et al. (1993); Kouamé et al. (2004); Adam (1947); Carr et al. (2015); Müller (2007); White (1983); Jongkind (2007)

Life zones: Tropical perhumid lowland and submontane; 362-1140 m a.s.l. (mean: 540 m)

Eco-genera/species: Inland streams ([10]: DD), rivers ([16]: DD), waterfalls ([18]: DD), freshwater swamps ([28]: EN), Riparian forest on alluvial soil ([34]: VU), Mesic ([40]: VU; [41]: EN), Overdrained ([47]: DD; [48]: DD), Ravine forests ([82]: VU; [83]: VU), Saxicolous open vegetation ([57]: DD; [58]: DD) and subsaxicolous dwarf forest on granitic outcrops ([67]: DD; [68]: DD).

Description: The Wonegizi KBA (288 km²), just like the north-east of Wologizi, is the continuation of the massif of Ziama further north, and this area is characterized by granitic inselbergs spread within a hilly landscape. The Wonegizi being closer to the Ziama, more hills and inselbergs reaching the submontane belt are progressively found northward. Due to the more exclusive granitic bedrock, saxicolous savannas on ironstone outcrops such as those observed at the foothill of Mount Wuteve (Wonegizi) are lacking in the Wonegizi. This area, and in particular the submontane belt (likely biodiversity-rich), is poorly explored and documented, especially concerning the vegetation.

KBA assessment: Global KBA under criteria A2a ([41]), B4 ([58],[68]). The Wonegizi contains about six well forested mountains that reach the submontane belt, with a dominance of mesic conditions ([41]). Considering the global rarity of submontane perhumid rain forests, these few mountains of the Wonegizi are enough to trigger the status of global KBA under the criterion A2a (5.2% of the global distribution). In addition, although distribution data are not available, we know that granitic inselbergs (both lowland and submontane) are relatively rare in West Africa for the perhumid bioclimate. It is likely that the inselbergs of the south-west Ziama and the Wonegizi represent most of what remains undisturbed of these inselberg landscapes. Therefore, it is likely that, regardless of the RLE status of perhumid inselberg ecosystems (currently DD), they would be triggers of global KBA status under the criterion B4 (KBA 2019: 63).

III.3.9 GIN8 Massif du Ziama

Bibliography: Couch et al. (2019: 199); Diabaté et al. (2019b); Schnell (1979: 176)

Life zones: Tropical humid/perhumid lowland/submontane/montane; 396-1385 m a.s.l. (mean: 687 m)

Eco-genera/species: Inland streams ([10]: DD; [11]: DD; [12]: DD; [13]: DD; [14]: VU), rivers ([16]: DD; [17]: DD), waterfalls ([18]: DD; [19]: DD), Freshwater swamps ([28]: EN; [29]: EN; [30]: CR; [31]: EN), Riparian forests ([34]: VU; [35]: EN), Mesic forests ([40]: VU; [41]: EN; [42]: EN; [43]: EN; [44]: VU; [45]: VU), Overdrained forests ([47]: DD; [48]: DD; [49]: DD; [51]: CR; [52]: CR), Granite rocks ([53]: DD; [54]: DD), Saxicolous open vegetation on granitic outcrops ([57]: DD; [58]: DD; [59]: CR; [60]: LC; [61]: DD; [62]: DD), Subsaxicolous dwarf forests on granitic outcrops ([67]: DD; [68]: DD; [69]: DD; [70]: DD; [71]: DD; [72]: DD), Ravine forests ([82]: VU; [83]: VU; [84]: EN; [85]: EN; [86]: VU; [87]: VU).

Description: The Massif du Ziama KBA (915 km²) contains most of the best-preserved remains of submontane and montane rain forests of the region. It is also located at the bioclimatic transition between perhumid and humid zones, which results in tremendous ecosystem diversity, comparable to that of Mount Nimba. Unlike Mount Nimba, the Ziama is entirely granitic. The forest cover is interrupted only locally on some of the granitic outcrops (inselbergs) and seems to be dominated by very old and mature rain forests, if not pristine (Diabaté et al., 2019b; Fairhead and Leach, 1994a, 1994b). In addition, our landform analysis suggests the presence of riparian forests in the perhumid submontane life zone (see Figure 14), which would be very much outstanding considering the known importance of those environmental factors for species endemism. If such ecosystem could be verified in the field, it would be unique to the Ziama.

KBA assessment: Global KBA under criteria A2a ([41],[42]), A2b ([44]), B4 ([41],[44]): 26% of the global distribution of submontane perhumid mesic rain forests ([41]: EN), 17.8% of the montane perhumid mesic rain forests ([42]: EN) and 22.6% of the submontane humid mesic rain forests ([44]: VU). None of the lowland ecosystems constitutes a trigger to the status of global KBA.

III.3.10 GIN10 Pic de Fon

Bibliography: Baena et al. (2011); Cheek et al. (2006); McCullough (2004); Schnell (1979, 1961).

Life zones: Tropical humid lowland/submontane/montane; 546-1652 m a.s.l. (mean: 797 m)

Eco-genera/species: Inland streams ([12]: DD; [13]: DD), Seasonal marsh on ironstone rock sheet ([24]: DD; [25]: EN), Pyrophilic disclimax herb-savannas on mesic landforms ([36]: LC; [37]: LC; [38]: LC), Mesic forest ([43]: EN; [44]: VU), Overdrained forest ([51]: CR), Ironstone rock ([55]: DD), Saxicolous open vegetation on ironstone outcrops ([63]: LC; [64]: DD; [65]: DD), Subsaxicolous dwarf forest on ironstone outcrop ([76]: EN; [77]: CR; [78]: CR), Saxicolous ravine grassland on ironstone ([79]: LC), Ravine forest ([85]: EN; [86]: VU; [87]: VU).

Description: The Pic de Fon KBA (321 km²) does not contain a particularly large proportion of the global distribution of ecosystems of the lowland/submontane/montane humid rain forests. Nevertheless, it is one of the few areas in West Africa with well preserved landscapes on quartzite and schist (like at Mount Nimba and some places of the Fouta Djalon). As already noted by Schnell (1961, 1952), the Pic de Fon has more relicts of submontane and montane forests compared to Nimba (i.e. less replacement by pyrophilic disclimax savannas), including some stands of the Subsaxicolous dwarf forest on ironstone outcrop ([77], [78]: CR). It has also a rare site of Seasonal marsh on ironstone rock sheet in the submontane belt, at Oueleba ([25]: EN)

KBA assessment: Global KBA under criteria A2a ([25],[77],[78]), B4 ([25],[77],[78]). According to ecosystem criteria, Subsaxicolous dwarf forest on ironstone outcrop ([77], [78]: CR) and Seasonal marsh on ironstone rock sheet in the submontane belt ([25]: EN) are likely to trigger the status of global KBA under criteria A2a and B4 (i.e. more than 20% of the global distribution, although exact distribution maps are not available). For submontane and montane bowe that are not on temporary wetlands, distribution data are insufficient to evaluate criteria A2 and B4.

III.3.11 GIN4 Forêt Classée de Mont Bero

Bibliography: Couch et al. (2019: 149, 2007); Wright et al. (2006: 44)

Life zones: Tropical humid lowland and submontane; 447-1187 m a.s.l. (mean: 737 m)

Eco-genera/species: Inland streams ([12]: DD; [13]: DD), Swamp forest ([30]: CR; [31]: EN), Riparian forest ([35]: EN), Pyrophilic disclimax herb-savannas on mesic landform ([36]: LC; [37]: LC), Mesic forests ([43]: EN; [44]: VU), Granite rocks ([53]: DD; [54]: DD), Saxicolous open vegetation on granitic outcrops ([60]: LC; [61]: DD), Subsaxicolous dwarf forests on granitic outcrops ([70]: DD; [71]: DD), Ravine forests ([85]: EN; [86]: VU).

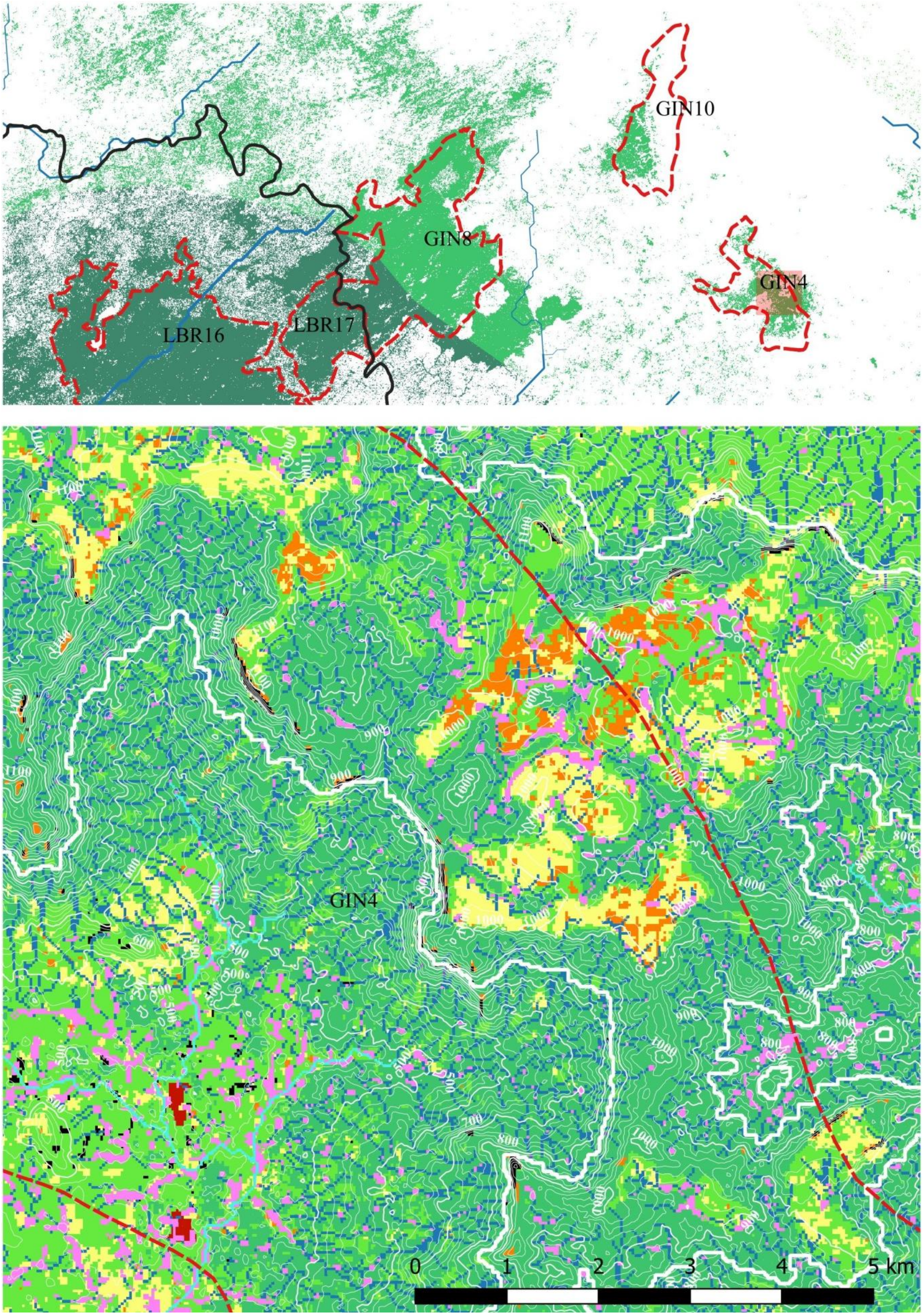


Figure 15. Overview of the stand scale ecosystems mapped for the Mont Bero (GIN4, Guinea). The complete legend is provided with Figure 9. Secondary forests and anthropic savannas are common in the lowland. In the submontane belt, the large areas of secondary forests, savannas and woodlands likely correspond to a mosaic of different types of ecosystems, some truly anthropic and secondary, others possibly disclimacic.

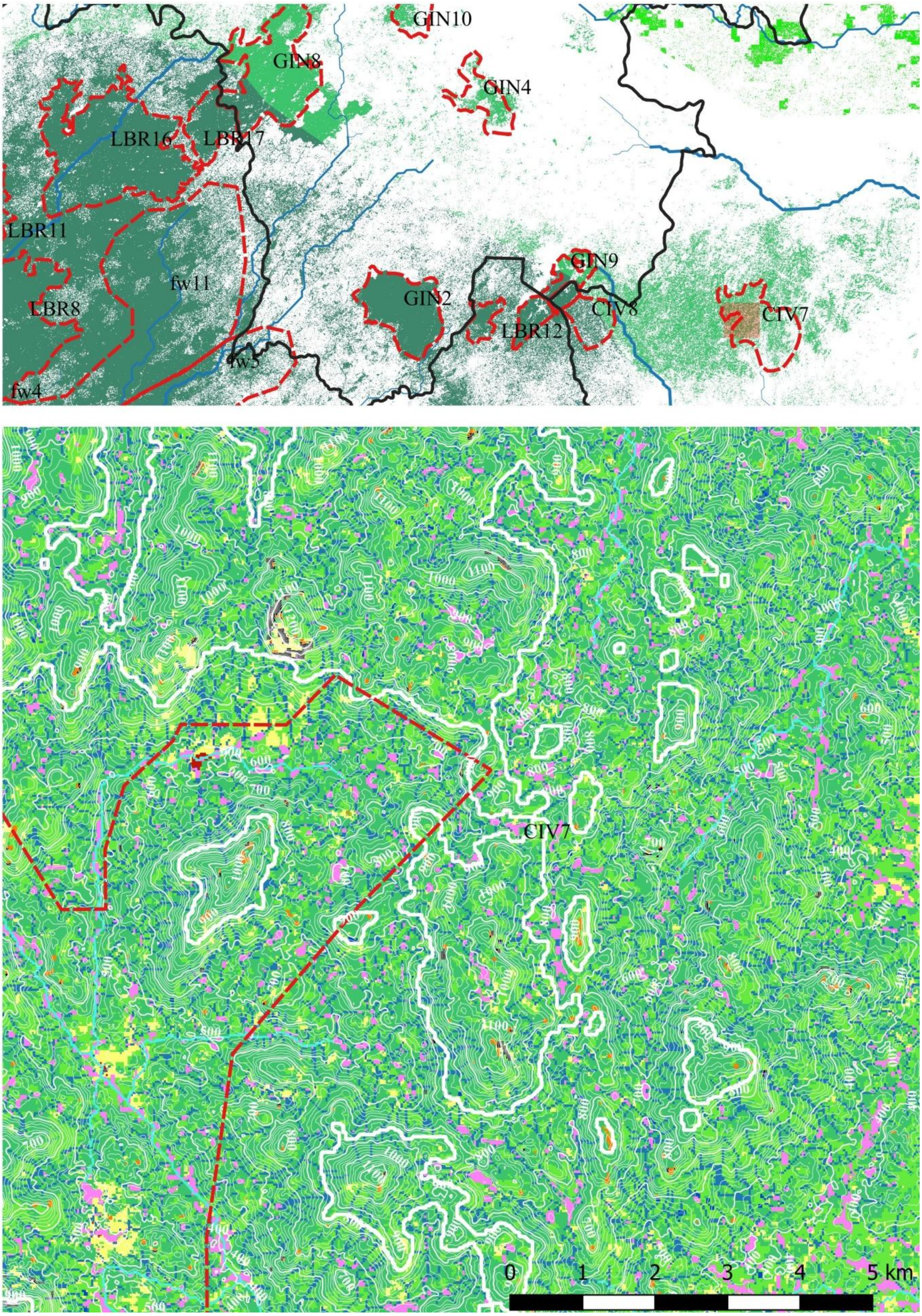


Figure 16. Overview of the stand scale ecosystems mapped for the Massif des Dans (CIV7, Ivory Coast). The complete legend is provided with Figure 9. Secondary forests and anthropic savannas are common in the lowland. In the submontane belt, the large areas of secondary forests, savannas and woodlands correspond to a mosaic of different types of ecosystems, some truly anthropic and secondary, others possibly disclimacic or saxicolous of granite inselbergs. The most interesting features are the submontane swamps.

Description: The Forêt Classée du Mont Bero (275 km²) is one of the rare sites in West Africa where forests of the humid submontane life zone can still be observed on a relatively large area (ca. 40 km²). The other important areas for this ecosystem group are the north-west Ziama, the Massif du Man and Mount Loma (all on granite bedrock). Mount Bero differs from the other submontane granitic forests mentioned by its position slightly more continental. This might explain the presence on the widely convex summit of savannas that seem to be related to ancient fires (i.e. pyrophilic progressive climax or disclimax rather than saxicolous granitic). A few biotic descriptions of the forests and savannas of the Mount Bero are available but make no distinction between the lowland slopes and the submontane belt: e.g. Couch et al. (2019: 149, 2007); Wright et al. (2006: 44). Although Couch et al. (2007; 2019) mention the presence of submontane bowe (saxicolous grassland on ironstone outcrop) near the summit, it is unclear to us if this is a good observation or rather a confusion with a pyrophilic disclimax savanna (see photo of the summit in Couch et al. 2019: 149).

KBA assessment: Potentially a global KBA under criteria A2a ([31]). If we consider all mesic forests of the submontane humid life zone as corresponding to the same type of ecosystem regardless of the different lithologies (sandstone, ferralitic, granitic), Mont Bero only represent 5.9% of the global distribution of this ecosystem ([44]: VU) and therefore it does not qualify as a global KBA under ecosystemic criteria. In addition, lowland mesic forests of Mont Bero ([43]: EN) represent only 0.4% of their global distribution and therefore also do not trigger a global KBA status. Nevertheless, Mont Bero could qualify as a global KBA under criterion A2a if the submontane mesic forests could be considered EN (which is within the assessed uncertainty of our RLE evaluation) or if the distribution of Swamp forests of the submontane humid life zone ([31]: EN) could be better known. In the current state of knowledge, we consider that Mont Bero contains 5.9% of the global distribution of that ecosystem (same ratio as for the ecosystem group of the submontane humid forests).

III.3.12 CIV7 Forêt Classée des Monts Guéoulé et Mont Glo Réserves

Bibliography: Schnell (1979: 175)

Life zones: Tropical humid lowland/submontane; 327-1256 m a.s.l. (mean: 577 m)

Eco-genera/species: Inland stream ([12]: DD; [13]: DD), waterfall ([19]: DD), Swamp forest ([30]: CR; [31]: EN), Riparian forest ([35]: EN), Pyrophilic disclimax herb-savanna on mesic landform ([36]: LC; [37]: LC), Mesic forest ([43]: EN; [44]: VU; [45]: VU), Granite rock ([53]: DD; [54]: DD), Saxicolous open vegetation on granitic outcrops ([60]: LC; [61]: DD), Subsaxicolous dwarf forest on granitic outcrop ([70]: DD; [71]: DD), Ravine forest ([85]: EN; [86]: VU).

Description: The Forêt Classée des Monts Guéoulé et Mont Glo Réserves (490 km²) belong to the Massif des Dans and present similarities with Mont Bero, both being a landscape of granitic hills with a fine grain mosaic of anthropic disturbances. The Massif des Dans has extensive areas in the submontane belt and it even reaches the montane belt. Probably the most interesting feature is the presence of gently hilly landscapes located at more than 900 m a.s.l. (in the submontane humid life zone), and where there is a possibility for some submontane swamps ([31]) to remain in a still well preserved state, which would be of high conservation value and in need for more exploration.

KBA assessment: Global KBA under criterion A2a ([31]). This area contains only a small proportion (1%) of the global distribution of the endangered lowland humid mesic forests ([43]). The same is true for the vulnerable ecosystem types of submontane belt (only 6.2% of their global distribution). Nevertheless, submontane swamps have been evaluated as EN and can therefore trigger the global KBA status under criterion A2a. Their description and in particular their conservation state needs to be evaluated within the Massif des Dans.

III.3.13 GIN9-LBR12-CIV8-CIV14 Monts Nimba

Bibliography: Couch et al. (n.d.); Fournier (1987); Hawthorne et al. (2010, 2009); Lamotte et al. (2003); Poilecot and Loua (2009); Schnell (1952, 1945); Senterre et al. (2019a)

Life zones: Tropical perhumid/humid lowland/submontane/montane; 368-1752 m a.s.l. (mean: 700 m)

Eco-genera/species: Inland stream ([10]: DD; [11]: DD; [12]: DD; [13]: DD; [14]: VU), river ([16]: DD; [17]: DD), waterfall ([18]: DD; [19]: DD; [20]: CR), Seasonal marsh on ironstone rock sheet ([24]: DD; [26]: CR), Freshwater swamps ([28]: EN; [29]: EN; [30]: CR; [31]: EN), Seasonal swamp on ironstone rock sheet ([32]: CR), Riparian forest on alluvial soil ([34]: VU; [35]: EN), Pyrophilic disclimax herb-savanna on mesic landform ([36]: LC; [37]: LC; [38]: LC), Mesic forest ([40]: VU; [41]: EN; [42]: EN; [43]: EN; [44]: VU; [45]: VU), Overdrained forest ([47]: DD; [48]: DD; [49]: DD; [50]: DD; [51]: CR; [52]: CR), Ironstone rock ([55]: DD), Ultramafic rock ([56]: DD), Saxicolous open vegetation on ironstone outcrops ([63]: LC; [64]: DD; [65]: DD), Saxicolous open vegetation on ultramafic outcrop ([66]: VU), Subsaxicolous dwarf forest on ironstone outcrop ([73]: DD; [74]: CR; [75]: CR; [76]: EN; [77]: CR; [78]: CR), Saxicolous ravine grassland on ironstone ([79]: LC; [80]: CR), Ravine forest ([82]: VU; [83]: VU; [84]: EN; [85]: EN; [86]: VU; [87]: VU).

