# Appendix 16 Census of Reptiles and Amphibian Communities
# Environmental and Social Impact Assessment
# Yaoure Gold Project, Côte d'Ivoire

Submitted to

**Amara Mining Côte d'Ivoire SARL**

Submitted By

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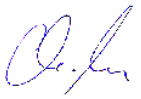
| Project Manager Approval | **Christian Kunze** |  12 November 2015 | |

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## EXECUTIVE SUMMARY

**Background** - The following report summarises the rapid assessment conducted within the Yaoure Gold Project concession to gather baseline data for reptiles and amphibians. The survey took place from the 1st to the 21st of May 2015 and was commissioned by Amec Foster Wheeler Earth & Environmental UK Ltd for Amara Mining Côte d'Ivoire SARL. In total, 35 species of reptiles and 29 species of amphibians were recorded.

**Methods** - Reptiles and amphibians were searched via visual and acoustic encounter surveys in suitable habitats. Trapping with drift fences and funnel traps at two sites supplemented the records. Complementary information was gathered through interviews, especially to assess crocodile presence in the area.

**Main findings** - No regional or national Red Lists are publicly available. None of the recorded species are currently listed as threatened by the global IUCN Red List. Nine species of reptiles are of conservation concern because they are either regularly harvested (*Bitis arietans*, *Bitis rhinoceros*, *Pelusios castaneus*, *Chamaeleo gracilis*, *Python sebae*, *Python regius*, *Varanus niloticus*; the last four species are listed in CITES Appendix II) or have restricted ranges (*Hemidactylus fasciatus*, *Hemidactylus* cf. *muriceus*). The latter two species are also indicators for forests. Three species of amphibians are also of conservation concern due to their restricted ranges (*Afrixalus vittiger*, *Hyperolius igbettensis*, *Kassina schioetzi*). Four specimens of reed frogs (Family Hyperoliidae: *Hyperolius* sp.) cannot be assigned to any known species yet. Further research is needed to verify whether they might be a new species.

Overall, the concession contains a diverse herpetofauna because it is located at the transition zone between the biomes forest and savannah. A number of species of reptiles (n=39) and amphibians (n=18) were not recorded during the present survey but are known from this region of Côte d'Ivoire. The absence of larger patches of good humid forests from the study area might be the main explanation for the absence of many forest dependent species.

**Impacts** - Artisanal and industrial mining activities have been on-going throughout the concession for several years and have significantly altered the vegetation and landscape so that many species are confined to the remaining natural small forest or savannah patches. Thus the site is already impacted but a further increase in habitat degradation is expected with further developments.

The main recommendation is to raise awareness on the importance of biodiversity at the mine site but also in the area in general as well as to start coherent environmental and offset planning as soon as possible.

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## LIST OF ABBREVIATIONS AND ACRONYMS

Amara - Amara Mining Côte d'Ivoire SARL

Amec Foster Wheeler - Amec Foster Wheeler Earth & Environmental UK Ltd

CBD - Convention on Biological Diversity,

for details: https://www.cbd.int/

CITES - Convention on International Trade in Endangered Species of Wild Fauna and Flora,

for details: http://www.cites.org/

ESIA - Environmental and Social Impact Assessment

IUCN - International Union for the Conservation of Nature,

for details: http://www.iucnredlist.org/

# 1.0 INTRODUCTION

Biodiversity is an integral part of life on earth in general and human well-being in particular. At the same time, biodiversity is heavily threatened (CBD 2000) and not evenly distributed. In order to focus and prioritise conservation efforts, several attempts have been put forward to quantify areas which harbour a high amount of biodiversity and at the same time a high number of threatened species. The so called biodiversity hotspot concept, identified 25 regions across the globe which have the highest numbers of endemic (species occurring only in that region and nowhere else) and threatened species. One of these regions is the "West African forests", covering the forest biome from Togo, Ghana, Côte d'Ivoire, Liberia and Sierra Leone to Guinea (Myers et al. 2000) and being of outstanding regional importance for biodiversity.

The forests within that region have experienced a severe degradation, fragmentation and area loss (Mayaux et al. 2004, Hansen et al. 2008, 2013, Mallon et al. 2015). This habitat loss is very pronounced in forested areas though it occurs also regularly in savannah regions but is much harder to quantify there.

The main threat to biodiversity in the region is habitat loss (Mallon et al. 2015) affecting amphibians and reptiles which are an essential part of their respective ecosystems. West Africa harbours unique amphibian assemblages, making it a distinct region from Central Africa (Penner et al. 2011). Summaries of declines of amphibian populations have been reported and the main factors have been identified (habitat loss, pollution, etc.; see summary in Stuart et al. 2008). More detailed analyses for Côte d'Ivoire show also negative effects of habitat alterations (Ernst & Rödel 2005, Kouamé et al. 2007, Hillers et al. 2008a). It is suggested that reptiles experience a similar decline (Gibbons et al. 2000) which has not been well quantified yet. It is for these above mentioned reasons that especially large scale activities which might impact biodiversity, such as mining, need to anticipate and quantify their impacts, in order to better plan mitigation measures in an effort to reduce the magnitude of their impacts on ecosystems and human well-being.

The presented study was conducted by Dr. Johannes Penner and Dr. LeGrand Nono Gonwouo. Both have extensive experience in the fields of African herpetology as well as consulting for environmental impact studies.

## 1.1 Purpose of the Study

Within Côte d'Ivoire, as well as in other countries, one major impact on biodiversity is open cast mining. The mining site located in the Yaoure concession in central Côte d'Ivoire has been running since the 1980s under different names and different companies. Within the area the main resources sought after are gold and diamonds. In the present study we aimed at quantifying baseline levels for amphibians and reptiles. A previous study conducted within the same area focused on birds and mammals and only included notes on amphibians and reptiles (Tano et al. 2007). The documented results are not up to date because they were obtained more than 7 years ago and are questionable due to doubtful identifications, the lack of deposited voucher specimens and the fact that the work was conducted during the dry season which is not optimal for

amphibian and reptile surveys. The more specific aims of our survey and the present report are to:

- Gather occurrence data and determine species richness for amphibians and reptiles within the study area;
- Identify species of conservation concern;
- Identify areas of special importance within the study area; and
- Give recommendations on mitigation and offsetting measures.

## 1.2 Desktop Findings

### 1.2.1 Previous Studies

West Africa harbours unique amphibian assemblages (Penner et al. 2011) and within that region Côte d'Ivoire is one of the best studied countries with at least six endemic and overall at least 96 recorded species (Rödel et al. 2010). Estimated diversity can be very high (max. 73 species per km²; Penner et al. 2010). Literature was reviewed on what species of amphibians and reptiles could be expected within the concession. For amphibians the two main assemblages for comparison reasons are the one of Lamto (Adeba et al. 2010) and Marahoué (Rödel & Ernst 2003). However, it should be noted that in the latter protected area (i.e. Marahoué National Park) most natural habitats are gone (see Hansen et al. 2013 and Figure 2.3). For reptiles three sources were considered relevant, Chippaux 2006 for snakes, Shirley et al. 2009 for crocodiles and Trape et al. 2012 for all other groups. In a conservative approach, only geographically close records were considered relevant.

### 1.2.2 Regional and International Importance

Forests are a rapidly dwindling habitat in West Africa in general and in Côte d'Ivoire in particular (see section 2.2 and Figure 2.3 for details). Previous work identified two amphibian species (see Tano et al. 2007 and section 3.2) and two crocodile species (Shirley et al. 2009) which might occur in the study area and that are listed as threatened by the IUCN Red List. Thus, the study area has regional and international importance as outlined later in the text (see sections 3.4 and 4.3).

## 1.3 Legal Requirements

We refer to Tano et al. (2007), Mallon et al. (2015) and the main parts of the current ESIA for details of national and regional legislation. In addition, the "Convention on International Trade in Endangered Species of Wild Fauna and Flora" also known as the "Washington Convention" regulates the trade of listed species (CITES 2015). Côte d'Ivoire adopted this convention on 21st of November 1994 and its implementation within the European Union is regulation 1320/2014. In the present case, this concerns only reptile species and details are given in section 3.1.

# 2.0 METHODOLOGY

## 2.1 Study Topic

We conducted a biodiversity baseline study for reptiles and amphibians. So the aim was to find out which species occur in the study area, how they might be or are already impacted by the mine and what measures can be put in place to alleviate the impacts.

## 2.2 Study Area and Survey Period

The field survey took place from the 1st to the 21st of May 2015 inside the area of Amara's "Outer Exploration Licence", focussing on the "Inner Exploration Licence" and proposed infrastructure locations. The daily reports with specific activities and sites visited are given in Appendix A. The field survey took place at the beginning of the rainy season after consultation with Amec Foster Wheeler and climate data from previous studies. However, rains were unusually scarce this year and it rained only twice with heavy rains in the night from the 3rd to the 4th of May, and light ones on the evening of the 17th of May which is not optimal for such a survey.