Description: Mount Nimba includes several contiguous KBAs corresponding to administrative subdivisions (Guinea: 145 km²; Liberia: 132 km² and Ivory Coast: 65 km²). In Ivory Coast, the Réserve Intégrale du Mont Nimba (CIV14) is extended eastward by the Mount Nimba transboundary zone (270 km²), which is not actually part of the Mount Nimba. Because of the position at the transition between perhumid and humid climatic wetness zones, its altitudinal range and the diversity of its landforms and lithology, the Mount Nimba is certainly one of the sites in West Africa with the highest diversity of types of ecosystems. In addition, several of those ecosystems are rare and threatened (Senterre et al. 2019a).

KBA assessment: Global KBA under criteria A2a ([42],[75],[84],[29],[41],[74],[20],[26]), A2b ([66]), B4 ([42],[75],[84],[20],[26],[66]). Based on ecosystems of the montane perhumid rain forest group (mesic and ravine forests: [42], [84]; Subsaxicolous dwarf forest on ironstone outcrop: [75]), each of the three main KBAs of the Mount Nimba individually qualify to the status of global KBA under criteria A2a and B4. For ecosystems of the submontane perhumid rain forest group ([29],[41],[74]), the Liberian and the Guinean parts qualify as global KBAs under criteria A2a, but not the part located in Ivory Coast. Finally, the ecosystem group of the submontane and montane humid rain forest zones (found only in the Guinean part), are not triggers of global KBA status. Nevertheless, in terms of non-forest ecosystems, the humid wetness climatic zone contains several ecosystems that are likely to have more than 20% of their global distribution found in Mount Nimba: montane waterfall ([20]: CR), seasonal marsh on ironstone rock sheet ([26]: CR) and saxicolous open vegetation on ultramafic outcrop ([66]: VU). On its own, the Mount Nimba transboundary zone (in Ivory Coast) does not qualify as a global KBA under criteria A2 and B4.

III.3.14 LBR15 West Nimba

Bibliography: ArcelorMittal (2010); Hawthorne et al. (2010)

Life zones: Tropical perhumid lowland/submontane; 387-1010 m a.s.l. (mean: 529 m)

Eco-genera/species: Inland stream ([10]: DD), river ([16]: DD), Freshwater swamps ([28]: EN), Riparian forest on alluvial soil ([34]: VU), Mesic forest ([40]: VU; [41]: EN), Overdrained forest ([47]: DD; [48]: DD), Ravine forest ([82]: VU; [83]: VU).

Description: The West Nimba KBA (116 km²) is in many ways similar to the Diécké (lowland perhumid rain forest hilly landscape), with important riparian and swamp ecosystems. It differs by the presence of 4 mountains reaching the submontane belt (Mt. Yuelliton, Mt. Gangra, Mt. Beeton and Mt. Tokadeh), including several well preserved areas such as Mt. Beeton (South-West of Mt. Gangra). Hawthorn et al. (2010: 2, 66) considered as a "high priority to retain as much riparian vegetation as possible, and to survey the riverbanks" although "in general, there is nothing globally strictly exceptional in terms of vegetation types".

KBA assessment: Not a global KBA under ecosystem criteria A2 and B4. Considering the relatively small size of the West Nimba KBA and the wide distribution in Liberia of its types of ecosystems, this area cannot qualify to the status of global KBA under the criteria A2 and B4. If it was regrouped with the Liberian Nimba KBA (LIB12), the composite KBA (LBIB12-LIB15) would qualify as global KBA under the criterion A2a ([41]).

III.3.15 GIN2 Diécké

Bibliography: Couch et al. (2019: 71); Haba and Couch (2017); Pecher and Smida (2009); Wright et al. (2006)

Life zones: Tropical perhumid lowland; 288-621 m a.s.l. (mean: 411 m)

Eco-genera/species: Inland stream ([10]: DD), river ([16]: DD), Freshwater swamps ([28]: EN), Riparian forest on alluvial soil ([34]: VU), Mesic forest ([40]: VU), Overdrained forest ([47]: DD), Ravine forest ([82]: VU).

Description: Diécké (592 km²) is characterized by a gently undulating topography, without high mountains or rocky outcrops. According to Couch et al. (2019: 71), "It sits on the late Archean period Mani series of biotite gneiss with localized magnetite" and "is part of the Leonean-Liberian crystalline massif". Because of its large pristine area and its regularly hilly landform, Diécké is likely to hold a remarkable number of undisturbed swamps, ravines and even overdrained ridges, which remain all unexplored. Only mesic forests have been described for that massif.

KBA assessment: Not a global KBA under ecosystem criteria A2 and B4. Diécké contains less than 1% of the global distribution of the lowland perhumid rain forest ecosystem group and therefore does not qualify as a global KBA under the criteria A2 and B4. Nevertheless, for Guinea, it is the largest remaining area of pristine lowland perhumid rain forests and represents an area of high conservation value at the national scale. It is also necessary to develop a better knowledge of the global distribution of Swamp forests and their conservation state at the scale of West Africa.

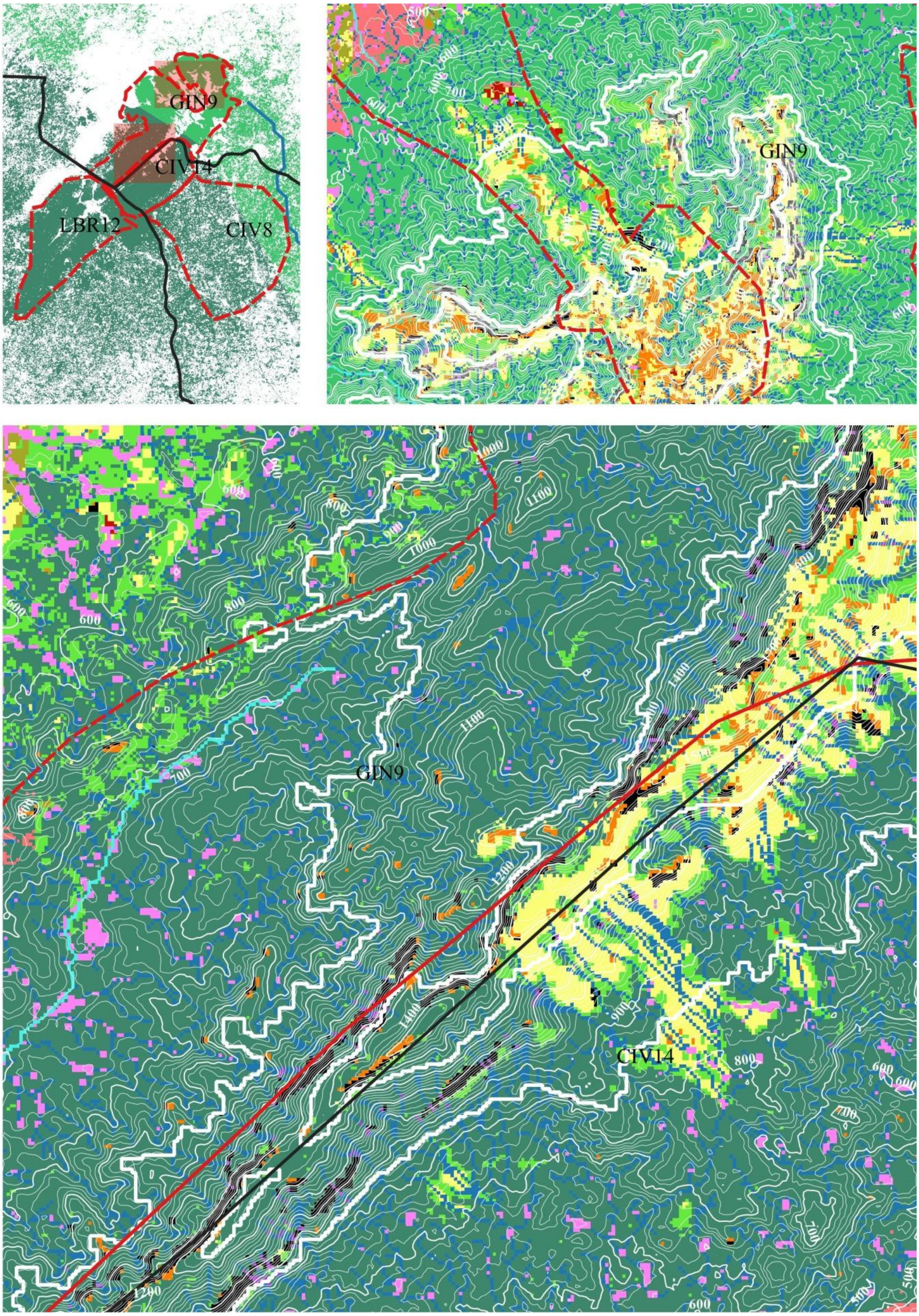


Figure 17. Overview of the stand scale ecosystems mapped for the Mount Nimba KBAs (GIN9, LBR12, CIV14, CIV8). The complete legend is provided with Figure 9. Overdrained landforms in the perhumid submontane and montane life zones have been modeled in this study and remain in a good conservation state mostly in the south-western part of the Guinean Nimba. They remain poorly studied. Several areas modeled as swamp forests in the submontane belt also deserve more attention and should be explored in the field.

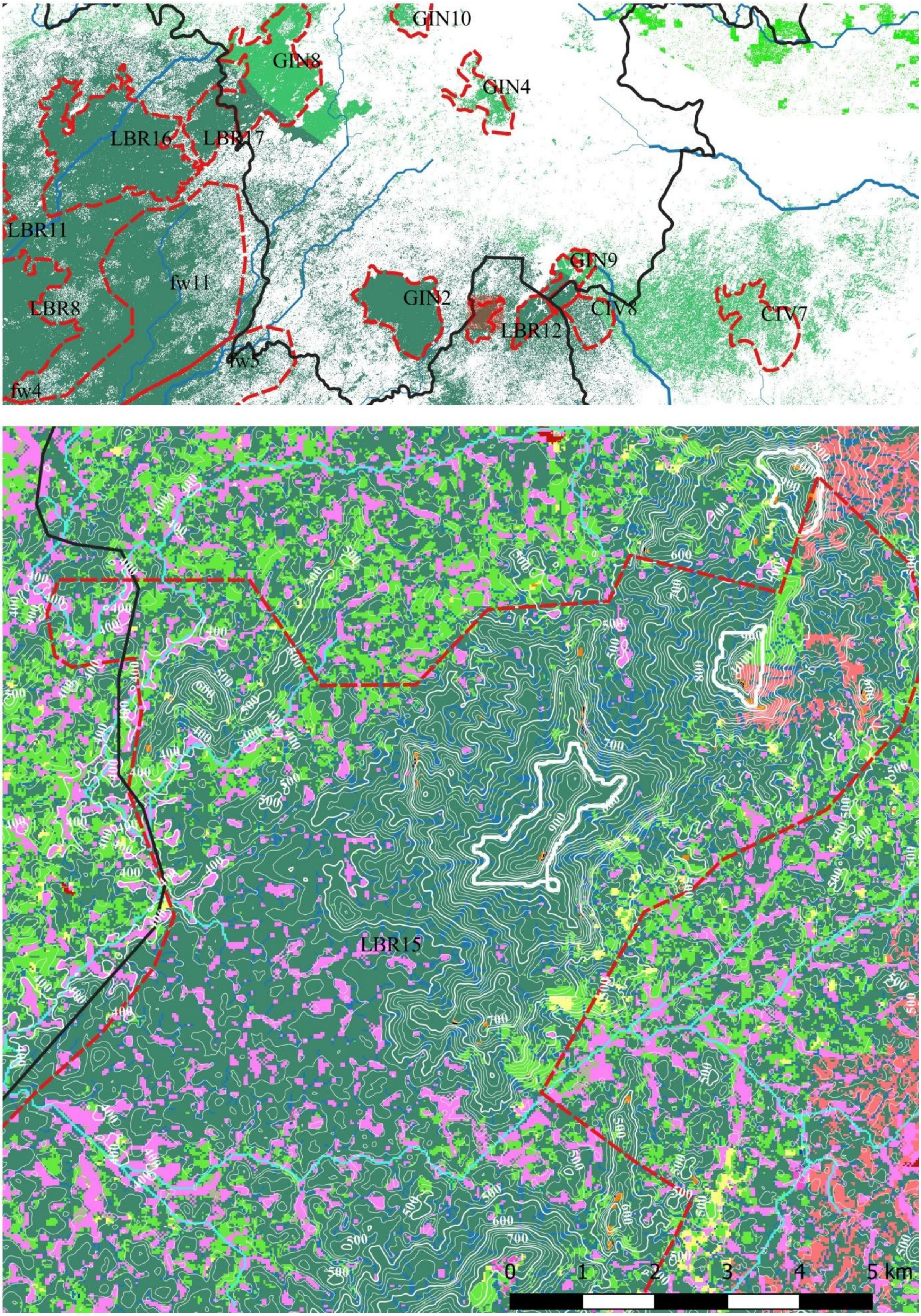


Figure 18. Overview of the stand scale ecosystems mapped for the West Nimba KBA (LBR15, Liberia). The complete legend is provided with Figure 9. Mount Beeton (in the center of the figure) and the moist plains to the west can be considered as priorities for further field explorations.

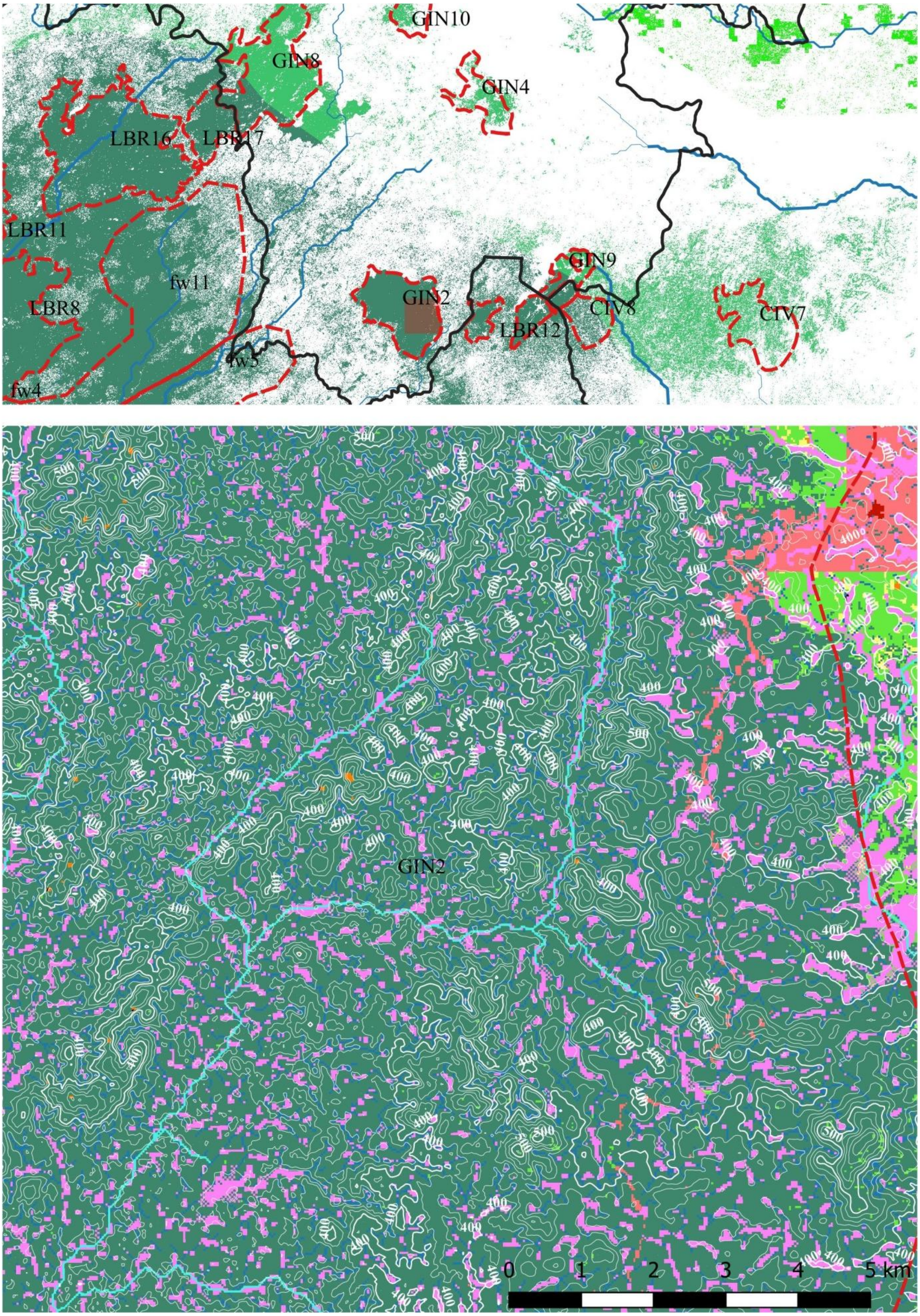


Figure 19. Overview of the stand scale ecosystems mapped for the Diécké KBA (GIN2, Guinea). The complete legend is provided with Figure 9.

III.3.16 fw4, 5, 7, 11 Lower/Middle/Upper reaches of St Paul River Freshwater

Bibliography: Carr et al. (2015: 71, 174)

Life zones: Tropical superhumid/perhumid lowland; 0-700 m a.s.l. (mean: 170 m)

Eco-genera/species: Inland stream ([10]: DD), river ([15]: DD; [16]: DD), waterfall ([18]: DD), Freshwater marsh ([23]: DD), Freshwater swamps ([27]: DD; [28]: EN), Riparian forest on alluvial soil ([33]: DD; [34]: VU), Mesic forest ([39]: EN; [40]: VU).

Description: The freshwater KBAs located in the lower, middle and upper reaches of the St. Paul river (7483 km²) have been defined based on the mapping of the water catchments draining into the Saint Paul River Carr et al. (2015: 59). They were recognized as "high priority KBA" based on the presence of threatened freshwater species (fishes, crabs, mollusks: Carr et al. 2015: 45-47, 71; Abell et al. 2008; Holland et al. 2012). According to Carr et al. (2015: 174), at least some of those freshwater species are threatened by an ongoing decline in habitat quality due to siltation and pollution from deforestation and mining. The rain forests of these water catchments are therefore important for the conservation of the biodiversity living in the aquatic environment of streams, rivers, lakes, and other wetlands. From an ecosystem point of view, those rain forests are mostly considered as VU, except for perhumid swamp forests ([28]: EN) and forests of the superhumid life zone ([39]: EN).

KBA assessment: If all St. Paul River freshwater KBAs are considered together, they can qualify to the status of global KBA under criterion A2a ([28]). When considered together, those KBAs include 7.9% of the global distribution of the lowland perhumid ecosystem group, and therefore likely more than 5% of the freshwater swamp forests ([28]: EN). Nevertheless, more studies are needed to improve knowledge on the global distribution of the various types of swamp forests in West Africa and on their conservation state.

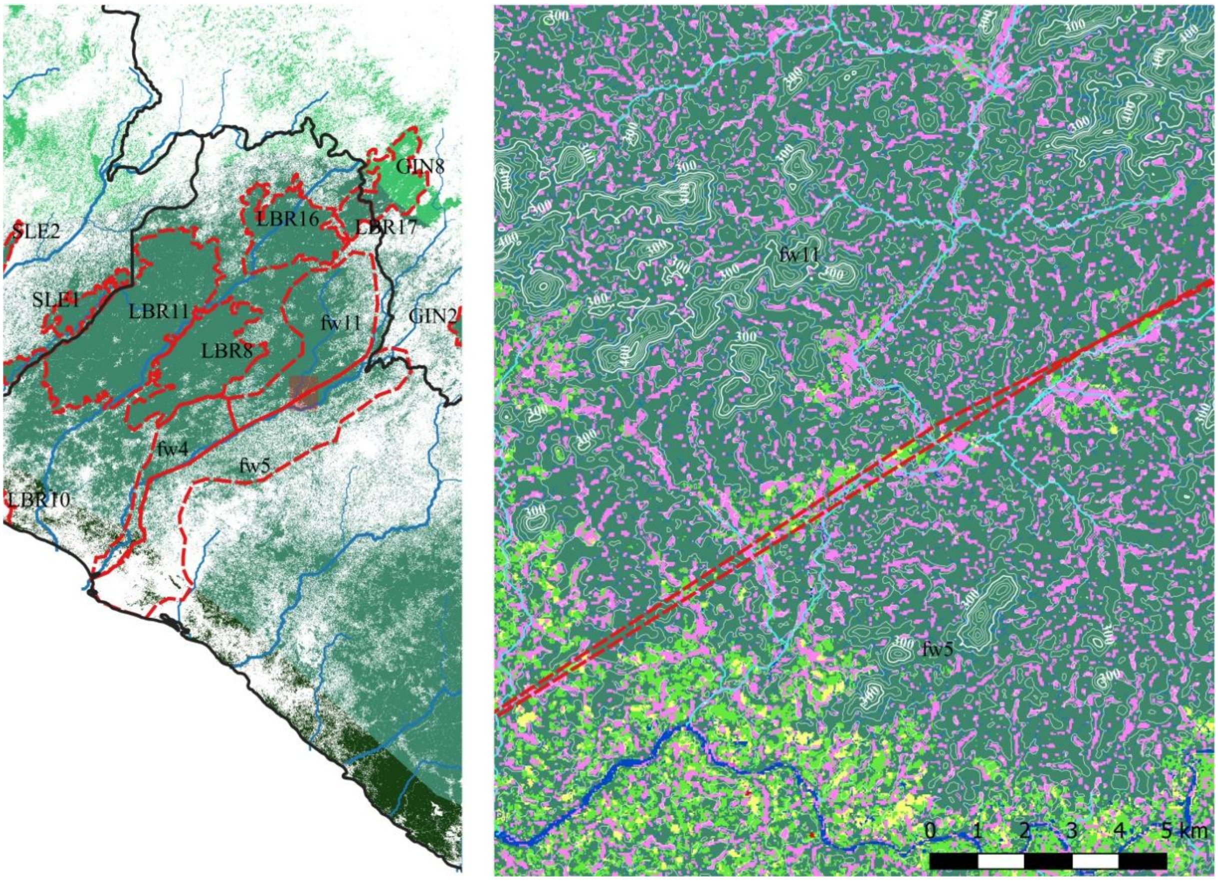


Figure 20. Overview of the stand scale ecosystems mapped for the Diécké KBA (GIN2, Guinea). The complete legend is provided with Figure 9.

IV. DISCUSSION

IV.1 Comparisons with other existing typologies of ecosystems

In a previous report (Senterre et al. 2019a), the application of our particular approach for conceptualizing ecosystems led to the recognition of 44 different types of ecosystems, for Mount Nimba alone, where previous studies within the last decade had distinguished just 13-15 different types. We therefore dedicated a chapter (Senterre et al. 2019a: III.3) to explain why we considered the approach proposed as more appropriate and, fortunately, our results were supported by the study of Schnell (1952). Here, the same problem appears: we end up suggesting a larger number of types of ecosystems (87) compared to most other studies (18 to 31: see below). Therefore, we discuss our results and compare them to types of ecosystems that would be recognized if we were using some of the main regional, continental or global standardized typologies available. This will also help the readers to understand better the pragmatic impact of our particular approach compared to those other, well known, typologies.

IV.1.1 The UNESCO world vegetation classification (1973)

In the years following the AETFAT congress at Yangambi (Keay 1959; Trochain 1957), the corresponding African vegetation typology matured into a global typology of vegetation (UNESCO 1973). This was the first exhaustive variant of the Yangambi classification. It gave a lot of importance to vegetation physiognomy (which was believed to be the only aspect of vegetation that could be generalized globally and locally) and went into more details for that aspect than any of the posterior classifications (except for Di Gregorio 2005). The UNESCO classification also went into more details (compared to posterior systems) regarding the altitudinal gradient, distinguishing submontane, montane, cloud, subalpine, alpine, and subnivean belts. Below, we present the vegetation classes present in our study area according to the UNESCO classification (Table 4).

Table 4. UNESCO classes of vegetation (29) present within the study area and correspondence with the types of ecosystems recognized in the current study. The UNESCO hierarchy contains 5 levels: Formation Class (I, II, etc.), Formation Subclass (A, B, etc.), Formation (a, b, etc.), Subformation ((1), (2), etc.) and "Further subdivisions" ((a), (b), etc.). A more complete extract from the UNESCO classification is given in Annex 1 to provide the reader with more context in a condensed format.

Code	Name	This study (code in [])
I.A.1.a.	Tropical ombrophilous lowland forest	9,39,40,46,47,81,82
I.A.1.b.	Tropical ombrophilous submontane forest	29,31,41,48,83
I.A.1.c.(1).	Tropical ombrophilous montane forest, Broad-leaved	32,42,49,69,72,75,78,84
I.A.1.f.	Tropical ombrophilous alluvial forest	33,34,35
I.A.1.g.	Tropical ombrophilous swamp forest	27,28,30
I.A.1.g.(1).	Broad-leaved, dominated by dicots	27,28,29,30,31,32
I.A.1.g.(2).	Dominated by palms, but broad-leaved trees in the undergrowth	27,28,30
I.A.1.h.	Tropical evergreen peat forest	Possibly at Lake Piso?
I.A.2.a.	Tropical (or subtropical) evergreen seasonal lowland forest	43,50,67,70,73,76,85
I.A.2.b.(1).	Tropical (or subtropical) evergreen seasonal submontane forest, Boad-leaved, most common form	44,51,68,71,74,77,86
I.A.2.c.	Tropical (or subtropical) evergreen seasonal montane forest	45,52,87
I.A.5.	Mangrove forests	1,3
II.B.1.	Drought-deciduous woodlands	36,37,38 (progressive)
III.B.1.	Drought-deciduous scrub	36,37,38 (progressive)
IV.A.2.b.	Evergreen mosaic dwarf-shrubland	7,57,58,59,61,62
IV.B.2.b.	Drought-deciduous creeping or matted dwarf-thicket	60

V.A.	Savannas and related grasslands (tropical or subtropical grasslands and parklands)	57,58,59,61,62
V.A.1.a.	Woodland with patches of tall-grass savanna (woodland savanna)	36,37,38 (progressive)
V.A.1.b.	Tall-grass savanna with isolated trees (tree savanna)	36,37,38
V.A.1.c.	Tall-grass savanna with shrubs (scrub savanna)	36,37,38 (progressive)
V.A.1.d.	Tall-grass savanna (grass savanna)	36,37,38
V.A.2.c.	Short-grass savanna (grass savanna)	80
V.B.1.c.	Tall-grass steppe without woody plants	63,64,65,66,79,80
V.D.1.a.	Tall-sedge swamp	22,23
V.D.1.b.	Low-sedge swamp	24,25,26
V.E.2.a.(2).	Marine salt meadow, Poor in succulents	2
VI.A.1.	Scarcely vegetated rocks	53,54,55,56
VI.B.1.c.	Forb dune	6,8
VI.B.2.	Bare sand dunes	5

The issues of the UNESCO classification are:

1. The bioclimatic gradient is not detailed enough. For example, the category "Tropical ombrophilous lowland" aggregates the categories superhumid and perhumid as recognized in this study (based on Holdridge 1967).
2. Altitudinal belts are inappropriately treated. For example, the difference between "I.A.1.c. Tropical ombrophilous montane forest" and "I.A.1.e. Tropical ombrophilous cloud forest" is due to a combination of climatic wetness and topographic wetness, responsible for a higher hygrometry and lower stature of what is called a "cloud forest" in the UNESCO classification, but the category Tropical ombrophilous montane forest can actually also be within the cloud belt and therefore the two categories (at the 'Formation' level) are not mutually exclusive.
3. The misconception of life zones and the deep rooting of the original Yangambi classification (i.e. macroclimatic vegetation physiognomy first, then major limiting ecological factors afterward) are responsible for the misconception of so-called "azonal" vegetation types. Mangroves, bare rocks, beaches, coastal dunes, streams, water surfaces, cities, etc., are driven by stand scale limiting factors that seem indeed (at first sight, and especially for a botanist) to be totally overriding bioclimatic influence. Nevertheless, specialized studies on these azonal ecosystem types suggest, on the contrary, that the bioclimatic gradients still represent different ecological contexts. Mangroves in dryer climates (all other things being kept constant) differ from mangroves in humid or perhumid bioclimates, although trees alone might not be the best indicators of these differences (Saravanakumar et al. 2009; Ximenes et al. 2016). Similarly, bioclimates remain a determinant factor (ecological context) for rock surfaces (see ecosystem type [53], in chapter III.1), streams and water surfaces (see III.1.6: Stream Biome Gradient Concept), and sandy beaches (see [5]).
4. The main vegetation physiognomy, dominating the first and second levels of the hierarchy, is too detailed: I. Closed Forest (including also very short mangroves), II. Woodland, III. Scrub, IV. Dwarf-scrub (including mixed with herbaceous vegetation), V. Herbaceous vegetation (including mixed with trees or shrubs, and with subdivision according to height: tall-grass, mid-grass, short-grass). This results in non-mutually exclusive classes (e.g. shrubland with grasses vs. grassland with shrubs) and in a reduced consideration of bioclimatic gradients (e.g. short-grass steppe of high latitude, or of continental arid lands, or of tropical rocky outcrops are not distinguished).

5. The combination of the four points given above altogether is responsible for another issue: the inconsistency in the criteria used at the different levels of hierarchy. For example, a moderately azonal vegetation type such as the "I.A.1.g. Tropical ombrophilous swamp forest" is treated as a subdivision of I.A.1, unlike mangroves which were treated as a subdivision of I.A. Therefore, again, bioclimatic gradients are overlooked for many groups of vegetation such as shrublands, grasslands, and (if considered) bioclimates are oversimplified to either latitude or altitude gradients. In addition, such types as "I.A.1.g. Tropical ombrophilous swamp forest" and "I.A.1.c. Tropical ombrophilous montane forest" are non-mutually exclusive. It is impossible to classify montane swamps, montane swamps in superhumid vs. humid zones, dwarf montane swamps on ironstone outcrops, etc. As discussed in Senterre et al. (in review), there are no linear solutions (i.e. a hierarchy of classes) to a complex, multi-dimensional problem (i.e. the multiple combinations of stand scale factors that can have more or less influence, depending on the context).
6. Landform factors are overlooked, although they are in fact important factors related to wetness, and therefore fundamental to understand vegetation. Climax vegetation physiognomy is indeed largely determined by climatic, topographic and edaphic wetness. Therefore, ravines vs. overdrained ridges are a distinction as important as the one recognizing swamps or mangroves. Ravines are very distinctive and have a high ecological conservation value (Radoux et al. 2019; Senterre and Wagner 2014).
7. Coastal gradients and estuaries are overlooked mostly due to the complex entanglement of wetland and coastal gradients (impossible to treat using a highly hierarchical classification), and because of the physiognomic complexity of those landscapes (see Senterre et al. 2015).
8. Some aspects of aquatic vegetation that are treated as distinct formations (VII.C. Rooted floating-leaf communities, VII.D. Rooted underwater communities, VII.E. Free-floating fresh water communities) represent in fact a distinct relative scale of space, i.e. the micro-ecosystem scale. Those types of vegetation are analogous, for example in a forest, to the understorey, trunk zone, or canopy.
9. Biogeography and biotic communities are not yet integrated.

IV.1.2 The International Vegetation Classification (USNVC / IVC: 1997-2020)

Toward the end of the last century, the UNESCO classification has led to the development of the United States National Vegetation Classification (USNVC, developed in parallel by the Federal Geographic Data Committee and The Nature Conservancy: FGDC 1997; Grossman et al. 1998). It included 5 levels of hierarchy for predominantly physiognomic aspects (directly derived from the UNESCO classification), plus two levels for biotic aspects (Alliances and Associations). This classification system intended to use more consistently physiognomic characters. In addition, supporting information was developed to explain the criteria used at each hierarchic level. "For example, in the UNESCO system, different criteria are used to distinguish formation subclasses depending on which formation class is being subdivided. In the USNVC, however, predominant leaf phenology is the single criterion used to define formation subclasses in the Forest, Woodland, Shrubland, and Dwarf-Shrubland Formation Classes." (Grossman et al. 1997: 21). In addition, the USNVC classification intended to be more practical for finer scale applications and "a new formation subgroup was added to support the Federal Geographic Data Committee’s need to classify managed and cultural vegetation" (Grossman et al. 1997: 21).

A decade later, FGDC, ESA (Ecological Society of America), NatureServe and others developed a second version of this classification system focusing on the production of a standard methodology for the definition and description of new Alliances and Associations, as well as for their dynamic revision process (Faber-Langendoen et al. 2009; FGDC 2008; Franklin et al. 2012; Jennings et al. 2009; Peet 2008). This classification system has continued to develop and is now mainly managed by NatureServe for the International Vegetation Classification (IVC), in collaboration with the IUCN and others (Faber-Langendoen et al. 2016, 2014: 553). The main modification is the addition of Mid levels to bridge the gap between the Formations and the Alliances (i.e. Division, Macrogroups and Groups). In addition, the detailed structural physiognomic characters and floristics characters are used in parallel at the lower levels of the hierarchy, rather than physiognomy first and floristics last. Although this classification system has been mostly applied to the Americas, it has also been applied to Africa: Sayre et al. (2013). Below (Table 3), we compile the ecosystem types recognized based on the GIS data from Sayre et al. (2013) and on our own interpretation of the IVC classification.

Table 5. USNVC-IVC classes of vegetation (18) present within the study area (based on Faber-Langendoen et al. 2016; Sayre et al. 2013) and correspondence with the types of ecosystems recognized in the current study. The IVC hierarchy (Faber-Langendoen et al. 2016) contains 8 levels: Formation Class (1, 2, etc.), Formation Subclass (A, B, etc.), Formation (1, 2, etc.), Division (Fd, Ff, etc.), Macrogroup (1, 2, etc.), Group, Alliance and Association. A more complete extract from the International Vegetation Classification (IVC) is given in Annex 2 to provide the reader with more context in a condensed format.

Code	Name	This study ([code])
1.A.2.Fd1	Guineo-Congolian Evergreen Rainforest	40,82
1.A.2.Fd2	Guineo-Congolian Semi-Evergreen Rainforest	43,50,85
1.A.2.Fd4	Guineo-Congolian Littoral Rainforest	39,46,81
1.A.3.Ff2	Afromontane Mesic Forest	42,45,49,52,84,87
1.A.3.Ff4	Moist Evergreen Montane Forest	41,44,48,51,83,86
1.A.4.Fg	Guineo-Congolian Swamp Forest	32
1.A.4.Fg1	Anthostema – Alstonia Swamp Forest	27,28,30
1.A.4.Fg2	Raphia Swamp	27,28,30
1.A.4.Fh2	Uapaca heudelotii Forest	33,34,35
1.A.4.Fh3	West African Mitragyna Riverine Forest	27,28,29,30,31
1.A.5.Ua1	Atlantic Ocean Mangrove	1,3
2.A.1.Ff2	Western African Mesic Woodland & Grassland	36,37,38
2.A.3	Tropical Scrub & Herb Coastal Vegetation	6,7,8
2.A.5.Fc1	African Tropical Freshwater Marsh (Dembos)	22,23
2.B.7.Fh1	Tropical African Coastal Salt Marsh	2
6.A.1.Fc2	Atlantic African Coastal Dune	5,6,7,8
6.A.1.Fc6	Western African Inselberg Vegetation	53,54,57-62,67-72
8.A	Lake	4

Most issues of the UNESCO classification persist in the IVC:

1. The climatic wetness gradient is complete (Table 6) but partly misinterpreted (superhumid zone confused with coastal/littoral effect) and is not explicitly defined as a higher ecosystemic scale but mixed with stand-scale limiting factors.
2. Altitudinal belts are still inappropriately treated, and even more so than in the UNESCO classification (absence of submontane belt, etc., which then loses the correspondence with the life zone definitions of Holdridge 1967).

3. Life zones and "azonal" vegetation types are still misconceived in the exact same way as in the UNESCO classification, overlooking therefore the effect of life zones on azonal types (the latter receiving therefore a higher rank in the hierarchy).
4. The excessive details on the general vegetation physiognomy have been one of the main issues addressed in the IVC. The first level of the hierarchy is now much more broadly conceptualized compared to UNESCO (1. Forest & Woodland, 2. Shrubland & Grassland, 3. Desert & Semi-Desert, 4. Polar & High Montane Scrub, Grasslands & Barrens, followed by basically the same unvegetated azonal and anthropic classes as in UNESCO). Nevertheless, the problem has not been totally eliminated as the categories 2 and 4 are not mutually exclusive: e.g. "2.A.2 Tropical Montane Grassland & Shrubland" vs. "4.A.1 Tropical High Montane Scrub & Grassland".
5. The inconsistency on the hierarchic levels to which ecological factors are used has been another main issue from the UNESCO classification addressed in the IVC. Nevertheless, the IVC still fails at dealing with this issue: e.g. "1.A.3. Tropical Montane Humid Forest" vs. "1.A.4 Tropical Flooded & Swamp Forest".
6. Landform is still largely overlooked. Topographic wetness is integrated as minor details into the 2 lowermost levels (Alliances and Associations).
7. Coastal gradients are also still overlooked and considered mostly at the 2 lowermost levels.
8. Aquatic vegetation still includes entities that are better understood as micro-ecosystems.
9. Biogeographic and biotic communities are integrated but are given too much importance as it is mixed with important stand scale gradients within the 5 lowermost levels of the hierarchy. Therefore, the IVC is too much dependant on biogeographic and phytosociologic hypothesis, which reduces the stability that could be achieved using ecologically determined ecosystem genera as proposed according to our approach. It also indicates a typically phytosociologic approach, based on the concept of more or less well defined and discreet plant communities. This interpretation of the biotic characteristics of ecosystems is problematic and a better model can be developed using an approach based on the concept of ecological groups (see Figure 2).
10. Finally, the predominance of the observed vegetation physiognomy (just like in the UNESCO classification) does not provide an appropriate model to account for the dynamics of ecosystems. In other words, if the vegetation of a stand of "1.A.2.Fd1 Guineo Congolian Evergreen Rainforest" is removed, the redeveloping pioneer vegetation could be classified as "2.A.1.Ff West-Central African Mesic Woodland & Savanna".

The main idea of the IVC was to stop opposing the divisive part of the hierarchy purely based on physiognomy and ecology vs. the agglomerative part of the hierarchy purely based on floristics. The solution was then to define the levels of the hierarchy from broad to narrow in parallel for bioclimatic, physiognomic and geoecologic factors. We partly agree with that. For example, at the eco-generic level, we consider disturbance factors that are catastrophic (resulting in primary series of vegetation), while moderate disturbance factors are considered at the lowermost level (as an individual stand character). At the eco-generic level, we also consider, for example, lithology, topographic wetness classes and broad soil texture classes, while at the lowermost level we consider detailed rock types, landforms and fine soil texture description (respectively). However, we disagree to define a hierarchy of stand scale factors and we disagree to mix that with a hierarchy of bioclimatic factors. To us, the solution can only come by integrating a modular component to the classification and by defining the hierarchic part according to natural entities based on relative scales of space where stand scale ecosystems are under the dependency of the life zones in which they are located.

Table 6. Comparison of conceptualizations and terminologies from various sources for the climatic wetness gradient (continentality), in the African tropical belt (see Figure 3 for a representation of the zones 1-8). According to our approach, bioclimates should not be named using any term with vegetation physiognomy connotation (e.g. tropical lowland superhumid). Nevertheless, here, for the purpose of comparability with terms found in the literature, we do include physiognomic terms in our own terminology, based on the physiognomy of climax mesic stand scale vegetation within a life zone.

Biblio. Source	1	2	3	4	5	6	7	8
Current study	Superhumid wet rainforest	Perhumid moist rainforest	Humid seasonal moist and monsoon rainforest	Subhumid seasonal dry rainforest	Semi-arid dry forest	Arid dry thorny / crassulent woodlands and scrubs	Perarid grasslands	Superarid desert
Senterre & Wagner 2014	Wet evergreen tropical rain forest	Moist evergreen tropical rain forest	Semi-deciduous tropical rain forest		Dry evergreen tropical forest			
Faber-Langendoen 2012-2016	1.A.2.Fd4 Guineo Congolian Littoral Rainforest	1.A.2.Fd1 Guineo-Congolian Evergreen Rainforest	1.A.2.Fd2 Guineo-Congolian Semi-Evergreen Rainforest	1.A.2.Fd3 Guineo-Congolian Semi-Deciduous Rainforest	1.A.1 Tropical Seasonally Dry Forest	2.A.1.Ff2 Western African Mesic Woodland & Grassland	2.A.1.Fi1 Sudano-Sahelian Herbaceous Savanna	3.A.2.Pf-Pg-Pj North Sahel-Saharan Treed Steppe & Grassland
Olson & Dinerstein 2012	Western and Eastern Guinea Forest			Guinean forest-savanna	West and East Sudanian savanna	Sahelian Acacia savanna		Sahara desert
White 1983	hygrophilous coastal evergreen rain forest	mixed moist semi-evergreen rain forest	drier peripheral semi-evergreen rain forest		Soudanian dry forests and woodlands			
White 1983	I. Guineo-Congolian regional centre			XI. Guineo-Congolia/Sudania regional transition zone	III. Sudanian regional centre		XVI. Sahel regional transition zone	XVII. Sahara reg. Trans. zone
Schnell 1979		forêt ombrophile	forêt dense humide semi-décidue de type méridional	forêt dense humide semi-décidue de type septentrional				
UNESCO 1973	I.A.1.a. Tropical ombrophilous lowland forest		I.A.2.a. Tropical (or subtropical) evergreen seasonal lowland forest	I.A.3.a. Tropical (or subtropical) semi-deciduous lowland forest	I.B.1.a. Drought-deciduous lowland (and submontane) forest	Drought-deciduous woodlands (II.B.1) and scrubs (III.B.1.)	V.A Savannas and related grasslands	VI. Deserts
Letouzey 1968	forêt littorale							
Aubréville 1957	forêt à légumineuses		forêt semi-décidue à malvales et ulmacées					
Lebrun & Gilbert 1954					forêts tropophiles			
Trochain 1951	forêt hyperombrophile				mesophilous forest			
Schnell 1949, 1950	forêts à Parinari excelsa des plaines côtières			mesophilous forest	forêt soudanienne xérophile			

IV.1.3 The IUCN habitat classification scheme (ver. 3.1: 2012-2016)

Like the IVC, the IUCN habitat classification scheme is a variation of the UNESCO classification based mostly on a simplification of the physiognomic classes. It presents the same issues as the other two classifications discussed above and is less useful in various ways due to oversimplification of bioclimatic and stand scale gradients. We only present it because it has sometimes been recommended for Red Listing of Ecosystems.

Table 7. IUCN classes of habitat (18) present within the study area and correspondence with the types of ecosystems recognized in the current study. The IUCN habitat classification scheme consists of a hierarchy with up to 3 unnamed levels.