The concession is located in central Côte d'Ivoire near the capital city of Yamoussoukro, west of the Bandama River and the dam of the lake Kossou at the base of the so called "V de Baoulé", a natural v shaped southern extension of the savannah into the forest biome (see Figure 2.1 a, b & c). Thus, the concession falls within the transition zone between the forest and savannah biomes which results in the presence of herpetofaunal communities from both ecoregions, thereby making it a biologically interesting ecotone. The concession itself harbours a number of different habitats, but from a herpetological viewpoint can be summarised into: drier forests on hilltops, subsistence farms along the rivers (cocoa, rice, yam, etc.) and grasslands/savannahs (see Figure 2.1c and Figure 2.5).

The whole concession is heavily impacted by humans and no pristine or natural habitats were found. The savannahs and grasslands are regularly used as grazing grounds for large numbers of cattle. In addition, subsistence small scale farming takes place throughout the area but especially along the river courses, which resulted in a complete loss of forests along running streams. Only a few patches of dry forest remain on the hilltops and steep slopes. Extensive logging of woody savannahs for charcoal production was noted in the area close to Lake Kossou.

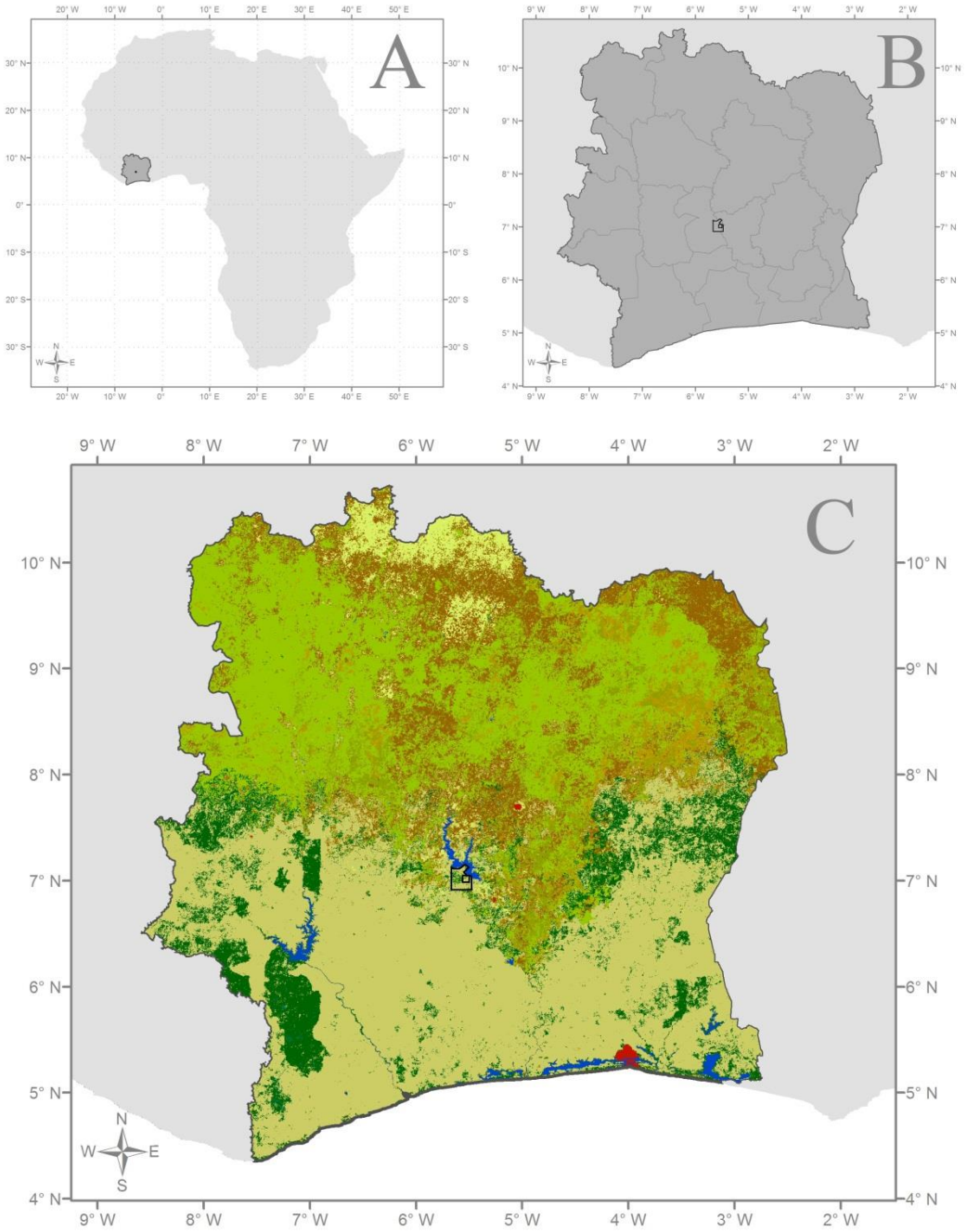
Artisanal mining takes place throughout the whole concession and has an impact on security as well as on habitat quality. The vegetation is cut down and deep vertical shafts (ranging from a few meters to more than 20 meters) of approximately 1m diameter are dug out. Thus, the vegetation is degraded and abandoned holes might be overlooked and are traps for humans and wildlife. In addition, several illegal large scale semi-industrial mines, apparently run by Chinese, destroyed most of the remaining gallery forests in the concession along a large stretch on the west side of the Bandama river (see Figure 2.6).

The industrial mining infrastructures of Amara (previously Cluff Gold Plc) are already in place for several years. Until now two large pits exist, one old, smaller abandoned one and a more recent large one, partly filled with water (Figure 2.5). Access roads are in place, exploration drillings took place and facilities exist to process gold ore (see Figure 2.4). For details of the mine infrastructure refer to the main ESIA documents.

Emphasis was laid on maximising the areas visited and in seeing as many different habitats as possible, covering the whole inner and outer licences. Thus, many but not all amphibians and reptiles encountered were recorded (too many repetitions or even a complete coverage including abundance data would have required a much more extensive survey). Sites were chosen after conducting reconnaissance walks and drives within the concession, consulting maps (i.e. satellite images & land cover classification) provided by Amara and Amec Foster Wheeler, and after discussing with local staff as well as people from villages close to the desired working area. A list of sampling locations with a short description of the encountered habitats is included in Appendix B.

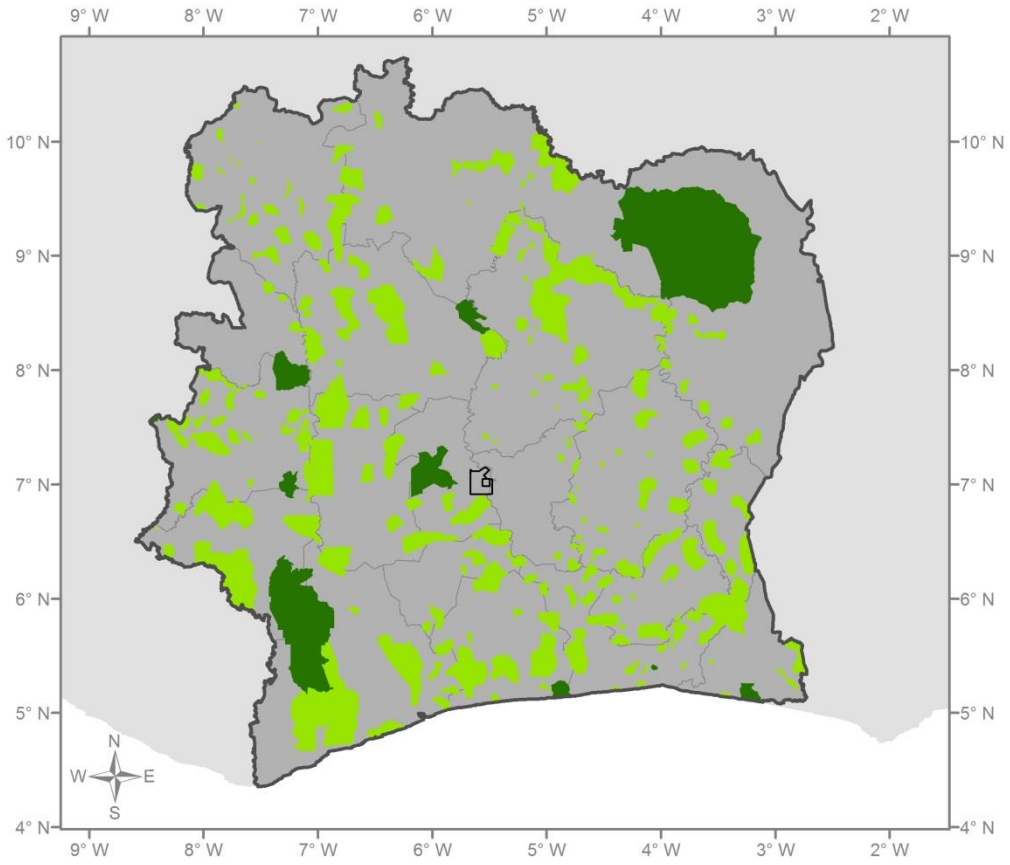
The mining activities are going to impact the whole concession either directly due to open cast mining and all related activities (e.g. excavation, waste piles, infrastructure) and indirectly due general increase in infrastructure and people in the area (which in turn need food, accommodation, have families, etc.).