Code	Code. Name	This study ([code])
1.5	Forest – Subtropical/tropical dry	67,68,69,70-78
1.6	Forest – Subtropical/tropical moist lowland	9,39-41,43,44,46-48,50,51,81,82,83,85,86
1.7	Forest – Subtropical/tropical mangrove vegetation above high tide level	1,3
1.8	Forest – Subtropical/tropical swamp	27-35
1.9	Forest – Subtropical/tropical moist montane	32,42,45,49,52,69,72,75,78,84, 87
2.1	Savanna - Dry	36,37,38
3.5	Shrubland – Subtropical/tropical dry	36,37,38 (progressive)
3.6	Shrubland – Subtropical/tropical moist	57,58,60,61
3.7	Shrubland – Subtropical/tropical high altitude	59,62
4.5	Grassland – Subtropical/tropical dry	2,36-38,57,58,60,61,63,64,79
4.7	Grassland – Subtropical/tropical high altitude	59,62,65,66,80
5.1	Wetlands (inland) – Permanent rivers/streams/creeks (includes waterfalls)	10-20
5.7	Wetlands (inland) – Permanent freshwater marshes/pools (under 8 ha)	21-23
5.8	Wetlands (inland) – Seasonal/intermittent freshwater marshes/pools (under 8 ha)	24-26
6	Rocky Areas (e.g., inland cliffs, mountain peaks)	53-56
12.2	Sandy Shoreline and/or Beaches, Sand Bars, Spits, etc.	5,6
13.3	Coastal Sand Dunes	7,8
13.4	Coastal Brackish/Saline Lagoons/Marine Lakes	4

IV.1.4 The USGS Terrestrial Ecosystems (2013-2020)

The earliest development of this approach started with Sayre et al. (2013). Unlike in all the other classification systems discussed above, the approach used is modular (i.e. non-hierarchical) and it is based on "biome-level vegetation assemblage classifier" (i.e. climatic climax vegetation physiognomy rather than observed/current vegetation physiognomy). The elements (or modules, or "classifiers", i.e. main ecosystem characters) combined to define "terrestrial ecosystems" are: (1) 29 bioclimates, (2) climatic climax physiognomy, (3) 7 landforms, (4) 19 lithologies and (5) 17 phytogeographic regions (for Africa). Interestingly, the terrestrial ecosystems recognized and mapped at the finest scale are defined and named according to the USNVC / IVC standards, but only the FGDC (2008) is cited. About 163 "Macrogroups" are recognized (Sayre et al. 2013: 17, 20–22) and we integrated them into Table 5 (see also Annex 2).

The next year, Sayre et al. (2014) extended and reviewed their own approach to World ecosystems. But this time, vegetation physiognomy was not anymore assessed based on expert knowledge of Potential Natural Vegetation (Sayre et al. 2013: 16) but rather based on actual land cover mapped using satellite imagery (Sayre et al. 2014: 23, 35), therefore going back to a classification of actual vegetation like in the UNESCO classification and its derivatives. In addition, there are other significant changes compared to the work of 2013. Bioclimates were termed using latitudinal gradient in 2013 (Tropical, Mediterrannean, Temperate) vs. predominantly temperature gradient in 2014 (Hot, Warm, Cool, Cold, Arctic). In 2013, the high mountains of Africa (e.g. Mount Cameroon) were entirely classified as

"Tropical" while in 2014 they include "Hot", "Warm" and "Cool" zones corresponding to altitudinal belts. The 2014 bioclimates therefore integrated better latitudinal and altitudinal gradients (both responsible for similar temperature gradients). However, it did not make a distinction between the "Cool" bioclimate of a tropical mountain vs. of a temperate lowland, which, beyond temperature, also differ in other important factors such as insulation. The climatic wetness part of the definition of bioclimates has also varied profoundly between the 2013 and 2014 studies. It went from a classification which integrated climatic wetness (Pluvial, Pluviseasonal, Xeric, Desertic, Hyperdesertic) and atmospheric wetness plus continentality/seasonality (Hyperoceanic, Semi-hyperoceanic, Euoceanic, Semi-continental, Continental) to a more symmetrical system (applied equally to all temperature zones) accounting only for overall climatic wetness (Very wet, Wet, Moist, Semi-dry, Dry, Very dry). Finally, in Sayre et al. (2014), landform and lithology classes are slightly modified, and phytogeographic regions are not considered anymore. The various components of the modular definition of terrestrial ecosystems are then compiled at two levels of resolution: (1) a fine level (48872 "Ecological Facets") based on the combinations of 37 bioclimates, 10 landforms, 16 lithologies and 23 land cover types, and (2) a coarse level (3923 "Ecological Land Units", or ELUs) based on simplified components or "classifiers" (19 bioclimates, 3 landforms, 11 lithologies and 9 land cover types). Finally, although Faber-Langendoen et al. (2012) are cited, the labeling of the ELUs was not done anymore using the USNVC (unlike in Sayre et al. 2013). Rather, ELUs were labeled using the concatenation of the descriptors for the input layers, to "avoid bias in selection and use of an a priori classification system which may or may not be considered a consensus, or widely accepted classification". Below (Table 8), we compile the ELUs present within our study area.

More recently, Sayre et al. (2020a, 2020b) have again reviewed their categorization of world terrestrial ecosystems. Bioclimates are defined using latitudinal terms (like in their work of 2013) and are considerably simplified (using 6 temperature zones that account for altitudinal gradient plus only 3 climatic wetness zones, i.e. Moist, Dry, Desert). Tropical montane belt, for example at Mount Cameroon, is then labeled as "Subtropical" (Sayre et al. 2020a: 7). Landforms are also simplified (4 classes) as well as land cover types (8 classes, including 2 land use classes: settlements and croplands). Lithology is not anymore considered, which we believe is motivated by the limited quality of global GIS data. In addition, two maps are produced: one for the potential natural vegetation (based on Hengl 2018) and one for the current vegetation (using the same approach as in Sayre et al. 2014). Finally, biogeographic stratification (eliminated in Sayre et al. 2014) is reintroduced (as in Sayre et al. 2013), but at a continental scale (biogeographic realms).

Table 8. USGS terrestrial ecosystem types (31) present within the study area (based on Sayre et al. 2014) and correspondence with the types of ecosystems recognized in the current study.

Name	**This study ([])**
Hot Wet Plains on Non-Defined with Mostly Needleleaf/Evergreen Forest	39,40,43
Hot Wet Plains on Unconsolidated Sediment with Mostly Needleleaf/Evergreen Forest	9
Hot Wet Hills on Acidic Plutonics with Mostly Needleleaf/Evergreen Forest	67,70
Hot Wet Hills on Non-Carbonate Sedimentary Rock with Mostly Needleleaf/Evergreen Forest	73,76
Hot Wet Hills on Non-Defined with Mostly Needleleaf/Evergreen Forest	39,40,43,46,47,50
Hot Wet Mountains on Acidic Plutonics with Mostly Needleleaf/Evergreen Forest	68,69,71,72
Hot Wet Mountains on Non-Carbonate Sedimentary Rock with Mostly Needleleaf/Evergreen Forest	74,75
Hot Wet Mountains on Non-Defined with Mostly Needleleaf/Evergreen Forest	41,42,44,45,48,49, 51,52
Hot Wet Plains on Non-Defined with Grassland, Scrub, or Shrub	36

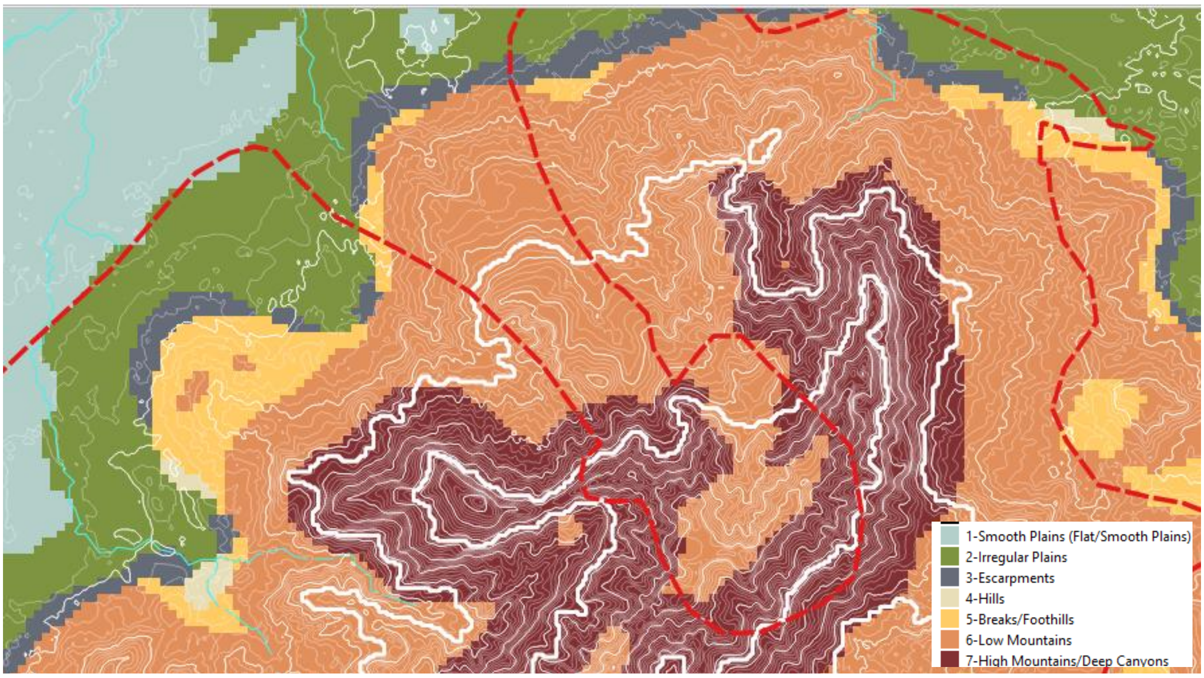
Hot Wet Plains on Unconsolidated Sediment with Grassland, Scrub, or Shrub	2,6-8
Hot Wet Hills on Acidic Plutonics with Grassland, Scrub, or Shrub	57,67
Hot Wet Hills on Non-Carbonate Sedimentary Rock with Grassland, Scrub, or Shrub	63
Hot Wet Hills on Non-Defined with Grassland, Scrub, or Shrub	36
Hot Wet Mountains on Acidic Plutonics with Grassland, Scrub, or Shrub	58,59,61,62
Hot Wet Mountains on Metamorphic Rock with Grassland, Scrub, or Shrub	66
Hot Wet Mountains on Non-Carbonate Sedimentary Rock with Grassland, Scrub, or Shrub	64,65
Hot Wet Mountains on Non-Defined with Grassland, Scrub, or Shrub	37,38
Hot Wet Plains on Unconsolidated Sediment with Bare area	5
Hot Wet Hills on Acidic Plutonics with Bare area	53
Hot Wet Mountains on Acidic Plutonics with Bare area	54
Hot Wet Mountains on Metamorphic Rock with Bare area	56
Hot Wet Mountains on Non-Carbonate Sedimentary Rock with Bare area	55
Hot Wet Plains on Non-Carbonate Sedimentary Rock with Swampy or Often Flooded Vegetation	24
Hot Wet Plains on Non-Defined with Swampy or Often Flooded Vegetation	22,23,27,28,30,33, 34,35
Hot Wet Plains on Unconsolidated Sediment with Swampy or Often Flooded Vegetation	1,3
Hot Wet Hills on Non-Carbonate Sedimentary Rock with Swampy or Often Flooded Vegetation	24
Hot Wet Hills on Non-Defined with Swampy or Often Flooded Vegetation	22,23,27,28,30
Hot Wet Mountains on Mixed Sedimentary Rock with Swampy or Often Flooded Vegetation	32
Hot Wet Mountains on Non-Carbonate Sedimentary Rock with Swampy or Often Flooded Vegetation	25,26
Hot Wet Mountains on Non-Defined with Swampy or Often Flooded Vegetation	29,31
Surface Water	4,15-17,21

Main issues of the USGS classification system:

1. The climatic wetness gradient is inappropriate. Sayre et al. (2013) started by considering the highly detailed classes of Rivas-Martínez et al. (2011), which we consider to be more descriptive of the climate than truly bioclimatic. Subsequently, they simplified it in order to have a manageable number of resulting ecosystems, but we consider it as oversimplified. We prefer to follow a typology of climatic wetness that is closer to the system proposed by Holdridge (1967) and that allows for a more efficient description of the continentality gradient that is actually observed in African vegetation (see Table 6).
2. Altitudinal gradient is inappropriate because it is mapped based on global climatic data. Consequently, submontane and montane vegetation of mountains with limited climatic data are not well identified. We consider as more accurate to use altitude data combined with local knowledge on the altitude threshold values for belts transitions (see Senterre et al. 2019a). In addition, a tropical montane climate is not equivalent to a lowland temperate one. Here again, we prefer to follow the model proposed by Holdrige (1967), with 7 latitudinal belts and 7 altitudinal belts possible within the tropical belt.
3. Life zones and their influence on "azonal" vegetation types are better accounted for, although not for water surfaces.
4. Vegetation physiognomy is better integrated than in classifications derived from Yangambi-UNESCO, because of the modular approach. Nevertheless, it is too broadly conceptualized (Forestland, Shrubland, Grassland, Bare). For example, dwarf forest physiognomy is a good indicator of some particular stand conditions (e.g. overdrained, subsaxicolous). There is therefore still a need to provide enough details in the

classification to classify types of ecosystem, more in line with field observations and less driven by what can be mapped using remote sensing techniques.

5. The inconsistency on the hierarchic levels to which bioclimatic and stand scale ecological factors are used (e.g. in UNESCO classification) is solved here due to the modular approach, i.e. it is possible to classify montane swamps under various climates and with various lithologies. Nevertheless, the USGS does not provide a solution to integrate the descriptions of individual stands (local scale). The back and forth observed in Sayre and collaborators' work regarding, for example, levels of details for landforms or lithologies are symptomatic of confusions between typology of ecosystem types (diagnostic landforms) and description of individual stands (descriptive landforms).
6. Landform is finally considered (unlike in UNESCO and USNVC / IVC classifications) but its conceptualization is inappropriate. For example, "hills", "high mountains", "low mountains" are more typically landscape descriptors, not stand scale descriptors. In other words, the possible states proposed for the character landform are not bioecological, i.e. they are describing a landscape rather than modeling the correlation between vegetation and local landform. Hills, low and high mountains can have overdrained landforms, wet ravines, swampy basins, etc., which better explain climax vegetation physiognomy and species distribution than the overall landscape landform (Figure 21).
7. Coastal gradients are completely ignored (no coastal 'classifiers'). The Macrogroups mentioned in 2013 and bearing the term "coastal" or "littoral" (e.g. 6.A.1.Fc.2-Atlantic African Coastal Dune and 1.A.2.Fd4. Guineo-Congolian Littoral Rainforest) are either truly coastal ecosystems interpreted by expert knowledge (the former) or confusions with maritime climate (the latter). Subsequently, e.g. in Sayre et al. (2014: 43), coastal ecosystems are explicitly excluded from the typology and left for future studies.
8. Aquatic vegetation is not mixing micro-ecosystems (as it was the case in UNESCO and USNVC / IVC classifications) but is now oversimplified, i.e. "Surface Water".
9. Biogeographic and biotic communities are integrated but inconsistently and too rigidly, using either ecoregions (Sayre et al. 2013) or biogeographic realms (Sayre et al. 2020a). By too rigidly, we mean that biogeography might not be the same 'classifier' (modular component according to Sayre et al. 2013) for all generic types of ecosystems. For example, mangroves might have a biogeographic pattern more in the form of Atlantic vs. Indo-Pacific than Neo- vs. Palaeo-tropics (see also discussion in [4] regarding the artificiality of ecoregions seen as 'discreet entities', which is analogous to the conceptualization of plant communities as discreet entities as opposed to entanglements of ecological groups).
10. Dynamics of ecosystems seems a priori to be accounted for, because of the dual mapping representing both the actual and the potential natural ecosystem distribution (Sayre et al. 2020a). However, in fact, the focus is only on anthropic disclimaxes (settlements and croplands) and is aimed at assessing the extent of losses of natural ecosystems. Therefore, no distinction is made between a perhumid grassland on an ironstone outcrop (bowal) and one corresponding to a pyrophilic disclimax, both being treated as "Tropical Moist Grassland on Plains" (Sayre et al. 2020a). To understand precisely why it is essential to interpret properly disclimaxes in a context of ecosystem typology, we suggest reading the discussion in Senterre et al. (2019: 31). Secondly, USGS typology is mostly driven by mapping objectives. Therefore, secondary series are not considered which makes it impossible to describe the development state of individual stands, and therefore prevent a complete integration of the local scale.



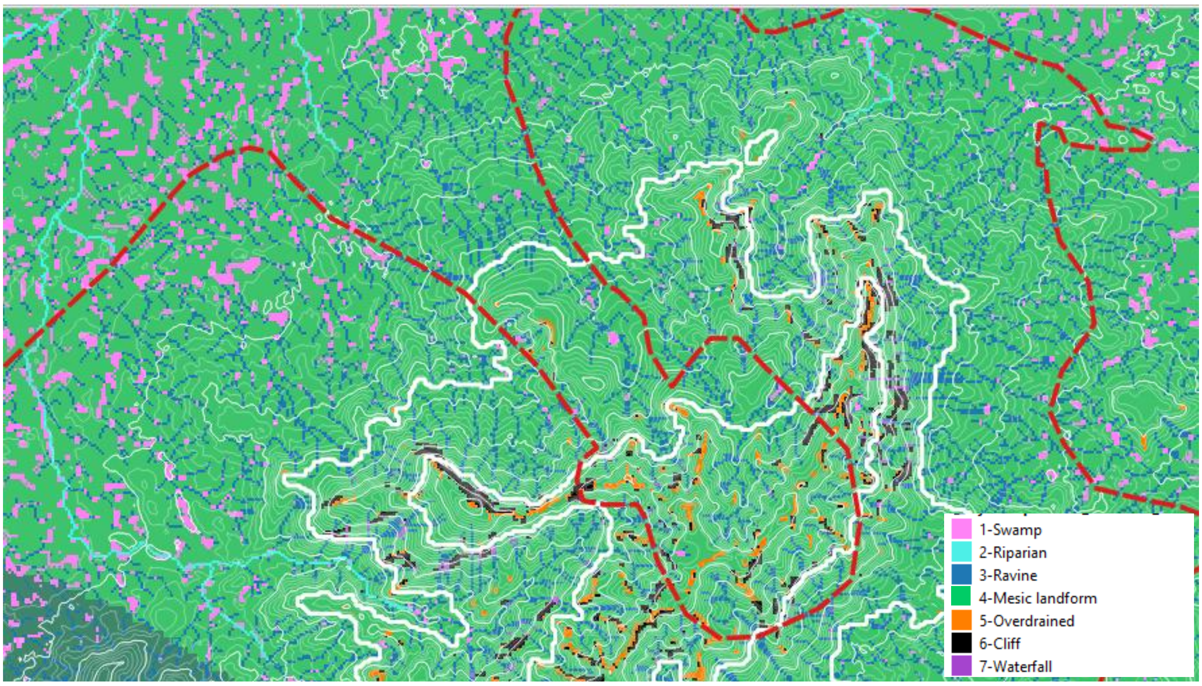


Figure 21. Comparison of the "landform" classifier as defined by Sayre et al. (2013) and Senterre et al. (2020), here given in example for the northern part of the Mount Nimba (Guinea). Sayre's typology corresponds more to a landscape attribute, also mixing aspects related to bioclimates. High mountains, low mountains as well as hills are landscapes that can have some stands in overdrained ridges, wet ravines or riparian conditions, which are much more relevant for modeling of vegetation because more directly related to topographic wetness.

Table 9. Synthetic table presenting the correspondences between our approach and the most widely used global standards.

eco-sp	eco-genus	life zone	UNESCO 1973	IUCN 2012-2016	Faber-Langendoen 2012-2016[a] / Sayre et al. 2013[b]	Sayre et al. 2014-2020
[1]	Coastal backshore hyperhaline dwarf mangrove forest	T.low. superh.	I.A.5. Mangrove forests	1.7. Forest – Subtropical/tropical mangrove vegetation above high tide level	1.A.5.Ua1. Atlantic Ocean Mangrove	Hot Wet Plains on Unconsolidated Sediment with Swampy or Often Flooded Vegetation
[2]	Coastal backshore hyperhaline grassland on muddy soil (back of mangrove)	T.low. superh.	V.E.2.a.(2). Salt meadows Poor in succulents	4.5. Grassland – Subtropical/tropical dry	2.B.7.Fh1. Tropical African Coastal Salt Marsh	Hot Wet Plains on Unconsolidated Sediment with Grassland, Scrub, or Shrub
[3]	Coastal backshore tidal estuarine backshore/sheltered mangrove forest	T.low. superh.	Idem [1]	Idem [1]	Idem [1]	Idem [1]
[4]	Coastal backshore tidal freshwater lake	T.low. superh.	-	13.4 Coastal Brackish/Saline Lagoons/Marine Lakes	8.A. Lake[a]	Surface Water
[5]	Coastal frontshore sandy beach	T.low. superh.	VI.B.2. Bare sand dunes	12.2 Sandy Shoreline and/or Beaches, Sand Bars, Spits, etc.	6.A.1.Fc2. Atlantic African Coastal Dune[b]	Hot Wet Plains on Unconsolidated Sediment with Bare area
[6]	Coastal frontshore sandy beach open vegetation	T.low. superh.	VI.B.1.c. Forb dune	Idem [5]	Idem [5]; 2.A.3. Tropical Scrub & Herb Coastal Vegetation[a]	Idem [2]
[7]	Coastal backshore dunes shrubland	T.low. superh.	IV.A.2.b. Evergreen mosaic dwarf-shrubland	13.3 Coastal Sand Dunes	Idem [6]	Idem [2]
[8]	Coastal backshore dunes grassland	T.low. superh.	Idem [6]	Idem [7]	Idem [6]	Idem [2]
[9]	Coastal backshore forest fringe on sandy beach	T.low. superh.	I.A.1.a. Tropical ombrophilous lowland forest	1.6. Forest – Subtropical/tropical moist lowland	-	Hot Wet Plains on Unconsolidated Sediment with Mostly Needleleaf/Evergreen Forest
[10]	Inland stream	T.low. perh.	-	5.1. Wetlands (inland) – Permanent rivers/streams/creeks (includes waterfalls)	-	-
[11]	Inland stream	T.subm. perh.	-	Idem [10]	-	-
[12]	Inland stream	T.low.h.	-	Idem [10]	-	-
[13]	Inland stream	T.subm.h.	-	Idem [10]	-	-
[14]	Inland stream	T.mont.h.	-	Idem [10]	-	-
[15]	Inland river	T.low. superh.	-	Idem [10]	-	Idem [4] (Surface Water)
[16]	Inland river	T.low.perh.	-	Idem [10]	-	Idem [4] (Surface Water)
[17]	Inland river	T.low.h.	-	Idem [10]	-	Idem [4] (Surface Water)
[18]	Inland waterfall	T.low.perh.	-	Idem [10]	-	-
[19]	Inland waterfall	T.subm.h.	-	Idem [10]	-	-
[20]	Inland waterfall	T.mont.h.	-	Idem [10]	-	-
[21]	Inland pool	T.low. superh.	-	5.7. Wetlands (inland) – Permanent freshwater marshes/pools (under 8 ha)	-	Idem [4] (Surface Water)
[22]	Freshwater marsh	T.low.	V.D.1.a. Tall-sedge swamp	Idem [21]	2.A.5.Fc1. African Tropical	Hot Wet Plains on Non-Defined with

eco-sp	eco-genus	life zone	UNESCO 1973	IUCN 2012-2016	Faber-Langendoen 2012-2016[a] / Sayre et al. 2013[b]	Sayre et al. 2014-2020
		superh.			Freshwater Marsh (Dembos)[b]	Swampy or Often Flooded Vegetation; Hot Wet Hills on Non-Defined with Swampy or Often Flooded Vegetation
[23]	Freshwater marsh	T.low.perh.	Idem [22]	Idem [21]	Idem [22]	Idem [22]
[24]	Seasonal marsh on ironstone rock sheet	T.low.h.	V.D.1.b. Low-sedge swamp	5.8. Wetlands (inland) – Seasonal/intermittent freshwater marshes/pools (under 8 ha)	-	Hot Wet Plains on Non-Carbonate Sedimentary Rock with Swampy or Often Flooded Vegetation; Hot Wet Hills on Non-Carbonate Sedimentary Rock with Swampy or Often Flooded Vegetation
[25]	Seasonal marsh on ironstone rock sheet	T.subm.h.	Idem [24]	Idem [24]	-	Hot Wet Mountains on Non-Carbonate Sedimentary Rock with Swampy or Often Flooded Vegetation
[26]	Seasonal marsh on ironstone rock sheet	T.mont.h.	Idem [24]	Idem [24]	-	Idem [25]
[27]	Freshwater swamps	T.low. superh.	I.A.1.g. Tropical ombrophilous swamp forest: I.A.1.g.(1). Dominated by Dicots; I.A.1.g.(2). Dominated by Palms	1.8. Forest – Subtropical/tropical swamp	1.A.4.Fg1. Anthostema - Alstonia Swamp Forest[b]; 1.A.4.Fg2. Raphia Swamp[b]; 1.A.4.Fh3. West African Mitragyna Riverine Forest[b]	Idem [22]
[28]	Freshwater swamps	T.low.perh.	Idem [27]	Idem [27]	Idem [27]	Idem [22]
[29]	Freshwater swamps	T.subm. perh.	Idem [27] I.A.1.g.(1).; I.A.1.b. Tropical ombrophilous submontane forest	Idem [27]	1.A.4.Fh3. West African Mitragyna Riverine Forest[b]	Hot Wet Mountains on Non-Defined with Swampy or Often Flooded Vegetation
[30]	Freshwater swamps	T.low.h.	Idem [27]	Idem [27]	Idem [27]	Idem [22]
[31]	Freshwater swamps	T.subm.h.	Idem [29]	Idem [27]	Idem [29]	Idem [29]
[32]	Seasonal swamp on ironstone rock sheet	T.mont.h.	Idem [27] I.A.1.g.(1).; I.A.1.c.(1). Tropical ombrophilous montane forest, Broad-leaved	Idem [27]; 1.9. Forest – Subtropical/tropical moist montane	1.A.4.Fg. Guineo-Congolian Swamp Forest	Hot Wet Mountains on Mixed Sedimentary Rock with Swampy or Often Flooded Vegetation
[33]	Riparian forest on alluvial soil	T.low. superh.	I.A.1.f. Tropical ombrophilous alluvial forest	Idem [27]	1.A.4.Fh2. Uapaca heudelotii Forest[b]	Hot Wet Plains on Non-Defined with Swampy or Often Flooded Vegetation
[34]	Riparian forest on alluvial soil	T.low.perh.	Idem [33]	Idem [27]	Idem [33]	Idem [33]
[35]	Riparian forest on alluvial soil	T.low.h.	Idem [33]	Idem [27]	Idem [33]	Idem [33]
[36]	Pyrophilic disclimax herb-savanna on mesic landform	T.low.h.	V.A.1.b Tall-grass savanna with isolated trees (tree savanna); V.A.1.d. Tall-grass savanna (grass savanna)	4.5. Grassland – Subtropical/tropical dry	2.A.1.Ff2. Western African Mesic Woodland & Grassland[b]	Hot Wet Plains on Non-Defined with Grassland, Scrub, or Shrub; Hot Wet Hills on Non-Defined with Grassland, Scrub, or Shrub
[37]	Pyrophilic disclimax herb-savanna on mesic landform	T.subm.h.	Idem [36]	Idem [36]	Idem [36]	Hot Wet Mountains on Non-Defined with Grassland, Scrub, or Shrub
[38]	Pyrophilic disclimax herb-savanna on mesic landform	T.mont.h.	Idem [36]	Idem [36]	Idem [36]	Idem [37]
[39]	Mesic forest	T.low. superh.	Idem [9] (Tropical ombrophilous lowland forest)	Idem [9] (Forest – Subtropical/tropical moist	1.A.2.Fd4. Guineo-Congolian Littoral Rainforest	Hot Wet Plains on Non-Defined with Mostly Needleleaf/Evergreen Forest; Hot

eco-sp	eco-genus	life zone	UNESCO 1973	IUCN 2012-2016	Faber-Langendoen 2012-2016[a] / Sayre et al. 2013[b]	Sayre et al. 2014-2020
				lowland)		Wet Hills on Non-Defined with Mostly Needleleaf/Evergreen Forest
[40]	Mesic forest	T.low.perh.	Idem [9]	Idem [9]	1.A.2.Fd1 Guineo-Congolian Evergreen Rainforest	Idem [39]
[41]	Mesic forest	T.subm. perh.	I.A.1.b. Tropical ombrophilous submontane forest	Idem [9]	1.A.3.Ff4. Moist Evergreen Montane Forest	Hot Wet Mountains on Non-Defined with Mostly Needleleaf/Evergreen Forest
[42]	Mesic forest	T.mont. perh.	I.A.1.c.(1). Tropical ombrophilous montane forest, Broad-leaved	1.9. Forest – Subtropical/tropical moist montane	1.A.3.Ff2. Afromontane Mesic Forest	Idem [41]
[43]	Mesic forest	T.low.h.	I.A.2.a. Tropical (or subtropical) evergreen seasonal lowland forest	Idem [9]	1.A.2.Fd2 Guineo-Congolian Semi-Evergreen Rainforest	Idem [39]
[44]	Mesic forest	T.subm.h.	I.A.2.b.(1). Tropical (or subtropical) evergreen seasonal submontane forest, Boad-leaved, most common form	Idem [9] (n.b.: submontane included into lowland)	Idem [41] (n.b.: submontane included into montane)	Idem [41]
[45]	Mesic forest	T.mont.h.	I.A.2.c. Tropical (or subtropical) evergreen seasonal montane forest	Idem [42]	Idem [42]	Idem [41]
[46]	Overdrained forest	T.low. superh.	Idem [9]	Idem [9]	Idem [39]	Hot Wet Hills on Non-Defined with Mostly Needleleaf/Evergreen Forest
[47]	Overdrained forest	T.low.perh.	Idem [9]	Idem [9]	Idem [40]	Idem [46]
[48]	Overdrained forest	T.subm. perh.	Idem [41]	Idem [9]	Idem [41]	Idem [41]
[49]	Overdrained forest	T.mont. perh.	Idem [42]	Idem [42]	Idem [42]	Idem [41]
[50]	Overdrained forest	T.low.h.	Idem [43]	Idem [9]	Idem [43]	Idem [46]
[51]	Overdrained forest	T.subm.h.	Idem [44]	Idem [9]	Idem [41]	Idem [41]
[52]	Overdrained forest	T.mont.h.	Idem [45]	Idem [42]	Idem [42]	Idem [41]
[53]	Granite rock	T.low.h.	VI.A.1. Scarcely vegetated rocks	6. Rocky Areas (e.g., inland cliffs, mountain peaks)	6.A.1.Fc6. Western African Inselberg Vegetation	Hot Wet Hills on Acidic Plutonics with Bare area
[54]	Granite rock	T.subm.h.	Idem [53]	Idem [53]	Idem [53]	Hot Wet Mountains on Acidic Plutonics with Bare area
[55]	Ironstone rock	T.mont.h.	Idem [53]	Idem [53]	-	Hot Wet Mountains on Non-Carbonate Sedimentary Rock with Bare area
[56]	Ultramafic rock	T.mont.h.	Idem [53]	Idem [53]	-	Hot Wet Mountains on Metamorphic Rock with Bare area
[57]	Saxicolous open vegetation on granitic outcrops	T.low.perh.	IV.A.2.b. Evergreen mosaic dwarf-shrubland; V.A. Savannas and related grasslands	3.6. Shrubland – Subtropical/tropical moist; 4.5. Grassland – Subtropical/tropical dry	Idem [53]	Hot Wet Hills on Acidic Plutonics with Grassland, Scrub, or Shrub
[58]	Saxicolous open vegetation on granitic outcrops	T.subm. perh.	Idem [57]	Idem [57]	Idem [53]	Hot Wet Mountains on Acidic Plutonics with Grassland, Scrub, or Shrub

eco-sp	eco-genus	life zone	UNESCO 1973	IUCN 2012-2016	Faber-Langendoen 2012-2016[a] / Sayre et al. 2013[b]	Sayre et al. 2014-2020
[59]	Saxicolous open vegetation on granitic outcrops	T.mont. perh.	Idem [57]	3.7. Shrubland – Subtropical/tropical high altitude; 4.7. Grassland – Subtropical/tropical high altitude	Idem [53]	Idem [58]
[60]	Saxicolous open vegetation on granitic outcrops	T.low.h.	IV.B.2.b. Drought-deciduous creeping or matted dwarf-thicket	Idem [57]	Idem [53]	Idem [57]
[61]	Saxicolous open vegetation on granitic outcrops	T.subm.h.	Idem [57]	Idem [57]	Idem [53]	Idem [58]
[62]	Saxicolous open vegetation on granitic outcrops	T.mont.h.	Idem [57]	Idem [59]	Idem [53]	Idem [58]
[63]	Saxicolous open vegetation on ironstone outcrops	T.low.h.	V.B.1.c. Tall-grass steppe without woody plants	4.5. Grassland – Subtropical/tropical dry	-	Hot Wet Hills on Non-Carbonate Sedimentary Rock with Grassland, Scrub, or Shrub
[64]	Saxicolous open vegetation on ironstone outcrops	T.subm.h.	Idem [63]	Idem [63]	-	Hot Wet Mountains on Non-Carbonate Sedimentary Rock with Grassland, Scrub, or Shrub
[65]	Saxicolous open vegetation on ironstone outcrops	T.mont.h.	Idem [63]	4.7. Grassland – Subtropical/tropical high altitude	-	Idem [64]
[66]	Saxicolous open vegetation on ultramafic outcrop	T.mont.h.	Idem [63]	Idem [65]	-	Hot Wet Mountains on Metamorphic Rock with Grassland, Scrub, or Shrub
[67]	Subsaxicolous dwarf forest on granitic outcrop	T.low.perh.	Idem [43] (I.A.2.a. Tropical (or subtropical) evergreen seasonal lowland forest)	1.5. Forest – Subtropical/tropical dry	Idem [53]	Hot Wet Hills on Acidic Plutonics with Mostly Needleleaf/Evergreen Forest
[68]	Subsaxicolous dwarf forest on granitic outcrop	T.subm. perh.	Idem [44]	Idem [67]	Idem [53]	Hot Wet Mountains on Acidic Plutonics with Mostly Needleleaf/Evergreen Forest
[69]	Subsaxicolous dwarf forest on granitic outcrop	T.mont. perh.	Idem [42]	1.5. Forest – Subtropical/tropical dry ; 1.9. Forest – Subtropical/tropical moist montane	Idem [53]	Idem [68]
[70]	Subsaxicolous dwarf forest on granitic outcrop	T.low.h.	Idem [43]	Idem [67]	Idem [53]	Idem [67]
[71]	Subsaxicolous dwarf forest on granitic outcrop	T.subm.h.	Idem [44]	Idem [67]	Idem [53]	Idem [68]
[72]	Subsaxicolous dwarf forest on granitic outcrop	T.mont.h.	Idem [42]	Idem [69]	Idem [53]	Idem [68]
[73]	Subsaxicolous dwarf forest on ironstone outcrop	T.low.perh.	Idem [43]	Idem [67]	-	Hot Wet Hills on Non-Carbonate Sedimentary Rock with Mostly Needleleaf/Evergreen Forest
[74]	Subsaxicolous dwarf forest on ironstone outcrop	T.subm. perh.	Idem [44]	Idem [67]	-	Hot Wet Mountains on Non-Carbonate Sedimentary Rock with Mostly Needleleaf/Evergreen Forest
[75]	Subsaxicolous dwarf forest on ironstone outcrop	T.mont. perh.	Idem [42]	Idem [69]	-	Idem [74]
[76]	Subsaxicolous dwarf forest on ironstone	T.low.h.	Idem [43]	Idem [67]	-	Idem [73]

eco-sp	eco-genus	life zone	UNESCO 1973	IUCN 2012-2016	Faber-Langendoen 2012-2016[a] / Sayre et al. 2013[b]	Sayre et al. 2014-2020
	outcrop					
[77]	Subsaxicolous dwarf forest on ironstone outcrop	T.subm. h.	Idem [44]	Idem [67]	-	Idem [74]
[78]	Subsaxicolous dwarf forest on ironstone outcrop	T.mont.h.	Idem [42]	Idem [69]	-	Idem [74]
[79]	Saxicolous ravine grassland on ironstone	T.low.h.	Idem [63] (V.B.1.c. Tall-grass steppe without woody plants)	Idem [63] (4.5. Grassland – Subtropical/tropical dry)	-	Idem [63] (Hot Wet Hills on Non-Carbonate Sedimentary Rock with Grassland, Scrub, or Shrub)
[80]	Saxicolous ravine grassland on ironstone	T.mont.h.	V.B.1.c. Tall-grass steppe without woody plants; V.A.2.c. Short-grass savanna (grass savanna)	Idem [65] (4.7. Grassland – Subtropical/tropical high altitude)	-	Idem [64] (Hot Wet Mountains on Non-Carbonate Sedimentary Rock with Grassland, Scrub, or Shrub)
[81]	Ravine forest	T.low. superh.	Idem [9] (Tropical ombrophilous lowland forest)	Idem [9] (Forest – Subtropical/tropical moist lowland)	Idem [39] (1.A.2.Fd4. Guineo-Congolian Littoral Rainforest)	Hot Wet Hills on Non-Defined with Mostly Needleleaf/Evergreen Forest
[82]	Ravine forest	T.low.perh.	Idem [9]	Idem [9]	Idem [40] (1.A.2.Fd1 Guineo-Congolian Evergreen Rainforest)	Idem [81]
[83]	Ravine forest	T.subm .perh.	Idem [41] (I.A.1.b. Tropical ombrophilous submontane forest)	Idem [9]	Idem [41] (1.A.3.Ff4. Moist Evergreen Montane Forest)	Idem [41] (Hot Wet Mountains on Non-Defined with Mostly Needleleaf/Evergreen Forest)
[84]	Ravine forest	T.mont. perh.	Idem [42] (I.A.1.c.(1). Tropical ombrophilous montane forest, Broad-leaved)	Idem [42] (1.9. Forest – Subtropical/tropical moist montane)	Idem [42] (1.A.3.Ff2. Afromontane Mesic Forest)	Idem [41]
[85]	Ravine forest	T.low.h.	Idem [43] (I.A.2.a. Tropical (or subtropical) evergreen seasonal lowland forest)	Idem [9]	Idem [43] (1.A.2.Fd2 Guineo-Congolian Semi-Evergreen Rainforest)	Idem [39]
[86]	Ravine forest	T.subm.h.	Idem [44] (I.A.2.b.(1). Tropical (or subtropical) evergreen seasonal submontane forest, Boad-leaved, most common form)	Idem [9] (n.b.: submontane included into lowland)	Idem [41] (n.b.: submontane included into montane)	Idem [41]
[87]	Ravine forest	T.mont.h.	Idem [45] (I.A.2.c. Tropical (or subtropical) evergreen seasonal montane forest)	Idem [42]	Idem [42]	Idem [41]

IV.2 The nature of ecosystems, their typology and conservation

IV.2.1 Recapitulation of the main existing typologies and their issues

In the previous chapter, we have presented the dominant global ecosystem typologies along with their history. We have explained that they all present a number of issues that prevent concretely the conceptualization of types of ecosystems from the global to the local scales. All hierarchical systems (UNESCO, IUCN, USNVC, IVC) inconsistently mix ecosystems of different spatial scales: for example, 1.A.2. Tropical Lowland Humid Forest (life zone scale, i.e. regional scale), 1.A.4. Tropical Flooded & Swamp Forest (stand scale), 5.A.2. Benthic Macroalgae Saltwater Vegetation (within stand scale, i.e. micro-ecosystem scale). In all these classification systems, the focus is not on the scale but rather on the most dominant limiting factor. However, the problem is that limiting factors may or may not be limiting, depending on their context. Therefore their position in a complicate hierarchy cannot be something determined or stable. This obvious but mostly untold difficulty to deal with scales was addressed by others using partly (Di Gregorio 2005) or totally modular, i.e. non-hierarchical, systems (Sayre et al. 2013, 2014, 2020ab). In both cases, the other major issue is related to the ontology of all the constitutive factors used in the hierarchical or modular system. For example, do we need to recognize many climatic wetness classes (Sayre et al. 2013) or just a few basic ones (Sayre et al. 2020), detailed landforms (Grossman et al. 1998) or more general ones (Sayre et al. 2013), etc.? In addition, the relative importance of biotic communities compared to abiotic factors has also been a major source of variability between classification systems. Sometimes biogeography and biotic communities are excluded (UNESCO, Sayre et al. 2014), sometimes they are considered only after having dealt with abiotic factors (USNVC: Grossman et al. 1998), and sometimes they are mixed with some local abiotic factors at the lower levels of the hierarchy (IVC: Faber-Langendoen et al. 2013).

IV.2.2 Recent recommendations by the IUCN for RLE and KBA assessments

Although the IUCN guidelines for the Red Listing of Ecosystems (Bland et al. 2015: 8–9) recommended using intermediate levels of the IVC (Macrogroups), it implicitly admitted some limitations by announcing that they were working on the development of an improved global ecosystem typology "guided by recent research on classifications of terrestrial vegetation (Faber-Langendoen et al. 2014)", i.e. IVC. In 2019, IUCN's work in progress was briefly revealed by defining the six levels of a new hierarchic classification system (KBA Standards and Appeals Committee 2019: 59). Surprisingly, from the description given in 2019, this developing classification system seemed to have only limited similarity with the IVC. The main difference with the IVC was the return to a system where biotic aspects are considered at the last three levels of the hierarchy (L4 to L6) separately from abiotic factors (L1 to L3). It seemed to differ from the UNESCO classification by not focusing on the observed vegetation physiognomy, and from the USNVC early version (1998) by regrouping stand scale factors into one level (L3: "Functional group") which is subordinate to what appeared to be closer to the concept of life zones (L2: "Biome").

At the time we first drafted the current report, the developing new IUCN classification system seemed in fact to present a lot of similarity with our own approach. The level 3 (L3: "Functional group") would correspond to our "eco-genera" and the level 4 (L4: "Biogeographic functional type") would correspond to our "eco-species", while the levels 5 and 6 (L5: "Ecosystem type"; L6: "Local ecosystem type") corresponded to a bottom-up classification of plant communities according to biotic similarity (phytosociology, which we largely consider here as ecosystem development stages or inter-individual stand variability). Therefore, considering that the KBA Standards and Appeals Committee (2019: 59) recommended the use of their level 4 (L4, i.e. equivalent to our "eco-species") for Red Listing of Ecosystems and KBA assessments with ecosystem criteria, we consider our conceptual approach of ecosystemology at the level of eco-species (Senterre et al. in review) as appropriate according to the IUCN guidelines, even if at first sight our approach appears to be overly detailed compared to other existing classification systems.