**Figure 2.1 Maps showing the study area**



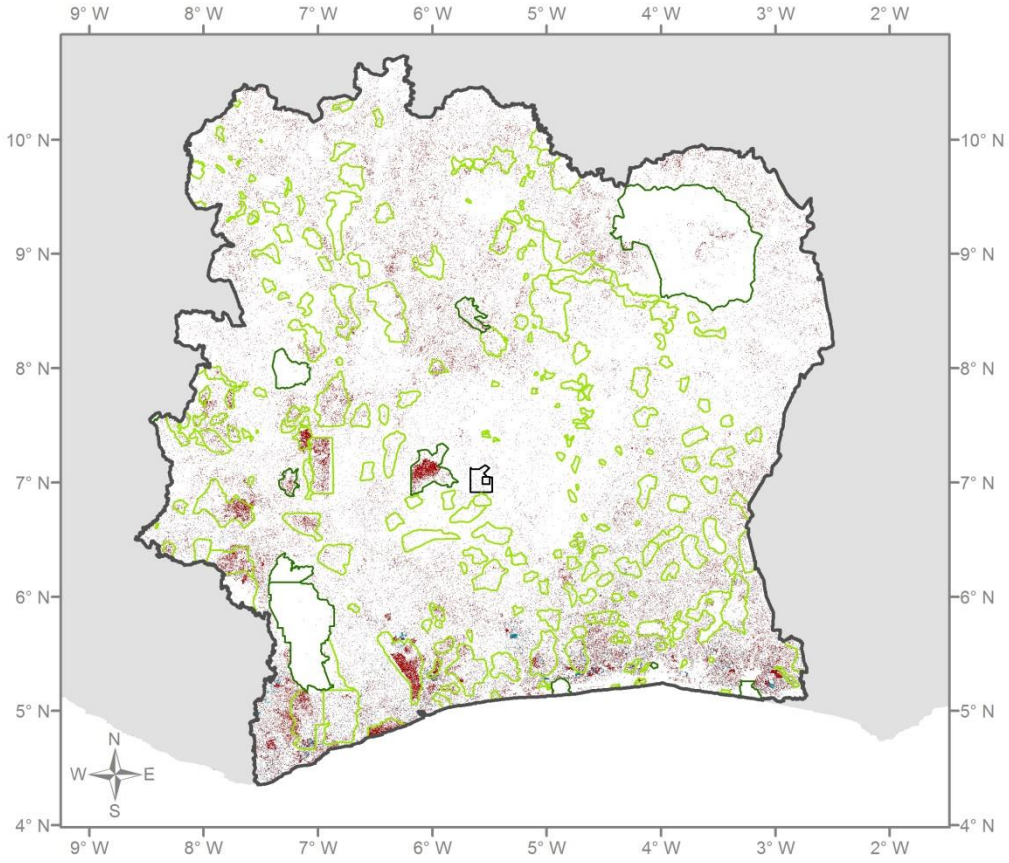

Legend: A) Outline of the African continent, showing Côte d'Ivoire (CI) and the location of the study area; B) Administrative regions of CI and the study area (outer and inner exploration licences); C) Global Land Cover 2009 for CI, the remaining forests (dark green) are clearly visible as well as the v-shaped form of the savannah zone (light green) extending into the forest zone (mostly converted for agriculture, represented in mud green), Lake Kossou (water in blue) and the major cities (red) are also obvious.

**Figure 2.2 Protected areas of Côte d'Ivoire**



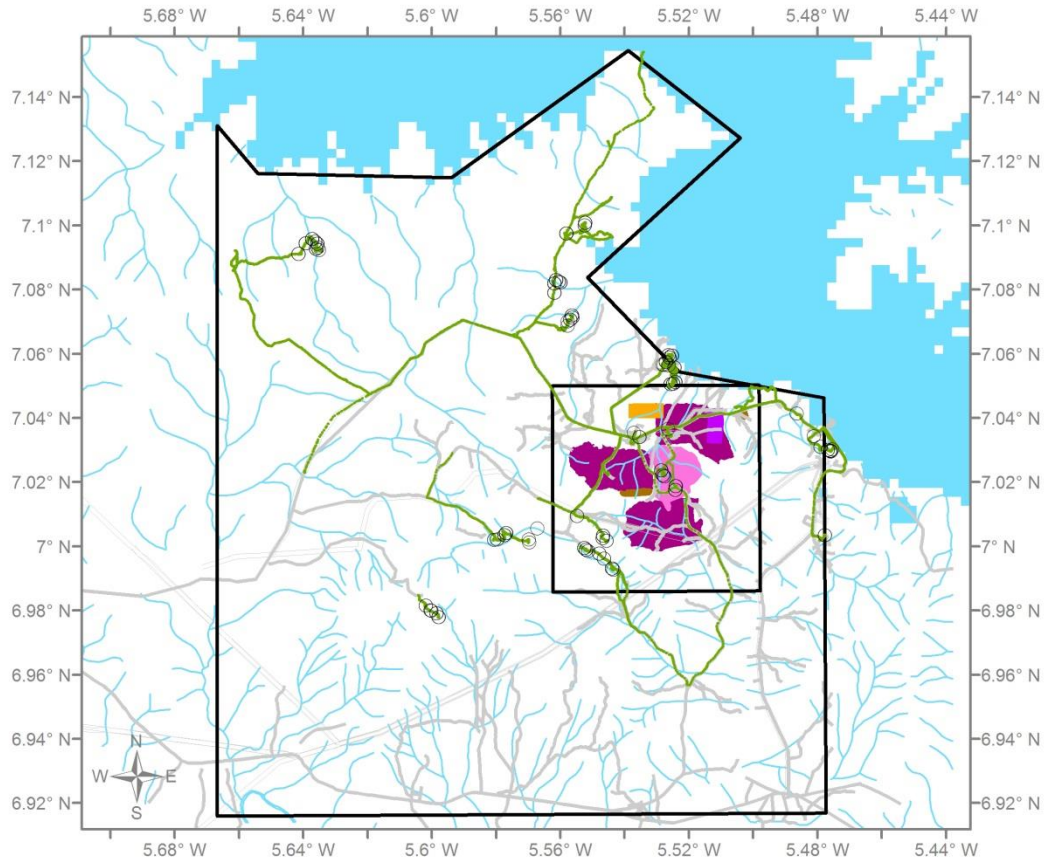

Legend: IUCN categories i-v in dark green, other protected areas (PAs) in light green and the study area (outer and inner exploration licences); administrative regions as in Figure 2.1B.

**Figure 2.3 Changes in forest cover between 2000 and 2013**



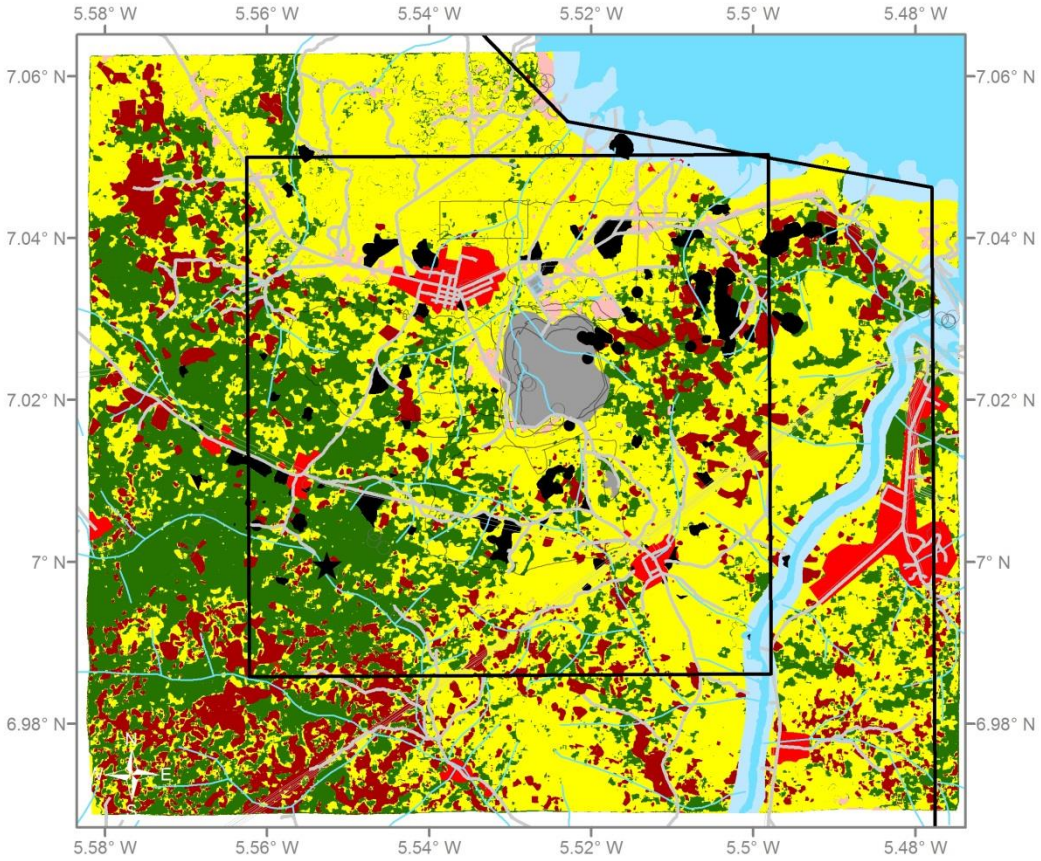

Legend: IUCN categories i-v outlined in dark green, other PAs in light green with recent forest losses (red) and gains (blue) from 2000 to 2013 (see Hansen et al. 2013 for details) and the study area (outer and inner exploration licences).