More recently (during the finalization of the current report), the newly developing IUCN classification system has been reveiled in more details (Murray et al. 2020). The formal publication of this new approach seems to be coming soon (Keith et al., in review, not seen but cited in Murray et al. 2020) and, when available, we will need to discuss it from the point of view of our own approach. The major difference with our approach is likely to be related to the concept of relative spatial scales (providing a natural distinction between life zone and stand scale characters) and relative time scales (allowing to conceptualize primary series as stand scale drivers but secondary series as individual stand characters). We also expect differences in the way to deal with landforms (topographic wetness vs. landscape descriptor vs. not considered), coastal gradients (and interactions with hydromorphy gradients) and with the ontology of life zones (number of temperature zones, latitudinal-altitudinal integration, and number of climatic wetness zones). Finally, unlike in the level 6 being proposed by the IUCN (in KBA Standards and Appeals Committee 2019), we do not advocate for a rigid consideration of biogeography through the only consideration of global ecoregions. For example, the biogeography of pyrophilic disclimax savannas (see [38]) might not be the same as the biogeography of perhumid rain forests or the biogeography of mangroves, etc.

IV.2.3 When is a typology of ecosystems too detailed or too simplified?

In RLE, the use of "intermediate levels" of a global typology of ecosystems (Bland et al. 2015: 8–9; KBA Standards and Appeals Committee 2019: 59) is mostly motivated by the instability of the agglomerative part (lower levels) of those typologies, the untold difficulty to manage synonymies of plant communities (across countries and authors), and the difficulty to manage a large number of entities with limited distribution data. In the modular system of USGS, the hesitation on the inclusion or not of biogeography and on the resolution level of classifiers' ontologies is also motivated by the aspect of manageability of ecosystem units to be mapped (number of types). Therefore, we need to ask the question: Does our hierarchical-modular approach recognize an excessive number of ecosystem species that sometimes differ only slightly? This question is pertinent and intuitively we are inclined to reject distinctions such as rivers of perhumid zone vs. rivers of superhumid zone, or rock of lowland perhumid zone vs. rock of montane perhumid zone. However, intuition is not always the greatest tool in science, and we need to control it with reasoning. The ecosystem types that seem particularly superfluous are those driven by extreme limiting factors, especially for non-aquatic organism. For example, how can we possibly consider exposed bare granite rock surfaces of inselbergs from the Ziama foothill, Ziama summit, Equatorial Guinea or the Seychelles as being distinct types of ecosystems when they cannot be distinguished based on biotic characters or their lithology?

Why do we distinguish lowland vs. montane rain forests, or ravine vs. mesic forests, etc.? We do so because these environmental differences correspond to biological differences that we see in the field. In other words, regardless of the species involved and whether or not they form communities, lowlands and mountains, or ravines and mesic lands tend to have a species turnover that is higher than one due to chance only. Thus, if we explored all mesic stands of a given study area, we could expect to have missed a number of species that are more typically found in ravines. Therefore, the ecosystem approach consists in modeling the environment as we see it through the prism of species and macroscopic abiotic factors. It is not a purely descriptive approach to the environment, distinguishing middle slope ravines, upper slope ravines, deep ravines, very deep ravines, etc., which have no obvious effect on species distribution (visible to us). It is not an ecological description (e.g. descriptive landforms, rock types, etc.) but a bioecological model (diagnostic landforms, lithologies, etc.). Then, again, why would we distinguish lowland vs. montane bare rock surfaces since no biotic difference is observed? In addition, if we decided to have absolutely no interest in plants, and we were paying attention only to microbes, would we really distinguish ravines from mesic landforms, etc.? In that case, we would probably model the environment according to things such as understorey humus, tree trunks, canopies, etc. (Compant et al. 2019), and lowland vs. montane bare rocks would probably end up looking much more different (Bryant et al. 2008). If we now become bird lovers, again, ravines vs. mesic landforms will not matter much, and we will be looking more likely at broader scales (e.g. landscapes). We conclude that all bioecological referentials are relative, i.e. types of environments as seen from the eyes of microbes, or plants, birds, or others. Yet, the Yangambi classification and other ecosystem typologies are more based on a botanical point of view than anything else. 'Local' vegetation types, as seen by us, are characterized by their phytocoenosia rather than by their microbiocoenosia or avicoenosia. This bias in favour of plants is related to our very nature as humans. If we were the size of ants, our modeling of ecosystems would be different to what it is now. However, the fact that our choice appears subjective does not mean that the modeled environment is an artifact. Our size is what it is and it explains our dominant interest to what we called the stand scale. Consequently, our choice for phytocoenosia rather than microbiocoenosia or avicoenosia is not as subjective and artificial as it seems. It just so happens that plants are, in general, better indicators of the ecological diversity of stand scale ecosystems. Although the distinction between ravines and mesic landforms means little for bacteria, we distinguish those bioecological landform categories based on the best indicators at that scale[3]. In addition, plants also happen to be good indicators of climatic gradients and therefore we use them again to model gradients such as climatic wetness or altitudinal belts. For example, by observing plants and vegetation, it is possible to recognize altitudinal belts on a given mountain range. In addition, just like we do not look primarily at bacteria to recognize types of stand scale ecosystems, we also do not look primarily at bare rock surfaces to recognize altitudinal belts. However, the environmental gradient modeled by looking at plants is real. Only its referential is subjective. The altitudinal belts described by looking at plants and vegetation are real and they correspond to gradients of temperature, wetness, insulation, etc., that act upon bacteria just like they act upon plants. From a bacteria, a micro-invertebrate or a bird point of view, we might probably model the reality of altitudinal belts differently, using different classes, but it would still be the same gradient. In conclusion, because we have observed that lowland and montane belts represent contrasted environments based on observation of plants in mesic conditions, we can consider that bare rocks of the lowland vs. montane belts represent different types of ecosystems, even though we do not know a priori if microalgae, cynaobacteria and endolithic microbial communities are different between the lowland and montane belts. Even if the rock surfaces given in our example had no (biological) species at all on them, we could still expect that their 'chemical species' and chemistry would be influenced by temperature and moisture. Or, in yet other words, if we

[3] Note that in the same example, not all plants have the same potential utility as indicators. Important landform variations (topographic wetness) are often better identified by using understorey herbs and shrubs rather than canopy trees. This is due to larger root systems of trees (compared to size of ravines for example) and also longer life spans.

think of the exciting "Mars 2020 Perseverance Rover" project by the Nasa, looking for life or traces of its past presence on the planet Mars, the way the landing site has been selected is totally in the same kind of approach as the one suggested here, i.e. recognizing the Jezero Crater as a very special kind of ecosystem (although so far devoid of known life). Ecosystems are defined based on our knowledge of life and its relations to abiotic factors, even in situations where life might not exist, yet/anymore.

Following the same reasoning, we suggest that all so-called "azonal" vegetation types at the stand scale such as bare rocks, water bodies, streams, mangroves, swamps, etc., are under the dependency of the same bioclimatic gradients based on latitudinal belts, altitudinal belts and zones of climatic wetness. The more limiting the azonal factor (e.g. bare rock), the less macroscopic differences in biota are visible to humans. However, this does not mean that there are no differences. In fact, specialized studies on mangroves, swamps, inselbergs, streams have shown that they differ according to bioclimates. Note that it is possible to test predictions made from our model. For example, we predict the presence in the southern part of the Ziama of a riparian forest within the perhumid/humid submontane life zone (see top of Figure 14), which is likely unique in West Africa. Considering the known tendency for local plant endemism for both riparian and submontane environments, the ecosystem model recognizing submontane riparian forests also predicts the presence of species associated with that ecosystem and therefore possibly endemic to that area.

The simplification (as major classes of vegetation) of azonal vegetation types and extreme vegetation physiognomies such as tropical savannas, overriding bioclimatic effects such as climatic wetness, is the result of deeply rooted principles developed more than a century ago and related to the law of the minimum (Rübel 1935). However, when applying the law of the minimum, it is important to look at regional scale and stand scale factors differently. In an arid bioclimate, there might be no ecosystemic distinction between a mesic landform and an overdrained ridge (at least from a topographic wetness point of view, since there is almost no wetness). However, the reverse is not true. An arid stand condition, such as a rocky outcrop on a ridge, cannot be considered as identical under different bioclimates, even if vegetation (there is none) and lithology are a priori the same. Stand scale limiting factors can cancel out the effect of other stand scale factors (such as landform), which results in the impossibility to build a hierarchy of stand scale factors (i.e. the issues of typologies derived from Yangambi), but they cannot cancel out the effects of factors acting at a higher level of ecosystemic integration (we could call this the "general law of the minimum").

Regarding the ontology of life zones, one needs to recognize the analogy in the temperature gradient of latitudinal zones and tropical altitudinal zones. We also have to understand that various combinations of latitudinal and altitudinal belts resulting in the same bioclimatic temperature zone still represent distinct life zones because of other factors related to latitudinal belts such as insulation. Therefore, we prefer the system proposed by Holdridge (1967) to those used more recently in global typologies of vegetation.

IV.2.4 What biogeographic units for the recognition of eco-species?

After admitting that bioclimates act as ecological drivers for all stand scale ecosystems (even azonal ones), we still have to ask if the ecoregions that we see mostly based on plants and vertebrates apply in the same way to all types of ecosystems? In other words, what is the biogeography of, for example, 'bare granite rock surfaces of perhumid montane zones'? In this study, we have considered the usual ecoregions for "West African" bare rock ecosystems, but not for "African" pyrophilic disclimax savannas (see [38]) and not for "Atlantic" mangroves

([1], [3]). Another way to investigate this question comes by imagining the situation of, for example, micro-ecosystems of a forest stand, such as canopy or soil biota. Considering that some stand scale ecosystems of small absolute spatial scale (e.g. inselbergs' ponds) have sometimes been confused with "micro-ecosystems" (as defined according to our approach based on relative scales), the question of the biogeography of micro-ecosystems within forest stands is a rich analogy. Because those micro-ecosystems are stuck with their context, i.e. are under the dependency of the biogeoclimatic factors of the forest stand ecosystem that they are in, the first biogeographic hypothesis would be to assume the same biogeography as for the stand scale ecosystem (i.e. same biogeographic model for canopy and understorey of a given stand scale ecosystem type). But if we dig deeper, what is then the biogeography of the so-called Deep Biosphere (Colman et al. 2017), i.e. the life that extends kilometers below the surface? At some point, the ecological determinism of the terrestrial surface ecosystems must vanish. Climatic wetness and temperature will be replaced by just wetness and temperature, and other things. Dispersal opportunities and drivers will also change. Marine and atmospheric biogeography can provide an insight on alternatives to terrestrial biogeography, based on other ecological and dispersal determinants. This leads to the question of what is really biogeography, from an ecosystemology point of view (i.e. a hybrid between historical and ecological biogeography)? If we consider the biogeography of lakes, certainly, the results will be contrasted depending on what we look at, e.g. amphibians vs. birds vs. fishes. The same is true for biotic communities (i.e. a kind of fine grain biogeography of landscapes trying to identify stand scale biotic communities): birds would not be the greatest indicators and this is why stand scale ecosystems are generally studied in the field using plant communities. Therefore, biogeography investigates patterns of distribution of species on Earth, looking at whatever group of species that indicates more precisely the result of a complex interplay between history of life (all of it), current dispersal drivers and current environmental conditions (filtering what can effectively achieve dispersal as opposed to what fails to establish after a dispersal attempt). If a bird feeds exclusively on a plant species that is restricted to a given biogeographic region, then that bird (although it is a bird) is a biogeographic indicator. In other words, just like the 20th century debate on the nature of plant communities (Duvigneaud 1946), biogeographic units (ecoregions) might not be seen as discreet biotic entities but rather as entanglements of 'biogeoecological groups' of which the most developed or most characteristic one is used to describe and delineate the biogeographic unit. These elements of discussion explain why we consider bare rock surfaces as West African, on the first hand, but pyrophilic disclimax savannas as African, on the other. Bare rock surfaces, described in this study, have an archipelago-like distribution in an ocean of forests or non-rocky substrates. On the contrary, pyrophilic disclimax savannas have a belt-like distribution at the periphery of the Guineo-Congolian region, and therefore dispersal opportunities by contact represent a very different situation. The same reasoning applies to the mangroves, that we considered as "Atlantic" rather than "West African" or "African", because the dispersal opportunities are more driven by oceanic currents (like for marine biogeography) than by dispersal factors predominant for other terrestrial ecosystems.

IV.2.5 Conclusion on typology needs and a discussion of conservation priorities

In conclusion, our proposal to distinguish types of ecosystems (eco-species) based on distinct combinations of life zones and types of environmental conditions at the stand scale (eco-genera) is necessary, regardless of their biotic correlations in highly limiting environments such as bare rock surfaces, as long as the ontology of life zones and eco-genera is based on biotic correlations in non-limiting conditions (i.e. bioecologic ontologies rather than descriptive categorizations). Biogeographic hypothesis have to come last and will be more unstable due to current state of knowledge. The intuitive reluctance to accept distinct types of ecosystem that are biologically indistinct comes from our own nature as species. In the example above, if the various bare rocks of various bioclimates had no life on it, we would not care much about distinguishing them. If the same rock would now have a very rare rupicolous plant species in the montane belt of the Ziama, it would become already more exciting (and much more so than if the rare endemic species was just an endolithic microbe). If the ecosystem approach aims at complementing our species approach for the evaluation of conservation priorities, for example as a proxy for all species (those that we know and those that we do not know), then ecosystem conceptualization should not be governed by species compositions although, at the same time, it is defined based on bioecological considerations.

The conceptualization of ecosystems that we suggested requires rethinking slightly KBA assessments, and other assessments of conservation values based on red listing of ecosystems. Although we pretend that all species are equal, they are not. A KBA (regardless of how we name such a hot spot of biodiversity conservation value) cannot just be a site that holds an important population of a species that is threatened of extinction. For example, if a dangerous virus emerges (a situation not too difficult to imagine) and, after a lot of effort, we almost manage to eradicate it. The remaining sites where the now Critically Endangered virus would persist would certainly not trigger the KBA status. On the contrary, if site A and site B are perfectly homologous, each site containing one CR species with the similar threat level, one of them being a giant panda (a nice flagship mammal) and the other being a species of cockroach (no offence), then we suspect that the site with the cockroach will receive less attention (regardless of what is currently in the KBA guideline). Let us consider now our sites A and B having, in one case, a cockroach species resulting from a recent radiation (i.e. having a number of other closely related species elsewhere) and, in the other case, a palaeo-endemic species of cockroach, phylogenetically isolated, representing a monotypic family. Such considerations are currently missing from the KBA assessment, at least explicitly. Implicitly, common sense takes these things into account, for example when selecting taxonomic groups that are included in the assessments and field inventories. By analogy, special types of ecosystems that are threatened of collapse might not be major triggers of KBAs if they hold no special species (analogous to a species resulting of a recent radiation, and therefore holding no special genes) or if they do not represent flagship ecosystems (unlike for example, a rare or touristic rock formation). Finally, accounting for the flagship nature of biota can potentially contribute to bridge the gap between global and regional scales of KBA assessments (the regional scale methodology being under development by the KBA Standards and Appeals Committee) by accounting for the local conservation value attributed by humans at a national scale.

V. CONCLUSION

Ecosystemology

In this work (see III.1), we illustrate more deeply the ecosystemology approach that we described in Senterre et al. (in review). The work produced recently for Mount Nimba (Senterre et al. 2019a) predates the finalization of the paper (in review) presenting the method in its fullest and, although mostly in agreement with the principles of ecosystemology, it lacks the use of explicit synonymies by defining biotypes for names coming from the literature. This gap has been addressed here and ecosystem species have been named for all the studied KBAs.

In addition (see IV.1), we describe into more details the fundamental differences of our ecosystemology approach compared to the four main global typologies of ecosystem available. We develop this comparison regarding both fundamental concepts and pragmatic implications, detailing the correspondences between ecosystem types recognized.

Then (see IV.2), we further discuss the choice of an ecosystem resolution level for Red Listing of Ecosystems (RLE) and KBA assessment according to the available international guidelines. We first show that our approach is in line with IUCN guidelines. Then we provide arguments supporting the consideration of bioclimatic gradients to recognize types of ecosystems even within so-called azonal types (putting the law of the minimum into a broader context, i.e. more relativistic, more integrated across scales). Finally, we discuss briefly on how to integrate biogeography for the recognition of ecosystem species. Nevertheless, more has to be done to compile and integrate biogeography literature from the last 15 years, and to look at these from the angle of ecosystemology (where our approach could bring a contribution to unification of global to local scales, historical and ecological biogeography, biogeography and ecology).

The current study includes the first attempt of Red Listing of Ecosystems done at a regional scale for West Africa.

KBA assessment using ecosystem criteria (A2 & B4)

The KBAs included in the study area have been assessed under criteria A2 and B4, i.e. KBA containing 5% of the global distribution of a CR/EN type of ecosystem, 10% of a VU type of ecosystem or 20% of a type of ecosystem regardless of its threat level (Table 10).

Twenty one KBAs have already been recognized in the study area, which we grouped into 16 units (Table 10). Among them, those with the highest global ecosystem conservation value are the Nimba, the Ziama and the Wologizi KBAs, mostly due to submontane and montane perhumid ecosystems. For lowland perhumid ecosystems, the Lofa-Mano KBA (Liberia) is the most important site. If it could be merged with Kpelle Forest, it would give to the latter access to the status of Global KBA and both would contain nearly 10% of the global distribution of this ecosystem group. Gola and Kambui KBAs have limited value as global KBAs but have an outstanding conservation value for Sierra Leone. Ecosystems of the lowland humid life zone (considered as EN to CR mostly due to their reduction in distribution, with an historical reduction up to 93%: Senterre et al. 2019a: 66) are poorly represented within the study area, in terms of percentage of the currently remaining global distribution, with several forest blocks remaining mostly in Ghana. Note that considering the extreme fragmentation of this ecosystem group, hardly any KBA alone will likely hold the minimum 5% of global distribution, which is a bit unfortunate. KBAs of Mount Bero, Massif de Man and Pic de Fon are global KBAs mostly thanks to their ecosystems of the submontane and montane humid life zones, but they also include important remains of the lowland humid forest group (together with the northern parts of Ziama and Nimba). Finally, Lake Piso has an outstanding diversity of types of ecosystems, including several possibly unique and poorly explored.

Table 10. Synthesis of the results proposed for the KBA assessments using the ecosystemic criteria and suggestions for ecosystemic exploration priorities.

KBA code	KBA name	Global KBA status under A2 & B4	Exploration priorities
LIB10	Piso	B4([7],[8],[9])	Lowland superhumid mesic and ravine forests of Cape Mount; Coastal rocky shores of Cape Mount; Coastal backshore dunes, savannas and forests (see [7], [8] and [9]); Various types of swamp forests ([27]) especially peat swamps, if existing in the area.
SLE2	Kambui	-	Rupicolous vegetation on subsaxicolous dwarf forests
SLE1	Gola	-	Waterfalls, Inselbergs, Swamps, Ravines
SLE7	Tiwai	-	
LIB11	Lofa-Mano	A2a ([28])	Waterfalls, Inselbergs, Swamps, Ravines
LIB8	Kpelle	-	Could be grouped with Gola-Mano
LIB16	Wologizi	A2a ([41],[42],[74]), B4 ([41])	The few and hardly accessible remains of montane forests of Mount Wuteve having not burn; Large extent of submontane forests East of Mount Wuteve
LIB17	Wonegizi	A2a ([41]), B4 ([58],[68])	Submontane inselbergs
GIN8	Ziama	A2a ([41],[42]), A2b ([44]), B4 ([41],[44])	Riparian forests and swamps mapped in the submontane belt, at the southern limit of the humid climatic wetness zone; Submontane and montane belts of the perhumid and humid zones
GIN10	Fon	A2a ([25],[77],[78]), B4 ([25],[77],[78])	
GIN4	Bero	A2a ([31])	Submontane swamps
CIV7	Man	A2a ([31])	Submontane swamps
GIN9	Nimba	A2a ([42],[75],[84],[29],[41],[74],[20],[26]), A2b ([66]), B4 ([42],[75],[84],[20],[26],[66])	Dwarf forests on overdrained and subsaxicolous stands
LIB12			
CIV14			
CIV8			
LIB15	West Nimba	-	Could be grouped with Liberian Nimba LIB12
GIN2	Diécké	-	
fw4	Saint Paul River	-	
fw5			
fw11			

VI. LITERATURE CITED

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Annexes

Annex 1. Overview of the UNSECO classification and its representation in our study area.

Annex 2. Overview of NatureServe-FGDC classification and its representation in our study area.