**Figure 2.4 Details of the study area**




Legend: Lake Kossou and rivers in blue, roads in grey (single line), power lines (double lines), majority of GPS tracks (green), recorded amphibians and reptiles (black circles) and the study area (outer and inner exploration licences).

**Figure 2.5 Detailed land cover map of the study area**




Legend: Land cover classification based on a QuickBird satellite image provided by Amec Foster Wheeler. Main depicted habitat features are: degraded secondary forests (green); agricultural fields (dark red); settlements (light red); savannahs (yellow); sacred sites (black) and mining infrastructure (grey). Roads, power lines and sampling sites have been added as in Figure 2.4. The one locality of *Hyperolius* sp. recorded within the Inner Exploration Licence (see section 3.2.1) is added as well (black star).

**Figure 2.6 Recent destruction of the gallery forest along the Bandama River**

Legend: The river bank has completely been destroyed by the ''illegal Chinese mine''. Artisanal mining by locals is taking place in the degraded area on a smaller scale. The photos were taken at N6.9815° W5.9815.

## 2.3 Sampling Methodology

Reptiles and amphibians were surveyed during the day and night via visual and acoustic encounter surveys in suitable habitats (Heyer et al. 1993; Rödel & Ernst 2004; Veith et al. 2004). More specifically, individuals were either identified by their unique advertisement calls (amphibians) and/or identified on sight. Additionally, drift fences (material: black plastic: straight line, 30m long, 1m high) with funnel traps (material: wire mesh, n = 16, 8 traps on each side) were set up (see Figure 2.7). Unfortunately, conditions were not ideal because very few suitable trapping sites were found. The reason was that disturbance by humans or cattle were too high in most sites and that traps have to be checked twice per day (to avoid death of trapped animals by overheating and/or predators) which was also not possible in most sites due to the long daily distances travelled by car each day. Traps were set up at two localities (see Appendix B) and left in place from 3rd to 12th of May (Trap 1a & 1b: disturbed open area inside mining pit with flat standing water and low herbaceous cover) and 13th to 18th of May (Trap 2: secondary gallery forest along Bandama River, from forest edge into the forest). Trap site 1 did not permit the installation of a single 30m fence line and thus the fence was split in half and set up in two different areas but close to each other.

When species identification was unclear and where necessary, voucher specimens were collected. These were euthanized with chlorobutanol (amphibians) or benzocaine (reptiles). Afterwards, DNA samples (muscle or liver tissue) were collected and specimens fixed in formaldehyde (4%). All vouchers were stored in ethanol (75%) and

were deposited in the herpetological collection of the Museum für Naturkunde Berlin, Germany.

**Figure 2.7 Trap set up**

Legend: Trap set up at site 1b. The drift fence is clearly visible; the funnel traps are harder to see because they were covered with vegetation matter to avoid desiccation of captured individuals.

Interviews were conducted with all assistants as well as other staff of Amara to find out which species of amphibians and reptiles might occur in the area. In addition, similar questions were asked when introductions to local chiefs were made, in the villages of Doulabougou and Lotanzia, and in targeted villages along the Bandama River (see section 3.2). Further interviews were conducted in villages along the Bandama River to assess whether crocodiles were still present in the area (see section 3.1.1).

## 2.4 Analyses

Most species were identified to species level based on acoustic, morphological and/or genetic characters. Morphological analyses took place on site or in the laboratory of the Natural History Museum Berlin. Genetic analysis used approximately 550 base pairs of 16S rRNA and compared them to sequences of published (GenBank 2015) and unpublished sequences. Genetic laboratory work was conducted by “Services in Molecular Biology GmbH, Berlin, Germany”. Statistical analyses are described in the respective chapters.

# 3.0 RESULTS

## 3.1 Reptiles

Overall, we recorded 35 species of reptiles, 31 of them by direct observation and four were deduced from interviews. In addition, based on literature data, 39 species could potentially occur in the study area (see Table 3.1 for details). However, all species depend on intact forests (e.g. *Cnemaspis spinicollis*, *Holaspis guentheri*, *Varanus ornatus*) are unlikely to occur in the area today as significant patches of intact forest have disappeared from the area. In general, a complete list of snakes is always impossible to obtain within such short time frames because their cryptic behaviour makes them a very hard to detect study group. This is especially true for two families of burrowing snakes (Typhlopidae & Leptotyphlopidae) which live exclusively in the earth and mostly feed on ant and termite eggs. Knowledge is so scarce on these species that they were completely omitted from the analyses. Targeted surveys with a different sampling regime are required to gather more knowledge on snakes. Other misses of species which might occur can be attributed to the very low amounts of rainfall.

**Table 3.1 List of reptile species**

| Scientific name | English name | Info | IUCN RL | CITES | EU | Cons.conc. |
|---|---|---|---|---|---|---|
| **Order: Testudines**  | **Suborder: Cryptodira** | **Family: Testudinidae** | | | | |
| *Kinixys* sp. | Hingeback Tortoise | i(i) | NA | II | B | y |
| *Kinixys homeana* Bell, 1827 | Home's Hingeback Tortoise | i(l) | VU↓ | II | B | y |
| Order: Testudines  | Suborder: Cryptodira | **Family: Trionychidae** | | | | |
| *Trionyx triunguis* (Forskål, 1775) | Nil Soft-shelled Turtle | i(l) | NE | | | y |
| Order: Testudines  | Suborder: Pleurodira | **Family: Pelomedusidae** | | | | |
| *Pelusios castaneus* (Schweigger, 1812) | African Mud Turtle | d(s) | NE | | | y |
| *Pelusios cupulatta* Bour & Maran, 2003 | Ivory Coast Mud Turtle | i(l) | NE | | | y |
| **Order: Squamata**  | **Suborder: Sauria** | **Family: Agamidae** | | | | |
| *Agama agama* (Linnaeus, 1758) | Common Agama | d(s) | NE | | | n |
| Order: Squamata  | Suborder: Sauria | **Family: Chamaeleonidae** | | | | |
| *Chamaeleo gracilis* Hallowell, 1844 | Graceful Chameleon | d(s) | LC | II | B | y |
| Order: Squamata  | Suborder: Sauria | **Family: Eublepharidae** | | | | |
| *Hemitheconyx caudicinctus* (Duméril, 1851) | Fat-tail Gecko | i(l) | LC? | | | n |
| Order: Squamata  | Suborder: Sauria | **Family: Gekkonidae** | | | | |
| *Cnemaspis spinicollis* (Müller, 1907) | Spiny-necked Forest Gecko | i(l) | NE | | | n |
| *Lygodactylus conraui* Tornier, 1902 | Conrau's Dwarf Gecko | i(l) | NE | | | y |