Annex 1. Overview of the UNSECO classification and its representation in our study area. Formation classes (I, II, etc.) (7), subclasses (A, B, etc.) (28), groups (1, 2, etc.) (67), formations (a, b, etc.) (96), subformations ((1), (2), etc.) (72) and further subdivisions ((a), (b), etc.): total 225 entities regrouped into 6 hierarchic levels

Code	Name	This study (code in [])
I.	CLOSED FORESTS	
I.A.	Mainly evergreen forests	
I.A.1.	Tropical ombrophilous forests	
I.A.1.a.	Tropical ombrophilous lowland forest	9,39,40,46,47,81,82
I.A.1.b.	Tropical ombrophilous submontane forest	29,31,41,48,83
I.A.1.c.	Tropical ombrophilous montane forest	
I.A.1.c.(1).	Broad-leaved	32,42,49,69,72,75,78,84
I.A.1.c.(2).	Needle-leaved or microphyllous	
I.A.1.c.(3).	Bamboo	
I.A.1.d.	Tropical ombrophilous "subalpine" forest	
I.A.1.e.	Tropical ombrophilous cloud forest	
I.A.1.e.(1).	Broad-leaved, most common form	
I.A.1.e.(2).	Needle-leaved or microphyllous	
I.A.1.f.	Tropical ombrophilous alluvial forest	33,34,35
I.A.1.f.(1).	Riparian	
I.A.1.f.(2).	Occasionally flooded	
I.A.1.f.(3).	Seasonally water-logged	
I.A.1.g.	Tropical ombrophilous swamp forest	27,28,30
I.A.1.g.(1).	Broad-leaved, dominated by dicots	27,28,29,30,31,32
I.A.1.g.(2).	Dominated by palms, but broad-leaved trees in the undergrowth	27,28,30
I.A.1.h.	Tropical evergreen peat forest	?
I.A.1.h.(1).	Broad-leaved, dominated by dicotylous plants	
I.A.1.h.(2).	Dominated by palms	
I.A.2.	Tropical and subtropical evergreen seasonal forests	
I.A.2.a.	Tropical (or subtropical) evergreen seasonal lowland forest	43,50,67,70,73,76,85
I.A.2.b.	Tropical (or subtropical) evergreen seasonal submontane forest	
I.A.2.b.(1).	Boad-leaved, most common form	44,51,68,71,74,77,86
I.A.2.b.(2).	Needle-leaved	
I.A.2.c.	Tropical (or subtropical) evergreen seasonal montane forest	45,52,87
I.A.2.d.	Tropical (or subtropical) evergreen dry "subalpine" forest	
I.A.3.	Tropical and subtropical semi-deciduous forests	
I.A.3.a.	Tropical (or subtropical) semi-deciduous lowland forest	
I.A.3.b.	Tropical (or subtropical semi-deciduous montane or cloud forest	
I.A.4.	Subtropical ombrophilous forests	
I.A.5.	Mangrove forests	1,3
I.A.6.	Temperate and subpolar evergreen ombrophilous forests	
I.A.6.a.	Temperate evergreen ombrophilous broad-leaved forest	
I.A.6.a.(1).	Without conifers	
I.A.6.a.(2).	With conifers admixed	
I.A.6.b.	Temperate evergreen ombrophillous alluvial forest	
I.A.6.c.	Temperate evergreen ombrophillous swamp forest	
I.A.6.d.	Subpolar evergreen ombrophillous forest	
I.A.7.	Temperate evergreen seasonal broad-leaved forests	
I.A.8.	Winter-rain evergreen broad-leaved scierophyllous forests	
I.A.8.a.	Winter-rain evergreen sclerophyllous lowland forest (including submontane)	
I.A.8.b.	Alluvial and swamp forests of this type	
I.A.9.	Temperate and subpolar evergreen coniferous forests	
I.A.9.a.	Evergreen giant conifer forest	
I.A.9.b.	Evergreen (nongiant) conifer forest with rounded crowns	
I.A.9.b.(1).	With evergreen sclerophyllous understory (Mediterranean)	
I.A.9.b.(2).	Without evergreen sclerophyllous understory	
I.A.9.c.	Evergreen (nongiant) conifer forest with conical crowns	
I.A.9.d.	Evergreen (nongiant) conifer forest with cylindrical crowns (boreal)	
I.B.	Mainly deciduous forests	
I.B.1.	Drought-deciduous forests (Tropical and subtropical)	
I.B.1.a.	Drought-deciduous lowland (and submontane) forest	
I.B.1.b.	Drought-deciduous montane (and cloud) forest	
I.B.2.	Cold-deciduous forests with evergreen trees (or shrubs) admixed	
I.B.2.a.	Cold-deciduous forest with evergreen broad-leaved trees and climbers	
I.B.2.b.	Cold-deciduous forest with broad-leaved sclerophyllous understory	
I.B.2.c.	Cold-deciduous forest with evergreen needle-leaved trees	
I.B.3.	Cold-deciduous forests without evergreen trees	

I.B.3.a.	Temperate lowland and submontane cold-deciduous forest	
I.B.3.b.	Montane or boreal cold-deciduous forest	
I.B.3.b.(1).	Mainly broad-leaved	
I.B.3.b.(2).	Mainly deciduous coniferous	
I.B.3.b.(3).	Mixed broad-leaved and deciduous coniferous	
I.B.3.c.	Subalpine or subpolar cold deciduous forest	
I.B.3.c.(1).	With primarily hemicryptophytic undergrowth	
I.B.3.c.(2).	With primarily chamaephytic undergrowth	
I.B.3.d.	Cold-deciduous alluvial forest	
I.B.3.e.	Cold-deciduous swamp or pest forest	
I.C.	Extremely xeromorphic forests	
I.C.1.	Sclerophyllous-dominated extremely xeromorphic forests	
I.C.2.	Thorn-forests	
I.C.2.a.	Mixed deciduous-evergreen thorn forest	
I.C.2.b.	Purely deciduous thorn forest	
I.C.3.	Mainly succulent forests	
II.	WOODLANDS	
II.A.	Mainly evergreen woodlands	
II.A.1.	Evergreen broad-leaved woodlands	
II.A.2.	Evergreen needle-leaved woodlands	
II.A.2.a.	Evergreen coniferous woodlands with rounded crowns (e.g., Pinus)	
II.A.2.b.	Evergreen coniferous woodland, with conical crowns prevailing (mostly subalpine)	
II.A.2.c.	Evergreen coniferous woodland with very narrow cylindro-conical crowns (e.g., Picea in the boreal region)	
II.B.	Mainly deciduous woodlands	
II.B.1.	Drought-deciduous woodlands	36,37,38 (progressive)
II.B.2.	Cold-deciduous woodlands with evergreen trees	
II.B.3.	Cold-deciduous woodlands	
II.B.3.a.	Broad-leaved deciduous woodland	
II.B.3.b.	Needle-leaved deciduous woodland	
II.B.3.c.	Mixed deciduous woodland (broad-leaved and needle-leaved)	
II.C.	Extremely xeromorphic woodlands	
III.	SCRUB	
III.A.	Mainly evergreen scrub	
III.A.1.	Evergreen broad-leaved shrublands (Or thickets)	
III.A.1.a.	Low bamboo thicket	
III.A.1.b.	Evergreen tuft tree shrubland (or thicket)	
III.A.1.c.	Evergreen broad-leaved hemi-sclerophyllous thicket (or shrubland)	
III.A.1.c.(1).	Evergreen broad-leaved sclerophyllous shrubland (or thicket)	
III.A.1.c.(2).	Evergreen suffiuticose thicket (or shrubland)	
III.A.2.	Evergreen needle-leaved and microphyllous shrublands (or thickets)	
III.A.2.a.	Evergreen needle-leaved thicket (or shrubland)	
III.A.2.b.	Evergreen microphyllous shrubland (or thicket)	
III.B.	Mainly deciduous scrub	
III.B.1.	Drought-deciduous scrub	36,37,38 (progressive)
III.B.2.	Cold-deciduous scrub with evergreen trees	
III.B.3.	Cold-deciduous scrub	
III.B.3.a.	Broad-leaved deciduous scrub	
III.B.3.b.	Needle-leaved deciduous scrub	
III.B.3.c.	Mixed deciduous scrub (broad-leaved and needle-leaved)	
III.B.4.	Cold-deciduous shrublands (Or thickets)	
III.B.4.a.	Temperate deciduous thicket (or shrubland)	
III.B.4.b.	Subalpine or subpolar deciduous thicket (or shrubland)	
III.B.4.b.(1).	With primarily hemicryptophytic undergrowth, mainly forbs	
III.B.4.b.(2).	With primarily chamaephytic undergrowth, mainly dwarf shrubs and fruticose lichens	
III.B.4.c.	Deciduous alluvial shrubland (or thicket)	
III.B.4.c.(1).	With lanceolate leaves	
III.B.4.c.(2).	Microphyllous	
III.B.4.c.(3).	Deciduous peat shrubland (or thicket)	
III.C.	Extremely xeromorphic (subdesert) shrublands	
III.C.1.	Mainly evergreen subdesert shrublands	
III.C.1.a.	(Truly) evergreen subdesert shrubland	
III.C.1.a.(1).	Broad-leaved, dominated by sclerophyllous nanophanerophytes, including some phyllocladous shrubs	
III.C.1.a.(2).	Microphyllous, or leafless, but with green stems	
III.C.1.a.(3).	Succulent, dominated by variously branched stem and leaf succulents	
III.C.1.b.	Semi-deciduous subdesert shrubland	
III.C.1.b.(1).	Facultatively deciduous (e.g., Atriplex-Kochia-saltbush in Australia)	
III.C.1.b.(2).	Mixed evergreen and deciduous	
III.C.2.	Deciduous subdesert shrublands	

III.C.2.a.	Deciduous subdesert shrubland without succulents	
III.C.2.b.	Deciduous subdesert shrubland with succulents	
IV.	DWARF-SCRUB AND RELATED COMMUNITIES	
IV.A.	Mainly evergreen dwarf-scrub	
IV.A.1.	Evergreen dwarf-shrub thickets	
IV.A.1.a.	Evergreen caespitose dwarf-shrub thicket	
IV.A.1.b.	Evergreen creeping or matted dwarf-shrub thicket	
IV.A.2.	Evergreen dwarf-shrublands	
IV.A.2.a.	Evergreen cushion shrubland	
IV.A.2.b.	Evergreen mosaic dwarf-shrubland	7,57,58,59,61,62
IV.A.3.	Mixed evergreen dwarf-scrub and herbaceous formations	
IV.A.3.a.	Truly evergreen dwarf-scrub and herb mixed formation	
IV.A.3.b.	Partially evergreen dwarf-scrub and herb mixed formation	
IV.B.	Mainly deciduous dwarf-scrub	
IV.B.1.	Facultatively drought deciduous dwarf-thickets (Or dwarf-shrublands)	
IV.B.2.	(Obligatory) drought-deciduous dwarf-thickets (Or dwarf-shrublands)	
IV.B.2.a.	Drought-deciduous caespitose dwarf-thicket	
IV.B.2.b.	Drought-deciduous creeping or matted dwarf-thicket	60
IV.B.2.c.	Drought-deciduous cushion dwarf-shrubland	
IV.B.2.d.	Drought-deciduous mosaic (or mixed) dwarf-shrubland	
IV.B.3.	Mixed cold-deciduous and evergreen dwarf-thickets	
IV.B.4.	Cold-deciduous dwarf-thickets (Or dwarf-shrublands)	
IV.C.	Extremely xeromorphic dwarf-shrublands	
IV.D.	Moss, lichen and dwarf-shrub tundras	
IV.D.1.	Mainly bryophyte tundras	
IV.D.1.a.	Caespitose dwarf-scrub-moss tundra	
IV.D.1.b.	Creeping or matted dwarf-scrub-moss tundra	
IV.D.2.	Mainly lichen tundras	
IV.D.2.a.	Dwarf-scrublichen tundra	
IV.E.	Mossy bog formations with dwarf-shrubs	
IV.E.1.	Raised bogs	
IV.E.1.a.	Typical raised bog (suboceanic, lowland and submontane)	
IV.E.1.b.	Montane (or 'subalpine') raised bog	
IV.E.1.c.	Subcontinental "wood" and bog	
IV.E.2.	Nonraised bogs	
IV.E.2.a.	Blanket bog (oceanic lowland, submontane or montane)	
IV.E.2.b.	String bog (Finnish aapa' bog)	
V.	TERRESTRIAL HERBACEOUS COMMUNITIES	
V.A.	Savannas and related grasslands (tropical or subtropical grasslands and parklands)	57,58,59,61,62
V.A.1.	Tall-grass savannas	
V.A.1.a.	Woodland with patches of tall-grass savanna (woodland savanna)	36,37,38 (progressive)
V.A.1.b.	Tall-grass savanna with isolated trees (tree savanna)	36,37,38
V.A.1.b.(1).	With evergreen broad-leaved trees	
V.A.1.b.(2).	With palms	
V.A.1.b.(3).	With deciduous trees	
V.A.1.b.(4).	With extremely xeromorphic trees or succulents	
V.A.1.c.	Tall-grass savanna with shrubs (scrub savanna)	36,37,38 (progressive)
V.A.1.d.	Tall-grass savanna (grass savanna)	36,37,38
V.A.1.e.	Flood savanna	
V.A.1.e.(1).	With trees	
V.A.1.e.(2).	With scrub	
V.A.1.e.(3).	Without woody plants	
V.A.2.	Short-grass savannas	
V.A.2.a.	Short-grass savanna with isolated trees	
V.A.2.a.(1).	With evergreen trees	
V.A.2.a.(2).	With deciduous trees	
V.A.2.a.(3).	With xerornorphic trees except succulents	
V.A.2.a.(4).	With tree-succulents	
V.A.2.b.	Short-grass savanna with shrubs	
V.A.2.c.	Short-grass savanna (grass savanna)	80
V.B.	Steppes and related grasslands	
V.B.1.	Tall-grass steppes (Or prairies)	
V.B.1.a.	Tall-grass steppe with trees	
V.B.1.b.	Tall-grass steppe with shrubs	
V.B.1.c.	Tall-grass steppe without woody plants	63,64,65,66,79,80
V.B.2.	Mid-grass steppes (Or prairies)	
V.B.3.	Short-grass steppes (Or prairies)	
V.B.3.a.	Short-grass steppe with trees	
V.B.3.b.	Short-grass steppe with shrubs	
V.B.3.c.	Short-grass steppe without woody plants	

V.B.3.d.	Short-grass steppe with suffrutescent plants	
V.B.4.	Forb-rich steppes	
V.C.	Meadows, pastures or related grasslands	
V.C.1.	Meadows and pastures below tree line	
V.C.1.a.	Woodland pasture	
V.C.1.b.	Tree meadow (or pasture)	
V.C.1.d.	Grassy pasture without trees or shrubs	
V.C.1.c.(1).	Extensively grazed (German Triftweide,' not fertilized)	
V.C.1.c.(2).	Intensively grazed (German 'Standweide" or "UntriebsweIde," fertilized)	
V.C.1.e.	Grassy meadow without trees or shrubs	
V.C.1.e.(1).	Litter meadow	
V.C.1.e.(2).	Hay meadow	
V.C.1.f.	Sedge-rush meadow	
V.C.1.g.	Avalanche grassland	
V.C.1.g.(1).	With shrubs or damaged trees	
V.C.1.g.(2).	Without shrubs	
V.C.2.	Pastures and meadows above mountain tree line	
V.C.2.a.	Closed alpine (or subpolar) mat	
V.C.2.a.(1).	Rich in graminoids	
V.C.2.a.(2).	Rich in forbs	
V.C.2.a.(3).	With dwarf-shrubs	
V.C.2.b.	Alpine (or subnivean) mat-patches (upper alpine or subnivean)	
V.C.2.c.	Snow bed formation	
V.D.	Sedge swamps and flushes	
V.D.1.	Sedge peat swamps and similar swamps	
V.D.1.a.	Tall-sedge swamp	22,23
V.D.1.a.(1).	With creeping sedges, forming large homogeneous stand	
V.D.1.a.(2).	With caespitose sedges, forming tufts or hummocks	
V.D.1.b.	Low-sedge swamp	24,25,26
V.D.1.c.	Hard hummock swamp	
V.D.2.	Flushes	
V.D.2.a.	Forb flush	
V.D.2.a.(1).	Calcareous	
V.D.2.a.(2).	Non calcareous	
V.D.2.b.	Moss flush	
V.E.	Herbaceous and half-woody salt swamps	
V.E.1.	Halophytic half-woody shrub formations	
V.E.1.a.	Marine half-woody salt marsh	
V.E.1.a.(1).	Succulent	
V.E.1.a.(2).	Nonsucculent	
V.E.1.b.	Inland half-woody salt marsh	
V.E.1.b.(1).	Succulent	
V.E.1.b.(2).	Nonsucculent	
V.E.2.	Salt meadows	
V.E.2.a.	Marine salt meadow	
V.E.2.a.(1).	Rich in succulents	
V.E.2.a.(2).	Poor in succulents	2
V.E.2.b.	Inland salt meadow	
V.E.2.b.(1).	Closed	
V.E.2.b.(2).	Open	
V.F.	Forb vegetation and similar communities	
V.F.1.	Mainly perennial forb communities	
V.F.1.a.	Forest border herb formation	
V.F.1.b.	Tall-forb formation	
V.F.1.c.	Fern thicket (or heath)	
V.F.1.d.	Perennial forb formation on organic deposits at the flood lines	
V.F.1.e.	Perennial ruderal and clearing herb formation	
V.F.1.f.	Mainly perennial weed formation on cultivated land	
V.F.2.	Mainly ephemeral forb communities	
V.F.2.a.	Tropical or subtropical ephemeral cloud desert forb formation	
V.F.2.b.	Ephemeral halophytic formation	
V.F.2.c.	Ephemeral ruderal and clearing forb formation	
V.F.2.d.	Mainly ephemeral weed formation on cultivated	
V.F.3.	Episodical forb communities	
V.F.3.a.	Episodical desert forb formation ("flowering desert")	
V.F.3.b.	Episodical formation on pond muds and similar sites	
V.F.3.c.	Episodical forb formation on organic deposits at the flood lines	
V.F.3.d.	Episodical river bed formation	
VI.	DESERTS AND OTHER SCARCELY VEGETATED AREAS	
VI.A.	Scarcely vegetated rocks and screes	

VI.A.1.	Scarcely vegetated rocks	53,54,55,56
VI.A.1.a.	Chasmophytic vegetation	
VI.A.1.b.	Adnate Bromeliaceae on rocks	
VI.A.1.c.	Cryptogamic mat on rocks	
VI.A.1.c.(1).	Foliose lichens and mosses dominant	
VI.A.1.c.(2).	Crustose lichens dominant	
VI.A.1.c.(3).	Blue algae dominant	
VI.A.2.	Scarcely vegetated screes	
VI.A.2.a.	Lowland and submontane scree formation	
VI.A.2.b.	Montane scree formation	
VI.A.2.c.	High mountain scree formation	
VI.B.	Scarcely vegetated sand accumulations	
VI.B.1.	Scarcely vegetated sand dunes	
VI.B.1.a.	Tall-grass dune	
VI.B.1.a.(1).	Tropical and subtropical	
VI.B.1.a.(2).	Temperate, showing a marked annual growing rhythm	
VI.B.1.b.	Short-grass dune	
VI.B.1.c.	Forb dune	6,8
VI.B.2.	Bare sand dunes	5
VI.B.2.a.	Shifting dunes in desert climate	
VI.B.2.b.	Shifting dunes in forest climate	
VI.C.	True deserts	
VII.	AQUATIC PLANT FORMATIONS	
VII.A.	Floating meadows	
VII.A.1.	Mainly herbaceous floating meadows	
VII.A.1.a.	Tropical and subtropical herbaceous floating meadow	
VII.A.1.b.	Temperate and subpolar herbaceous floating meadow, with pronounced seasonal aspects	
VII.A.2.	Mainly mossy floating meadows	
VII.A.2.a.	Mossy floating meadow (temperate or subpolar)	
VII.B.	Reed-swamps	
VII.B.1.	Reed-swamp formations of fresh water lakes	
VII.B.1.a.	Tropical and subtropical fresh water reed-swamp	
VII.B.1.b.	Temperate and subpolar fresh water reed-swamp	
VII.B.2.	Reed-swamp formations of salt water lakes	
VII.B.2.a.	Tropical and subtropical salt water reed-swamp	
VII.B.2.b.	Temperate salt water reed-swamp	
VII.B.3.	Reed-swamp formations of flowing water	
VII.B.3.a.	Tropical and subtropical reed-swamp on river banks	
VII.B.3.b.	Temperate reed-swamp on river banks	
VII.C.	Rooted floating-leaf communities	
VII.D.	Rooted underwater communities	
VII.E.	Free-floating (nonrooted) fresh water communities	
VII.E.1.	Broad-leaved, free-floating communities	
VII.E.1.a.	Tropical and subtropical broad-leaved, free-floating formation	
VII.E.1.b.	Temperate broad-leaved, free-floating formation	
VII.E.2.	Lemna-type free-floating communities	
VII.E.3.	Free-floating macroscopic algal communities	

Annex 2. Overview of NatureServe-FGDC classification and its representation in our study area: Formation Class (1, 2, etc.). Formation Subclass (A, B, etc.), Formation (1, 2, etc.). Division (Fe, Ff, etc.). Macrogroup (1, 2, etc.) Sources: (1) Sayre et al. 2013; (2) Faber-Langendoen et al. 2016