| Scientific name | English name | Info | IUCN RL | CITES | EU | Cons.conc. |
|---|---|---|---|---|---|---|
| *Hemidactylus angulatus* Hallowell, 1854 | African House Gecko | d(s) | NE | | | n |
| *Hemidactylus fasciatus* Gray, 1842 | Banded Leaf-toed Gecko | d(s) | NE | | | y |
| *Hemidactylus mabouia* (Moreau de Jonnès, 1818) | House Gecko | d(s) | NE | | | n |
| *Hemidactylus* cf. *muriceus* Peters, 1870 | Guinea Leaf-toed Gecko | d(s) | NE | | | y |
| Order: Squamata  | Suborder: Sauria | **Family: Lacertidae** | | | | |
| *Holaspis guentheri* Gray, 1863 | Sawtail Lizard | i(l) | NE | | | n |
| Order: Squamata  | Suborder: Sauria | **Family: Scincidae** | | | | |
| *Mochlus brevicaudis* (Greer et al., 1985) | Short-tailed Writhing Skink | i(l) | LC? | | | n |
| *Mochlus guineensis* (Peters, 1879) | Guinea Writhing Skink | i(l) | LC? | | | n |
| *Panaspis togoensis* (Werner, 1902) | Togo Lidless Skink | d(s) | LC? | | | n |
| *Panaspis tristaoi* (Monard, 1940) | Triastao's Lidless Skink | i(l) | NE | | | n |
| *Trachylepis affinis* (Gray, 1838) | Senegal Skink | d(s) | NE | | | n |
| *Trachylepis buettneri* (Matschie, 1893) | Buettner's Skink | i(l) | NE | | | n |
| *Trachylepis maculilabris* (Gray, 1845) | Speckle-lipped Skink | i(l) | NE | | | n |
| *Trachylepis perroteti* (Duméril & Bibron, 1839) | Orange-flanked Skink | d(s) | NE | | | n |
| Order: Squamata  | Suborder: Sauria | **Family: Varanidae** | | | | |
| *Varanus niloticus* (Linnaeus, 1766) | Nile Monitor Lizard | d(s) | NE | II | B | y |
| *Varanus ornatus* (Daudin, 1803) | Ornate Monitor Lizard | i(l) | NE | II | B | y |
| **Order: Squamata**  | **Suborder: Ophidia** | **Family: Colubridae** | | | | |
| *Crotaphopeltis hotamboia* (Laurenti, 1768) | White-lipped Herald Snake | d(s) | NE | | | n |
| *Crotaphopeltis hippocrepis* (Reinhardt, 1843) | Horseshoe Herald Snake | i(l) | NE | | | n |
| *Dasypeltis confusa* Trape & Mané, 2006 | Confusing Egg Eater | d(s) | NE | | | n |
| *Dasypeltis fasciata* Smith, 1849 | Forest Egg Eater | d(s) | LC? | | | n |
| *Dasypeltis parascabra* Trape et al., 2012 | Additional Common Egg Eater | d(s) | LC | | | n |
| *Dipsadoboa unicolor* Günther, 1858 | Günther's Green Tree Snake | i(l) | NE | | | n |
| *Dipsadoboa viridis* (Peters, 1869) | Green Tree Snake | d(s) | NE | | | n |
| *Hapsidophrys* cf. *lineatus* Fischer, 1856 | Black-lined Green Snake | d(s) | NE | | | n |
| *Hapsidophrys smaragdina* (Schlegel, 1837) | Emerald Snake | i(l) | NE | | | n |
| *Meizodon coronatus* (Schlegel, 1837) | Western Crowned Snake | i(l) | NE | | | n |
| *Meizodon regularis* Fischer, 1856 | Eastern Crowned Smooth Snake | i(l) | NE | | | n |
| *Philothamnus* cf. *carinatus* (Andersson, 1901) | Green Snake | d(s) | NE | | | n |
| *Philothamnus irregularis* (Leach, 1819) | Irregular Green Snake | d(s) | LC? | | | n |
| *Philothamnus heterolepidotus* (Günther, 1863) | Slender Green Snake | i(l) | NE | | | n |
| *Thelotornis kirtlandii* (Hallowell, 1844) | Vine Snake / Twig Snake | d(s) | NE | | | n |
| *Toxicodryas blandingii* (Hallowell, 1844) | Blanding's Tree Snake | i(l) | NE | | | n |
| Order: Squamata  | Suborder: Ophidia | **Family: Elapidae** | | | | |
| *Dendroaspis viridis* (Hallowell, 1844) | Western Green Mamba | d(s) | LC | | | n |
| *Elapsoidea semiannulata* Bocage, 1882 | Angolan Garter Snake | i(l) | NE | | | n |
| *Naja* (*Afronaja*) *nigricollis* Reinhardt, 1843 | Black-necked Spitting Cobra | d(s) | NE | | | n |
| *Naja* (*Boulengerina*) *melanoleuca* Hallowell, 1857 | Forest Cobra | d(p) | NE | | | n |

| Scientific name | English name | Info | IUCN RL | CITES | EU | Cons.conc. |
|---|---|---|---|---|---|---|
| Order: Squamata  | Suborder: Ophidia | **Family: Lamprophiidae** | | | | |
| *Amblyodipsas unicolor* (Reinhardt, 1843) | Purple-glossed Snake | d(s) | NE | | | n |
| *Aparallactus modestus* (Günther, 1859) | Western Forest Centipede-eater | i(l) | NE | | | n |
| *Boaedon fuliginosus* (Boie, 1827) | Brown House Snake | i(l) | NE | | | n |
| *Boaedon lineatus* Duméril et al., 1854 | Striped House Snake | d(s) | NE | | | n |
| *Boaedon olivaceus* (Duméril, 1856) | Olive House Snake | i(l) | NE | | | n |
| *Gonionotophis crossi* (Boulenger, 1895) | Crosse's File Snake | i(l) | NE | | | n |
| *Gonionotophis grantii* (Günther, 1863) | Savanna Lesser File Snake | i(l) | NE | | | n |
| *Gonionotophis klingi* Matschie, 1893 | Matschie's African Ground Snake | d(s) | LC? | | | n |
| *Gonionotophis poensis* (Smith, 1849) | Western Forest File Snake | i(l) | NE | | | n |
| *Lycophidion irroratum* (Leach, 1819) | Leach's Wolf Snake | i(l) | NE | | | n |
| *Lycophidion nigromaculatum* (Peters, 1863) | Black-spotted Wolf Snake | i(l) | LC | | | n |
| *Lycophidion semicinctum* (Duméril et al., 1854) | Banded Wolf Snake | i(l) | LC? | | | n |
| *Lycophidion* sp. | Wolf Snake | d(s) | NA | | | n |
| *Psammophis elegans* (Shaw, 1802) | Elegant Sand Racer | d(s) | NE | | | n |
| *Psammophis lineatus* (Duméril et al., 1854) | Lined Olympic Snake | d(s) | NE | | | n |
| *Psammophis phillipsi* (Hallowell, 1844) | Phillip's Sand Racer | i(l) | NE | | | n |
| Order: Squamata  | Suborder: Ophidia | **Family: Natricidae** | | | | |
| *Afronatrix anoscopus* (Cope, 1861) | African Brown Water Snake | d(s) | LC | | | n |
| *Natriciteres olivacea* (Peters, 1854) | Olive Marsh Snake | i(l) | LC? | | | n |
| *Natriciteres variegata* (Peters, 1861) | Variable Marsh Snake | i(l) | NE | | | n |
| Order: Squamata  | Suborder: Ophidia | **Family: Pythonidae** | | | | |
| *Calabaria reinhardtii* (Schlegel, 1848) | Calabar Burrowing Python | i(l) | NE | II | B | y |
| *Python regius* (Shaw, 1802) | Ball Python | d(p) | LC? | II | B | y |
| *Python sebae* (Gmelin, 1789) | Rock Python | i(i) | NE | II | B | y |
| Order: Squamata  | Suborder: Ophidia | **Family: Viperidae** | | | | |
| *Bitis arietans* Merrem, 1820 | Puff Adder | i(i) | NE | | | y |
| *Bitis rhinoceros* (Schlegel, 1855) | West African Gaboon Viper | i(i) | LC? | | | y |
| *Causus maculatus* (Hallowell, 1842) | Spotted-African Night Adder | i(l) | NE | | | n |
| *Echis ocellatus* Stemmler, 1970 | West African Carpet Viper | i(l) | NE | | | n |
| **Order: Crocodylia**  | **Suborder: Eusuchia** | **Family: Crocodylidae** | | | | |
| *Crocodylus suchus* Geoffrey, 1807 | West African Crocodile | n | NE | | B | y |
| *Mecistops cataphractus* (Cuvier, 1825) | Slender-snouted Crocodile | i(l) | CR↓ | I | A | y |
| *Osteolaemus* cf. *tetraspis* Cope 1861 | Dwarf Crocodile | i(l) | VU? | I | A | y |

The first two columns give the scientific and English names. The third one indicates the type of evidence: indirect (gained from interviews and likely to occur (i) or from literature (l; from Chippaux 2006 for Ophidia; from Shirley et al. 2009 for crocodiles; from Trape et al. 2012 for all other groups, depicted in grey), direct (d) (observed directly by us (s) or from provided photos (p)). The global Red List status of the International Union for Conservation of Nature (IUCN RL) and the population trends (increasing = ↑, decreasing = ↓, unknown = ?; stable = left blank), the respective appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the regulation

1320/2014 of the European Union (EU) are given as well as the indication whether the species is of conservation concern for the current Environmental Impact Assessment, yes (y) or no (n; see text for more details on this column).

### 3.1.1 Reptiles of Conservation Concern

None of the species recorded during our survey are listed as threatened or near threatened on the current IUCN Red List (IUCN 2015). Most species (24) we recorded are not assessed yet. Ten species are listed as “Least Concern”. Two potentially occurring species of crocodiles are listed as “Critically Endangered” and “Vulnerable”.

Crocodiles are large, charismatic reptiles and in Côte d’Ivoire three different species can be found. During a survey in 2006, four localities close to the Amara concession were checked for crocodiles: Marahoué River, Lac de Kossou, Yamoussoukro and Bandama River (Shirley et al. 2009). *Crocodylus suchus* (formerly listed as *Crocodylus niloticus*, but considered to be a distinct species, Schmitz et al. 2003) was recorded from Yamoussoukro and the Bandama River. Though the species is not listed as threatened but as “Least Concern” on the IUCN Red List, it is certainly harvested in the wild as bush meat whenever possible, and thus of conservation concern. The two other species are listed as threatened and both were noted for the Bandama River (Shirley et al. 2009). *Mecistops cataphractus* is mostly a fish feeder and needs a good forest cover along large parts of intact flowing streams. In addition, the species is very sensitive to human disturbance and considered to be extinct from a number of sites, listing it as “Critically Endangered” (Waitkuwait 1989, IUCN 2015). In Côte d’Ivoire, populations have already been reduced significantly (Waitkuwait 1989). Furthermore, the species range is divided into two distinct areas, with no genetic exchange, justifying a taxonomic split so that the West African population is an own valid species with an even smaller distribution (Shirley et al. 2014). *Osteolaemus tetraspis* depends on at least partly shaded areas, along larger standing waters or calm areas along rivers (Pauwels et al. 2007), preferring swampy areas and utilising burrows along the edge of the water (Villiers 1956, Waitkuwait 1986, 1989). It is currently listed as “Vulnerable” by the IUCN Red List and under appendix I in CITES, mainly because of habitat loss and over exploitation (Ross 1998), which has resulted in severe population declines (Riley & Huchzermeyer 1999). Similarly to *M. cataphractus*, genetic and morphological analyses indicate that the two spatially separate distributions of *O. tetraspis* represent two separate species (Brochu 2007, Eaton et al. 2009), leaving the West African taxon with a much smaller overall distribution. *M. cataphractus* and especially *O. tetraspis* are under enormous pressure by unsustainable bush meat hunting (e.g. Hutton 1991, Behra 1993a, b, Thorbjarnarson 1999, Shirley et al. 2009, Zoer 2012). In combination with ongoing habitat loss both species are immensely imperilled.

During our survey we did not record any crocodiles or any signs of their presence in the concession. Interviews with locals (including village chiefs as well as fishermen) were conducted in the villages of Bozi, Amanifa and Toumbokro. All indicated that during the past crocodiles were encountered in the Bandama River until around approximately 10 years ago. No crocodiles were encountered during the past years in areas surrounding these localities. In the stretch of the Bandama River further south of the concession, few

individuals are occasionally encountered. It was also mentioned that the recent mining activities by the Chinese along the Bandama River not only completely destroyed the remaining gallery forests, the river bank and the potential places for sheltering burrows (for *O. tetraspis*; see Figure 2.6) but also altered water quality and fish (their main prey; e.g. Luiselli et al. 1999) have become scarce. The absence of a species or its local extinction is always very difficult to prove. We conclude that it is highly unlikely that currently any significant crocodile populations exist inside the concession. However, for several reasons it is important to restore the destroyed river bank and to monitor the possible recolonization and/or increase of the crocodile populations in the portion of the Bandama River included in the concession (i.e. dedicated night surveys by specialists to assure that the similar looking juveniles of *C. suchus* and *M. cataphractus* are properly recognised).

A number of other reptile species occurring in the area are also harvested regularly for several purposes (see Figure 3.1). The most common one is the use as a protein source (bush meat). This concerns crocodiles, the tortoises (*Kinixys* sp.), terrapins (*Pelusios castaneus*), large vipers (*Bitis arietans*, *Bitis rhinoceros*), pythons (*Python regius*, *Python sebae*) and Nile monitors (*Varanus niloticus*). Graceful chameleons (*Chamaeleo gracilis*) are also regularly caught and often used as fetish. In neighbouring countries in West Africa this species is also exported in high numbers in the pet trade (e.g. Carpenter et al. 2004). The vast majority of snakes are generally killed whenever encountered because people do not distinguish between dangerous and harmless species and mostly assume every snake to be dangerous.

For all above mentioned species the magnitude of the impact on their populations is generally unknown. However, estimates indicate that it might be detrimental (Gibbons et al. 2000, Reading et al. 2010). In order to properly investigate population trends, dedicated long-term studies are needed.

**Figure 3.1 Harvested reptile species of the study area**

Legend: Reptile species of the study area which are of conservation concern due to unsustainable harvesting: *Pelusios castaneus* (left top), *Python regius* (left middle; picture by Jan Mertens), *Python sebae* (left bottom; picture from Guinea by Johannes Penner & Michael F. Barej), *Bitis arietans* (middle top; picture from South Africa by Mark-Oliver Rödel), *Bitis rhinoceros* (middle middle; picture from Liberia by Johannes Penner), *Varanus niloticus* (middle bottom) and *Chameleo gracilis* (right side).

Two species are considered range restricted species: *Hemidactylus fasciatus* and *Hemidactylus* cf. *muriceus* (see Figure 3.2).

*Hemidactylus fasciatus* - The species was recently split in five distinct species (Leaché & Fujita 2010, Wagner et al. 2014). *H. fasciatus* occurs only in the Upper Guinea forests in Guinea, Liberia, Côte d'Ivoire and Ghana. These forests are highly threatened (see introduction and Figure 2.3), resulting in large habitat losses for species like *H. fasciatus*. Due to its dependence on forests, the species is considered to be an indicator of forests.

*Hemidactylus* cf. *muriceus* - The species has a widespread distribution across forests in West Africa, including Cameroon, Central African Republic, Gabon and Republic of Congo. However, previous analysis revealed that it is a species complex and several cryptic species are hidden (Penner et al. unpublished). Therefore, the distribution of the species occurring within the concession is unknown but substantially smaller. As a forest dependent species, habitat loss is also the biggest threat for the species.

**Figure 3.2 Range restricted reptile species of the study area**

Legend: Range restricted reptile species from the concession which are therefore of conservation concern: *Hemidactylus fasciatus* (left) and *Hemidactylus cf. muriceus* (right).

No snake species were recorded which are unique to the site. However, snake populations are probably declining globally (Reading et al. 2010) and especially in combination with bush meat hunting some species might become locally extinct.

## 3.2 Amphibians

The previous ESIA (Tano et al. 2007) mentioned two noteworthy amphibian species: *Amietophrynus taiensis* and *Nimbaphrynoides occidentalis* (formerly called *Nectophrynoides occidentalis* but see Sandberger et al. 2010). The latter species is well known and only occurs on the Nimba Mountain range along the border between Liberia, Guinea and Côte d'Ivoire. It only occurs above 1200m a.s.l. in high altitude grasslands (Angel & Lamotte 1948, Hillers et al. 2008b). Thus there is no suitable habitat available inside the concession and it was only mentioned in the previous ESIA (Tano et al. 2007), and the species has no relevance for the study area. *Amietophrynus taiensis* is currently only recorded from intact lowland primary rainforests of the Taï National Park in south-western Côte d'Ivoire and the Gola National Park in Sierra Leone (Rödel & Ernst 2000, IUCN 2015). It might occur in similar forests in Liberia which is still comparatively under sampled but was not recorded during the last 5 years (Penner et al. unpublished). Furthermore, the potential occurrence of *Kassina arboricola* was also mentioned (Rogers 2014, based on literature reviews). However, this species also occurs only in intact lowland primary rainforests and was not recorded from comparable sites (see Table 3.2). There is no suitable habitat for both species inside the Amara concession and in regard of missing voucher specimens, as well as photos, we currently doubt the validity of the record of *A. taiensis* and the presence of *K. arboricola*.