Code	Name	CEPF presence	Source
1	Forest & Woodland		(1);(2)
1.A	Tropical Forest & Woodland		(1);(2)
1.A.1	Tropical Seasonally Dry Forest		(1);(2)
1.A.1.Fe	Malagasy Dry Deciduous & Evergreen Forest & Woodland		(1)
1.A.1.Fe1	Madagascar Western Dry Forest		(1)
1.A.1.Fe2	Madagascar Tapia Forest		(1)
1.A.1.Ff	Eastern African Dry Semi-Deciduous Forest		(1)
1.A.1.Ff1	Eastern African Dry Coastal Semi-Deciduous Forest		(1)
1.A.1.Ff2	Eastern African Coastal Dry Semi-Deciduous Forest		(1)
1.A.1.Fg	Albany Subtropical Thicket		(1)
1.A.1.Fg1	Albany Subtropical Thicket		(1)
1.A.1.Fh	Southern African Dry Tropical Forest		(1)
1.A.1.Fh1	Richtocephalum Dry Forest		(1)
1.A.1.Fh2	Maputaland Sand Forest		(1)
1.A.1.Fh3	Zambesian Cryptosepalum Dry Forest		(1)
1.A.2	Tropical Lowland Humid Forest		(1);(2)
1.A.2.Fd	Guineo-Congolian Evergreen & Semi-Evergreen Rainforest		(1)
1.A.2.Fd1	Guineo-Congolian Evergreen Rainforest	40,82	(1)
1.A.2.Fd2	Guineo-Congolian Semi-Evergreen Rainforest	43,50,85	(1)
1.A.2.Fd3	Guineo-Congolian Semi-Deciduous Rainforest		(1)
1.A.2.Fd4	Guineo-Congolian Littoral Rainforest	39,46,81	(1)
1.A.2.Fe	Malagasy Evergreen & Semi-Evergreen Forest		(1)
1.A.2.Fe1	Eastern Madagascar Lowland Rainforest		(1)
1.A.2.Fe2	Eastern Madagascar Subhumid Forest		(1)
1.A.2.Fe3	Western Madagascar Subhumid Forest		(1)
1.A.2.Fe4	Western Madagascar Humid Forest		(1)
1.A.2.Fe5	Madagascar Evergreen Littoral Forest		(1)
1.A.2.Ff	Eastern & Southern African Lowland Evergreen & Semi-Evergreen Forest		(1)
1.A.2.Ff1	Eastern African Lowland Semi-Evergreen Forest		(1)
1.A.2.Ff2	Central Indian Ocean Coastal Forest		(1)
1.A.2.Ff3	Southern Indian Ocean Coastal Forest		(1)
1.A.2.Ff4	Southern African Scarp Forest		(1)
1.A.2.Ff5	Zimbabwean-Malawian Subtropical Forest		(1)
1.A.2.Ff6	Eastern Arc Subtropical Forest		(1)
1.A.2.Ff7	Somalia-Masai Coastal Maritime Forest		(1)
1.A.3	Tropical Montane Humid Forest		(1);(2)
1.A.3.Fd	Afromontane Dry Forest		(1)
1.A.3.Fd1	Eastern African Dry Evergreen Montane Forest		(1)
1.A.3.Ff	Afromontane Moist Forest		(1)
1.A.3.Ff1	Eastern Madagascar Montane Forest		(1)
1.A.3.Ff2	Afromontane Mesic Forest	42,45,49,52,84,87	(1)
1.A.3.Ff3	Entandrophragma - Newtonia - Parinari Forest		(1)
1.A.3.Ff4	Moist Evergreen Montane Forest	41,44,48,51,83,86	(1)
1.A.4	Tropical Flooded & Swamp Forest		(1);(2)
1.A.4.Fe	Eastern African Swamp Forest		(1)
1.A.4.Fe1	Uapaca guineensis Swamp Forest		(1)
1.A.4.Fe2	Makaranga Swamp Forest		(1)
1.A.4.Ff	Southern African Swamp Forest		(1)
1.A.4.Ff1	Zululand-Mozambique Coastal Swamp Forest		(1)
1.A.4.Fg	Guineo-Congolian Swamp Forest	32	(1)
1.A.4.Fg1	Antostema - Alstoneia Swamp Forest	27,28,30	(1)
1.A.4.Fg2	Raffia Swamp	27,28,30	(1)
1.A.4.Fg3	Central Congo Basin Swamp Forest		(1)
1.A.4.Fh	Sahelian Swamp Forest		(1)
1.A.4.Fh1	Western African Non-Riverine Swamp Forest		(1)
1.A.4.Fh2	Uapaca heudelotii Forest	33,34,35	(1)
1.A.4.Fh3	West African Mitragyna Riverine Forest	27,28,29,30,31	(1)
1.A.4.Fh4	Acacia Seasonally Flooded		(1)
1.A.5	Mangrove		(1);(2)
1.A.5.Ua	Atlantic & Caribbean & East Pacific Mangrove		(1)
1.A.5.Ua1	Atlantic Ocean Mangrove	1,3	(1)
1.A.5.Wb	Indo-West Pacific Mangrove		(1)

Code	Name	CEPF presence	Source
1.A.5.Wb1	Indian Ocean Mangrove		(1)
1.B	Temperate & Boreal Forest & Woodland		(1);(2)
1.B.1	Warm Temperate Forest & Woodland		(1);(2)
1.B.1.Fe	Southern African Warm Temperate Evergreen Forest		(1)
1.B.1.Fe1	Southern Afrotemperate Forest		(1)
1.B.1.Fe2	Northern Afrotemperate Forest		(1)
1.B.1.Fe3	Southern Mistbelt Forest		(1)
1.B.1.Fe4	Northern Mistbelt Forest		(1)
1.B.1.Ph	Northern African Mediterranean Forest		(1)
1.B.1.Ph1	Mediterranean Lowland Mixed Forest		(1)
1.B.1.Ph2	Northern African Pinus / Quercus Forest & Woodland		(1)
1.B.1.Ph3	Mediterranean Montane Coniferous Forest		(1)
1.B.2	Cool Temperate Forest & Woodland		(2)
1.B.3	Temperate Flooded & Swamp Forest		(1);(2)
1.B.3.Fe	Fynbos Riparian Thicket		(1)
1.B.3.Fe1	Fynbos Flooded Riparian Thicket		(1)
1.B.3.Ff	Southern African Riparian Phreatophyte Vegetation		(1)
1.B.3.Ff1	Southern African Riparian Phreatophyte Vegetation		(1)
1.B.4	Boreal Forest & Woodland		(2)
1.B.5	Boreal Flooded & Swamp Forest		(2)
2	Shrubland & Grassland		(1);(2)
2.A	Tropical Grassland, Savanna & Shrubland		(1);(2)
2.A.1	Tropical Lowland Grassland, Savanna & Shrubland		(1);(2)
2.A.1.Ff	West-Central African Mesic Woodland & Savanna		(1)
2.A.1.Ff1	Central African Mesic Woodland & Grassland		(1)
2.A.1.Ff2	Western African Mesic Woodland & Grassland	36,37,38	(1)
2.A.1.Ff3	Gabono-Congolian Mesic Woodland & Grassland		(1)
2.A.1.Fg	Eastern & Southern African Dry Savanna & Woodland		(1)
2.A.1.Fg1	Dry Combretum - Mixed Woodland & Savanna		(1)
2.A.1.Fg2	Dry Acacia Woodland & Savanna		(1)
2.A.1.Fg3	Dry Acacia - Terminalia - Combretum Woodland & Savanna		(1)
2.A.1.Fg4	Southern Kalahari Dunefield Woodland & Savanna		(1)
2.A.1.Fg5	Kalahari Camel Thorn Woodland & Savanna		(1)
2.A.1.Fh	Mopane Savanna		(1)
2.A.1.Fh1	Limpopo Mopane		(1)
2.A.1.Fh2	Zambezi Mopane		(1)
2.A.1.Fh3	Namibia-Angola Mopane		(1)
2.A.1.Fi	Sudano-Sahelian Dry Savanna		(1)
2.A.1.Fi1	Sudano-Sahelian Herbaceous Savanna		(1)
2.A.1.Fi2	Sudano-Sahelian Shrub Savanna		(1)
2.A.1.Fi3	Sudano-Sahelian Treed Savanna		(1)
2.A.1.Fn	Miombo & Associated Broadleaf Savanna		(1)
2.A.1.Fn1	Wet Miombo		(1)
2.A.1.Fn2	Dry Miombo		(1)
2.A.1.Fn3	Baikiaea Woodland & Savanna		(1)
2.A.1.Fn4	Southern African Broadleaf Savanna		(1)
2.A.1.Fn5	Pericopsis Woodland & Savanna		(1)
2.A.1.Fo	Eastern African Moist Woodland & Savanna		(1)
2.A.1.Fo1	Moist Combretum - Terminalia Woodland & Savanna		(1)
2.A.1.Fo2	Moist Acacia - (Combretum) Woodland & Savanna		(1)
2.A.1.Fp	Malagasy Dry Forest & Scrubland		(1)
2.A.1.Fp1	Madagascar Plateau Woodland & Grassland		(1)
2.A.1.Fp2	Madagascar Wooded Grassland-Bushland		(1)
2.A.1.Fq	Malagasy Subhumid Woodland & Savanna		(1)
2.A.1.Fq1	Malagasy Subhumid Woodland & Savanna		(1)
2.A.2	Tropical Montane Grassland & Shrubland		(1);(2)
2.A.2.Fe	African Montane Grassland & Shrubland		(1)
2.A.2.Fe1	African Subalpine Grassland & Moorland		(1)
2.A.2.Fe2	Afro-Alpine Moorland		(1)
2.A.2.Fe3	Afromontane Grassland		(1)
2.A.2.Fj	Malagasy Montane Thicket & Sclerophyllous Shrubland		(1)
2.A.2.Fj1	Malagasy Montane Scrub		(1)
2.A.3	Tropical Scrub & Herb Coastal Vegetation	6,7,8	(2)
2.A.5	Tropical Freshwater Marsh, Wet Meadow & Shrubland		(1)
2.A.5.Fc	Tropical Herbaceous Swamp & Aquatic Vegetation		(1)
2.A.5.Fc1	African Tropical Freshwater Marsh (Dembos)	22,23	(1)
2.A.5.Fc2	Malagasy Tropical Freshwater Marsh		(1)
2.A.5.Fc3	Sudano Tropical Riverine Marsh		(1)
2.A.5.Fc4	African Temperate Moorland		(1)

Code	Name	CEPF presence	Source
2.A.5.Fd	Southern African Phreatophyte Vegetation		(1)
2.A.5.Fd1	Okavango-Cuvelai Phreatophyte Vegetation		(1)
2.A.5.Fd2	Eastern African Alluvial Wash		(1)
2.A.5.Fd3	Karoo Flooded Riparian Woodland		(1)
2.A.5.Pm	Northern African Phreatophyte Vegetation		(1)
2.A.5.Pm1	Date Palm Oasis		(1)
2.A.5.Pm2	Northern African Alluvial Wash & Riparian Vegetation		(1)
2.A.5.Pm3	Western African Depressional Vegetation		(1)
2.A.5.Pm4	Sahelian Riparian Forest		(1)
2.A.5.Pm5	Northern African Flooded Riparian Woodland		(1)
2.A.5.Pm6	Northern African Riparian Phreatophyte Vegetation		(1)
2.B	Temperate & Boreal Grassland & Shrubland		(1);(2)
2.B.1	Mediterranean Scrub & Grassland		(1);(2)
2.B.1.Fh	South African Cape Mediterranean Scrub		(1)
2.B.1.Fh1	Fynbos		(1)
2.B.1.Fh2	Renosterveld		(1)
2.B.1.Fh3	Strandveld		(1)
2.B.1.Fh4	Cape Thicket		(1)
2.B.1.Pk	Northern African Mediterranean Scrub		(1)
2.B.1.Pk1	Mediterranean Montane Scrub		(1)
2.B.1.Pk2	Mediterranean Lowland Scrub		(1)
2.B.1.Pl	Mediterranean Alpine Scrub & Herbaceous		(1)
2.B.1.Pl1	Northern African Mediterranean Alpine Scrub & Herbaceous		(1)
2.B.2	Temperate Grassland, Meadow & Shrubland		(1);(2)
2.B.2.Fm	Southern African Montane Grassland		(1)
2.B.2.Fm1	Drakensberg Grassland		(1)
2.B.2.Fm2	Dry Highveld Grassland		(1)
2.B.2.Fm3	Moist Highveld Grassland		(1)
2.B.2.Fm4	Sub-Escarpment Grassland		(1)
2.B.2.Fm5	Southern Afromontane Grassland		(1)
2.B.3	Boreal Grassland & Shrubland		(2)
2.B.4	Temperate to Polar Scrub & Herb Coastal Vegetation		(2)
2.B.6	Temperate & Boreal Freshwater Marsh, Wet Meadow & Shrubland		(1)
2.B.6.Fd	African Temperate Herbaceous Swamp & Aquatic Vegetation		(1)
2.B.6.Fd1	African Temperate Freshwater Marsh		(1)
2.B.6.Fd2	African Temperate Vernal Pool		(1)
2.B.7	Salt Marsh		(1)
2.B.7.Fg	Southern African Temperate Coastal Marsh		(1)
2.B.7.Fg1	African Cape Coastal Salt Marsh		(1)
2.B.7.Fg2	Namib Sabkha Salt Marsh		(1)
2.B.7.Fh	Tropical Coastal Salt Marsh		(1)
2.B.7.Fh1	Tropical African Coastal Salt Marsh	2	(1)
2.B.7.Fi	Eastern African Salt Pan		(1)
2.B.7.Fi1	Eastern African Salt Marsh		(1)
2.B.7.Fj	Southern African Salt Pan		(1)
2.B.7.Fj1	Etosha Salt Pan		(1)
2.B.7.Fj2	Kalahari Salt Pan		(1)
2.B.7.Fj3	Bushmanland-Highveld Salt Pan		(1)
2.B.7.Fj4	Lowveld-Limpopo Salt Pan		(1)
2.B.7.Pr	Northern African Salt Pan		(1)
2.B.7.Pr1	Saharan Mediterranean Salt Pan		(1)
2.B.7.Pr2	Somalia-Masai Salt Pan		(1)
2.B.7.Ps	Northern African Temperate Coastal Marsh		(1)
2.B.7.Ps1	Mediterranean Coastal Salt Marsh		(1)
2.B.7.Ps2	Red Sea Sabkha Salt Marsh		(1)
2.C	Shrub & Herb Wetland		(2)
2.C.1	Tropical Bog & Fen		(2)
2.C.2	Temperate to Polar Bog & Fen		(2)
2.C.3	Tropical Freshwater Marsh, Wet Meadow & Shrubland		(2)
2.C.4	Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland		(2)
2.C.5	Salt Marsh		(2)
3	Desert & Semi-Desert		(1);(2)
3.A	Warm Desert & Semi-Desert Woodland, Scrub & Grassland		(1);(2)
3.A.1	Tropical Thorn Woodland		(2)
3.A.2	Warm Desert & Semi-Desert Scrub & Grassland		(1);(2)
3.A.2.Fc	Succulent Karoo		(1)
3.A.2.Fc1	Richtersveld		(1)
3.A.2.Fc2	Namaqualand Hardeveld		(1)
3.A.2.Fc3	Namaqualand Sandveld		(1)

Code	Name	CEPF presence	Source
3.A.2.Fc4	Knersvlakte		(1)
3.A.2.Fc5	Trans-Escarpment Succulent Karoo		(1)
3.A.2.Fc6	Rainshadow Valley Karoo		(1)
3.A.2.Fc7	Sperregebied Succulent Karoo		(1)
3.A.2.Fd	Madagascar Xeric Scrub & Grassland		(1)
3.A.2.Fd1	Madagascar Southwestern Coastal Bushland		(1)
3.A.2.Fd2	Madagascar Southwestern Dry Forest-Thicket		(1)
3.A.2.Fe	Eastern African Xeric Scrub		(1)
3.A.2.Fe1	Eastern African Bushland & Thicket		(1)
3.A.2.Fe2	Eastern African Semi-Desert Scrub		(1)
3.A.2.Fe3	Eastern African Acacia Woodland		(1)
3.A.2.Fe4	Eastern African Acacia - Commiphora Woodland		(1)
3.A.2.Fh	Nama Karoo Semi-Desert Scrub & Grassland		(1)
3.A.2.Fh1	Bushmanland Semi-Desert Scrub & Grassland		(1)
3.A.2.Fh2	Upper Karoo Semi-Desert Scrub & Grassland		(1)
3.A.2.Fh3	Lower Karoo Semi-Desert Scrub & Grassland		(1)
3.A.2.Fh4	Southern Namibian Semi-Desert Scrub & Grassland		(1)
3.A.2.Fh5	Pro-Namib Semi-Desert Scrub		(1)
3.A.2.Fh6	Kaokoveld Semi-Desert Scrub		(1)
3.A.2.Fi	Namib-Gariep Desert		(1)
3.A.2.Fi1	Gariep Desert		(1)
3.A.2.Fi2	Southern Namib Desert		(1)
3.A.2.Fi3	Namib Sand Sea		(1)
3.A.2.Fi4	Northern Namib Desert		(1)
3.A.2.Pf	North Sahel Semi-Desert Scrub & Grassland		(1)
3.A.2.Pf1	North Sahel Herbaceous Steppe		(1)
3.A.2.Pf2	North Sahel Shrubland Steppe & Grassland		(1)
3.A.2.Pf3	North Sahel Treed Steppe & Grassland		(1)
3.A.2.Pf4	Northern African Steppe		(1)
3.A.2.Pg	Sahara Warm Desert Scrub & Grassland		(1)
3.A.2.Pg1	Mountainous Saxicolous Grassland		(1)
3.A.2.Pg2	Saharan Herbaceous Steppe		(1)
3.A.2.Pg3	Saharan Shrub Steppe		(1)
3.A.2.Pg5	Saharan Sandy Grassland		(1)
3.A.2.Pg7	Saharan Swamp Grassland		(1)
3.A.2.Pj	Saharan Desert		(1)
3.A.2.Pj1	Saharan Desert Pavement		(1)
3.A.2.Pj2	Saharan Desert Rock Outcrop		(1)
3.A.2.Pj3	Saharan Desert Dune & Sand Plain		(1)
3.A.2.Pj4	Saharan Desert Rockland		(1)
3.B	Cool Semi-Desert Scrub & Grassland		(1);(2)
3.B.1	Cool Semi-Desert Scrub & Grassland		(2)
4	Polar & High Montane Scrub, Grasslands & Barrens		(2)
4.A	Tropical High Montane Scrub & Grassland		(2)
4.A.1	Tropical High Montane Scrub & Grassland		(2)
4.B	Temperate to Polar Alpine & Tundra Vegetation		(2)
4.B.1	Temperate & Boreal Alpine Vegetation		(2)
4.B.2	Polar Tundra & Barrens		(2)
5	Aquatic Vegetation		(2)
5.A	Saltwater Aquatic Vegetation		(2)
5.A.1	Floating & Suspended Macroalgae Saltwater Vegetation		(2)
5.A.2	Benthic Macroalgae Saltwater Vegetation		(2)
5.A.3	Benthic Vascular Saltwater Vegetation		(2)
5.A.4	Benthic Lichen Saltwater Vegetation		(2)
5.B	Freshwater Aquatic Vegetation		(2)
5.B.1	Tropical Freshwater Aquatic Vegetation		(2)
5.B.2	Temperate to Polar Freshwater Aquatic Vegetation		(2)
6	Open Rock Vegetation		(1);(2)
6.A	Tropical Open Rock Vegetation		(1);(2)
6.A.1	Tropical Cliff, Scree & Other Rock Vegetation		(1);(2)
6.A.1.Fc	African Tropical Cliff, Scree, Rock & Dune Vegetation		(1)
6.A.1.Fc1	Central African Inselberg Vegetation		(1)
6.A.1.Fc2	Atlantic African Coastal Dune	5,6,7,8	(1)
6.A.1.Fc3	Malagasy Granite Outcrop Vegetation		(1)
6.A.1.Fc4	Zimbabwean Inselberg Vegetation		(1)
6.A.1.Fc5	Namibian Inselberg Vegetation		(1)
6.A.1.Fc6	Western African Inselberg Vegetation	53,54,57-62,67-72	(1)
6.A.1.Fc7	African Tropical Dune Vegetation		(1)
6.A.1.Fc8	Sudano Rock Outcrop Sparse Vegetation		(1)

Code	Name	CEPF presence	Source
6.B	Temperate & Boreal Open Rock Vegetation		(1)
6.B.1	Mediterranean Open Rock Vegetation		(1)
6.B.1	Temperate & Boreal Cliff, Scree & Other Rock Vegetation		(2)
6.B.2	Temperate & Boreal Cliff, Scree & Other Rock Vegetation		(1)
6.B.2.Fd	African Temperate Cliff, Scree, Rock & Dune Vegetation		(1)
6.B.2.Fd1	Southern African Temperate Inselberg Vegetation		(1)
6.B.2.Fd2	African Temperate Dune Vegetation		(1)
6.B.2.Pe	Mediterranean Alpine Rock & Scree		(1)
6.B.2.Pe1	Northern African Mediterranean Alpine Rock & Scree		(1)
7	Agricultural & Developed Vegetation		(2)
7.A	Woody Agricultural Vegetation		(2)
7.A.1	Woody Horticultural Crop		(2)
7.A.2	Forest Plantation & Agroforestry		(2)
7.A.3	Woody Wetland Horticultural Crop		(2)
7.B.	Herbaceous Agricultural Vegetation		(2)
7.B.1	Row & Close Grain Crop		(2)
7.B.2	Pasture & Hay Field Crop		(2)
7.B.3	Herbaceous Horticultural Crop		(2)
7.B.4	Fallow Field & Weed Vegetation		(2)
7.B.5	Herbaceous Wetland Crop		(2)
7.C	Herbaceous & Woody Developed Vegetation		(2)
7.C.1	Lawn & Recreational Vegetation		(2)
7.C.2	Horticultural Garden Vegetation		(2)
7.C.3	Open Developed Vegetation		(2)
7.C.4	Developed Wetland Vegetation		(2)
7.D	Agricultural & Developed Aquatic Vegetation		(2)
7.D.1	Agricultural Aquatic Vegetation		(2)
7.D.2	Developed Aquatic Vegetation		(2)
8	Natural Open Fresh Water		(2)
8.A	Lake	4	(2)
8.B	River		(2)
8.C	Subterranean Freshwater		(2)
9	Natural Open Salt Water		(2)
9.A	Estuary and Ocean		(2)
10	Cultural Open Water		(2)
10.A	Reservoir and Canal (etc.)		(2)
11	Perennial Snow/Ice		(2)
11.A	Perennial Snowfield		(2)
11.B	Ice Sheet		(2)
11.C	Glacier		(2)
12	Natural Surface Bare Area		(2)
12.A	Consolidated Bare Area (Rock, etc.)		(2)
12.B	Unconsolidated Bare Area (Sand, Gravel, etc.)		(2)
13	Natural Subterranean		(2)
13.A	Cave (etc.)		(2)
14	Cultural Surface Bare Area		(2)
14.A	Developed, Low Intensity		(2)
14.B	Developed, Medium Intensity		(2)
14.C	Developed, High Intensity		(2)
15	Cultural Subterranean		(2)
15.A	Mine Shaft (etc.)		(2)