**Table 3.2 List of amphibian species**

| Scientific name | English name | Info | IUCN RL | Cons.conc. |
|---|---|---|---|---|
| **Family: Arthroleptidae**  | | | | |
| *Arthroleptis* spp. | Squeaking Frogs | d | NE | n |
| *Leptopelis macrotis* Schiøtz, 1967 | Big-eyed Treefrog | i(10) | NT↓ | y |
| *Leptopelis spiritusnoctis* Rödel, 2007 | Spirit of the Night Treefrog | d | LC? | n |
| *Leptopelis viridis* (Günther, 1869) | Green Treefrog | d | LC? | n |
| **Family: Bufonidae**  | | | | |
| *Amietophrynus maculatus* (Hallowell, 1854) | Hallowell's Toad | i(03/10) | LC | n |
| *Amietophrynus regularis* (Reuss, 1833) | Common African Toad | d | LC | n |
| *Amietophrynus taiensis* (Rödel & Ernst, 2000) | Taï Tree Toad | i(07) | CR | y |
| **Family: Dicroglossidae**  | | | | |
| *Hoplobatrachus occipitalis* (Günther, 1858) | African Groove-crowned Frog | d | LC | n |
| **Family: Hemisotidae**  | | | | |
| *Hemisus guineensis* Cope, 1865 | Guinea Shovel-nosed Frog | d | LC? | n |
| **Family: Hyperoliidae**  | | | | |
| *Afrixalus dorsalis* (Peters, 1875) | Striped Spiny Reed Frog | d | LC↑ | n |
| *Afrixalus nigeriensis* Schiøtz, 1963 | Nigeria Banana Frog | i(10) | NT | y |
| *Afrixalus vittiger* (Peters, 1876) | Savannah Banana Frog | d | LC? | y |
| *Afrixalus weidholzi* (Mertens, 1938) | Weidholz's Banana Frog | d | LC | n |
| *Hyperolius concolor* (Hallowell, 1844) | Variable Reed Frog | d | LC↑ | n |
| *Hyperolius fusciventris* Peters, 1876 | Lime Reed Frog | i(10) | LC? | n |
| *Hyperolius* cf. *guttulatus* Günther, 1858 | Dotted Reed Frog | d | LC? | n |
| *Hyperolius lamottei* Laurent, 1958 | Lamotte's Reed Frog | i(10) | LC? | n |
| *Hyperolius igbettensis* Schiøtz, 1963 | Igbetti Long Reed Frog | d | LC? | y |
| *Hyperolius nitidulus* Peters, 1875 | Plain Reed Frog | d | LC | n |
| *Hyperolius picturatus* Peters, 1875 | Variable Reed Frog | i(10) | LC? | n |
| *Hyperolius* sp.1 | Reed Frog | d | NE | y |
| *Kassina arboricola* | Arboreal Running Frog | i(14) | VU↓ | y |
| *Kassina schioetzi* Rödel et al. 2002 | Schiøtz's Running Frog | d | LC? | y |
| *Kassina senegalensis* Duméril & Bibron, 1841) | Senegal Running Frog | d | LC? | n |
| **Family: Microhylidae**  | | | | |
| *Phrynomantis microps* Peters, 1875 | Red Rubber Frog | d | LC? | n |
| **Family: Phrynobatrachidae**  | | | | |
| *Phrynobatrachus calcaratus* (Peters, 1863) | Peter's Puddle Frog | d | LC | n |
| *Phrynobatrachus francisci* Boulenger, 1912 | Francisc's Puddle Frog | d | LC? | n |
| *Phrynobatrachus latifrons* Ahl, 1924 | Ahl's Puddle Frog | d | LC | n |
| *Phrynobatrachus gutturosus* (Chabanaud, 1921) | Chabanaud's Puddle Frog | i(03) | LC? | n |
| *Phrynobatrachus natalensis* (Smith, 1849) | Natal Puddle Frog | i(03) | LC | n |

| Scientific name | English name | Info | IUCN RL | Cons.conc. |
|---|---|---|---|---|
| *Phrynobatrachus phyllophilus* (Rödel & Ernst, 2002) | Leaf-loving Puddle Frog | i(10) | NT↓ | y |
| *Phrynobatrachus plictaus* (Günther, 1858) | Coast Puddle Frog | i(03) | LC? | n |
| **Family: Pipidae**  | | | | |
| *Xenopus tropicalis* (Gray, 1864) | Forest Clawed Frog | d | LC? | n |
| **Family: Ptychadenidae**  | | | | |
| *Ptychadena aequiplicata* (Werner, 1898) | Victoria Grassland Frog | i(03/10) | LC | y |
| *Ptychadena bibroni* (Hallowell, 1845) | Broad-banded Grass Frog | d | LC? | n |
| *Ptychadena longirostris* (Peters, 1870) | Snouted Grassland Frog | i(03/10) | LC? | n |
| *Ptychadena mascareniensis* (Duméril & Bibron, 1841) | Mascarene Grass Frog | i(10) | LC? | n |
| *Ptychadena* cf. *oxyrhynchus* (Smith, 1849) | Sharp-nosed Rocket Frog | i(03/10) | LC | n |
| *Ptychadena pumilio* (Boulenger, 1920) | Pygmy Grass Frog | i(10) | LC? | n |
| *Ptychadena schillukorum* (Werner, 1908) | Schilluk Grass Frog | i(03) | LC? | n |
| *Ptychadena tellinii* (Peracca, 1904) * | Tellini's Grass Frog | d | LC? | n |
| *Ptychadena tournieri* (Guibé & Lamotte, 1955) | Tournier's Rocket Frog | i(10) | LC? | n |
| *Ptychadena trinodis* (Boettger, 1881) | Dakar Grassland Frog | d | LC? | n |
| *Ptychadena* sp. 1 | Grass Frog | d | NE | n |
| **Family: Pyxicephalidae**  | | | | |
| *Aubria occidentalis* Perret, 1995 | West African Brown Frog | d | LC? | n |
| **Family: Ranidae**  | | | | |
| *Hylarana albolabris* (Hallowell, 1856) | Forest White-lipped Frog | d | LC? | n |
| *Hylarana galamensis* (Duméril & Bibron, 1841) | Galam White-lipped Frog | d | LC? | n |
| **Family: Rhacophoridae**  | | | | |
| *Chiromantis rufescens* (Günther, 1869) | African Foam-nest Frog | i(03/10) | LC? | n |

Legend: The first two columns give the scientific and English names. The third one indicates the type of evidence: direct (d) (observed directly by us) or indirect (i) (when gained from the literature: Rödel & Ernst 2003, Tano et al. 2007, Adeba et al. 2010, Rogers 2014 and not recorded during the present survey, depicted in grey). The global Red List status of the International Union for Conservation of Nature (IUCN RL), the population trends (increasing = ↑, decreasing = ↓, unknown = ?; stable = left blank) and the indication whether the specie is of conservation concern for the current Environmental Impact Assessment, yes (y) or no (n; see text for more details on this column) are given in the last two columns. Please note that *Ptychadena schubotzi* is currently considered a synonym of *Ptychadena tellinii* (Largen 2001) [marked with an *], thus we listed our specimens under the latter name. However, it is likely that the West African populations will regain separate species status in the near future.

It should be noted that *Hyperolius* sp. might be a new species but see the following section 3.2.1. *Ptychadena* sp. is definitively not a new species but the collected individuals are currently not assignable to known species already included in the list.

### 3.2.1 Amphibians of Conservation Concern

Most amphibian species recorded in the concession are known to occur all over forests and savannahs of West Africa. Due to the fact that the study area falls within the transition area between the two biomes, we recorded amphibians from both major habitat classes. Three species are considered to be range restricted species: *Afrixalus vittiger*, *Hyperolius* cf. *igbettensis*, *Kassina schioetzi* (see Figure 3.3). As with all other amphibian species, they suffer from habitat loss, alteration, pollution and fragmentation. Thus all three are of conservation concern.

*Afrixalus vittiger* - A species widespread throughout the savannahs of West Africa, the distribution does not extend east of the river Niger (IUCN 2015). Though the species occurs only in West Africa (see Penner et al. 2011) it is not considered threatened by the global IUCN Red List at the moment.

*Hyperolius* cf. *igbettensis* - The species belonged to the complex *Hyperolius nasutus* and the currently recognized species are notoriously difficult to identify (compare to Amiet 2005, Channing et al. 2002, 2013). Currently, the species is thought to range from central Côte d'Ivoire to western Cameroon only and inhabits savannahs and grassy areas (IUCN 2015).

*Kassina schioetzi* - A species of Guinean woody savannahs with a rather small distributional range, occurring only in Côte d'Ivoire and in a small area around the Nimba Mountains in Guinea where it occurs in syntopy with its sister taxon *K. cochranae* but both species are easily distinguished (Rödel et al. 2002, IUCN 2015).

*Hyperolius* sp. - In total two sites were found which harboured individuals of this taxon (Figure 3.4). At the first site only a single individual was found on a coffee tree close to an old cocoa plantation. At the second site numerous males were calling along a small stream close to a well at the edge of the forest with a cocoa plantation. Three individuals were collected. Both sites were in close proximity. Morphologically they appear to be similar to *Hyperolius picturatus* and *Hyperolius sylvaticus*. However, genetic analysis determined a difference of 3.9% to the most similar species (*H. sylvaticus*, Figure 3.5). In general, a difference above 3% is assumed to be an "objective" threshold for differences between species (Vences et al. 2005 a,b, Fouqeut et al. 2007, Vieites et al. 2009). Calls are similar to *H. picturatus* (see Figure 3.6; however, genetic difference is 6.5 to 6.8%) and unfortunately no other calls of closely related species are currently available. In summary, the species status is unclear and cannot be resolved within the time frame of the current ESIA. Further morphological analyses, genetic and acoustic analyses are required to ascertain whether this really is a valid new species. If it is a valid species, it seems to be threatened because it only occurs at two localities (Figure 3.7) and only in small numbers. However, the species might be able to tolerate some degree of disturbance, and be more widespread and abundant when there is more precipitation.

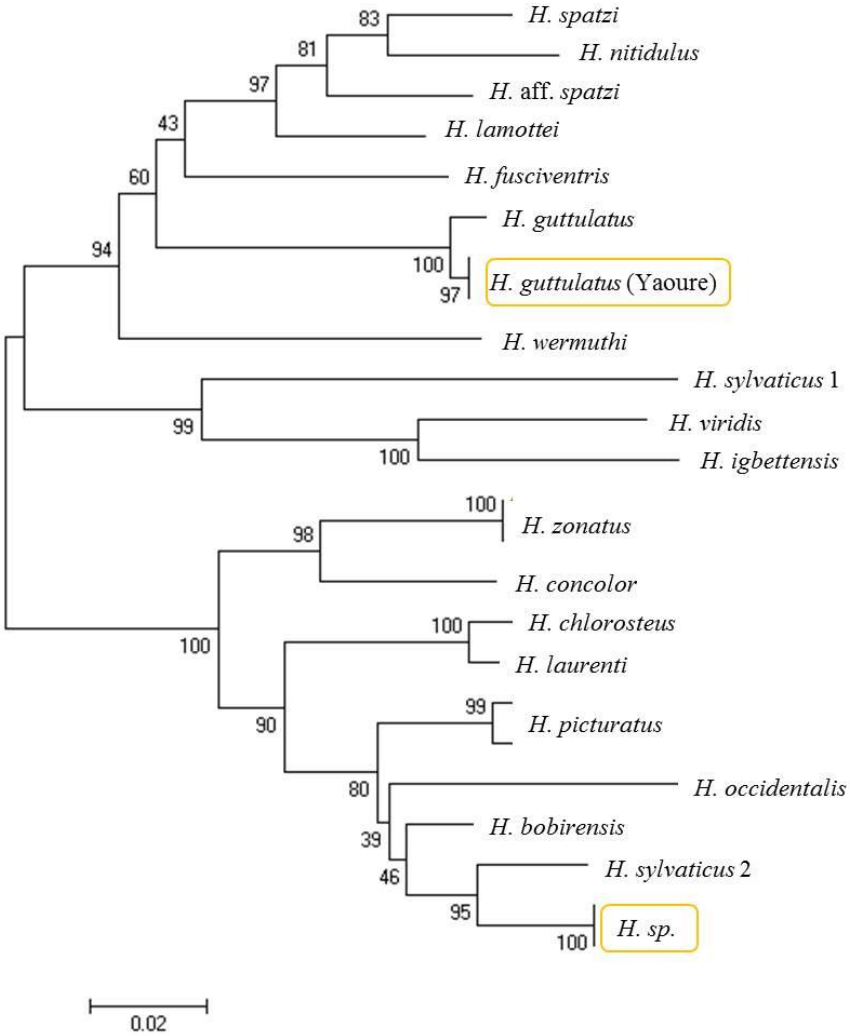
**Figure 3.3 Range restricted amphibian species of the study area**

Legend: Amphibian species which are range restricted and therefore of conservation concern for the study area: *Afrixalus vittiger* (left), *Hyperolius igbettensis* (middle), *Kassina schioetzi* (right).

**Figure 3.4 The tentative new *Hyperolius* species**

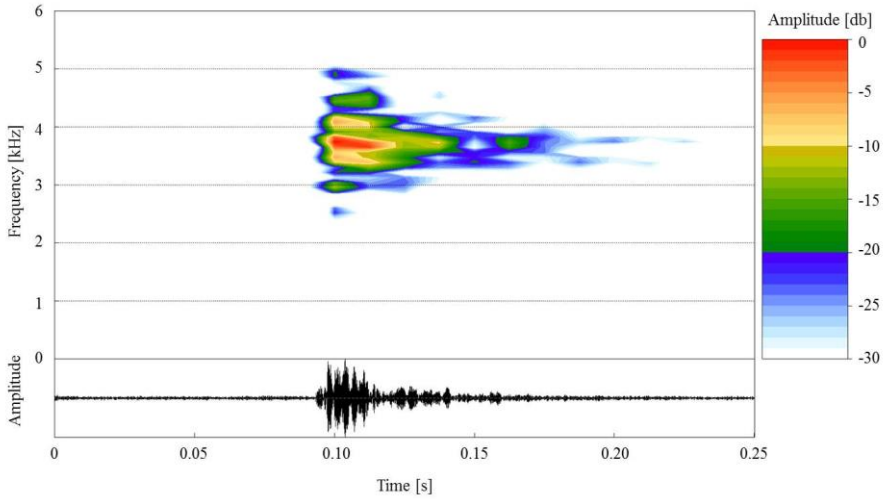
Legend: Pictures of two males of the tentative new species: *Hyperolius* sp. Left: the single male from the coffee tree; centre: the underside of the same male; right: typical colouration of a male from the second site where several were calling.

**Figure 3.5 Preliminary phylogenetic *Hyperolius* tree**



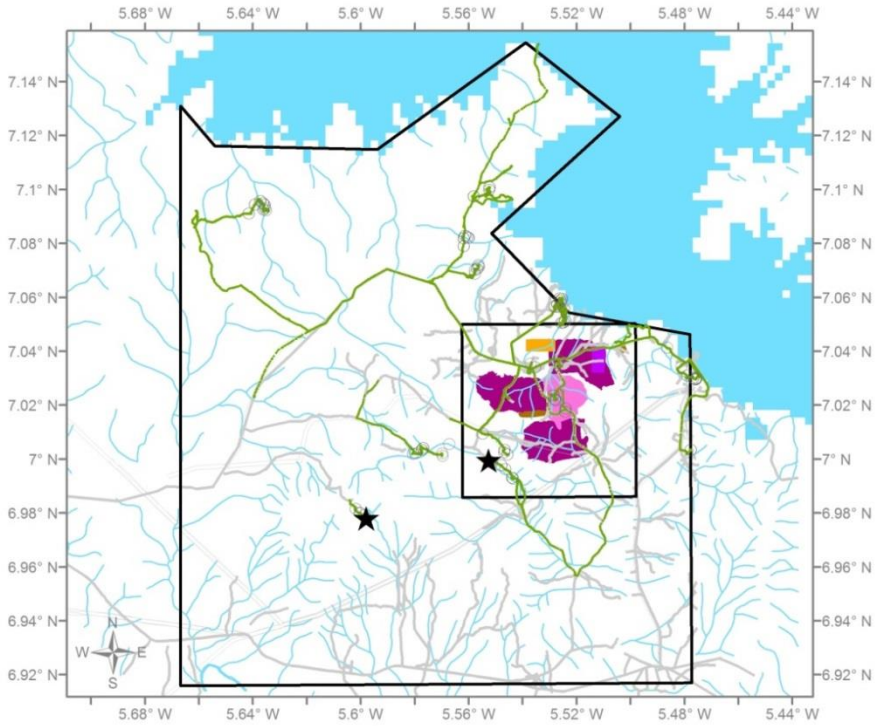

Legend: Neighbour-joining consensus tree with bootstrap values of known *Hyperolius* species from West Africa. The position of the *Hyperolius guttulatus* from Yaoure is shown (7th from top) as well as of the recorded *Hyperolius* sp. (bottom of tree).

**Figure 3.6 Call of *Hyperolius* sp**




Legend: The call is rather short (20ms), has a dominant frequency of ca. 3800 Hz +/- 100Hz (min. 3000Hz, max. 5000Hz) which is also the fundamental frequency. No modulation of the frequency is visible.

**Figure 3.7 Occurrence records of *Hyperolius* sp.**




Legend: Grey open circles represent all recorded amphibian and reptile species, and green tracks the visited areas. Lake Kossou and streams are coloured light blue, roads grey single lines, power lines grey double lines, other colours are the proposed mine infrastructures. The two locations where *Hyperolius* sp. was found are indicated by black stars.

## 3.3 Areas of Conservation Concern

**Forests** - Within the concession, apart from a small forest patch north of Patizia, there appears to be no forest left along smaller streams. Even the forest in Patizia covers only the eastern side of the stream. The western side is converted to cocoa plantations. Given the presence of a few single large trees spread over the southern portion of the concession, we deduce that large forest patches existed but have been transformed, also mostly into cocoa plantations. The hills around Akakro and Bokassou still harbour patches of dry forests on their hilltops and steeper flanks, but have recently been partly selectively logged.

**Bandama River** - On the west side of the Bandama River, directly south of the Kossou dam, tiny degraded patches of gallery forest remain. This river bank is constantly used by fishermen and has recently been invaded by artisanal miners driven away from the "inner exploration licence". The bank presently holds several recently dug pits which also serve as traps for many species. Urgent conservation measures need to be implemented to safeguard this site. Further south, large tracts of gallery forest have been cleared during recent Chinese mining activities. The remaining patches need to be immediately protected and the lost parts be restored.

**Streams** - In general, the concession has very few running waters. One stream flows across the Amara processing site into the savannah to Lake Kossou. Given its disturbed nature, the stream does not appear to be suitable for very diverse amphibian and reptile communities. One natural looking stream flows between the hills of Patizia and Akakro but all forests have been transformed for subsistence farming, allowing no room for forest dependent species.

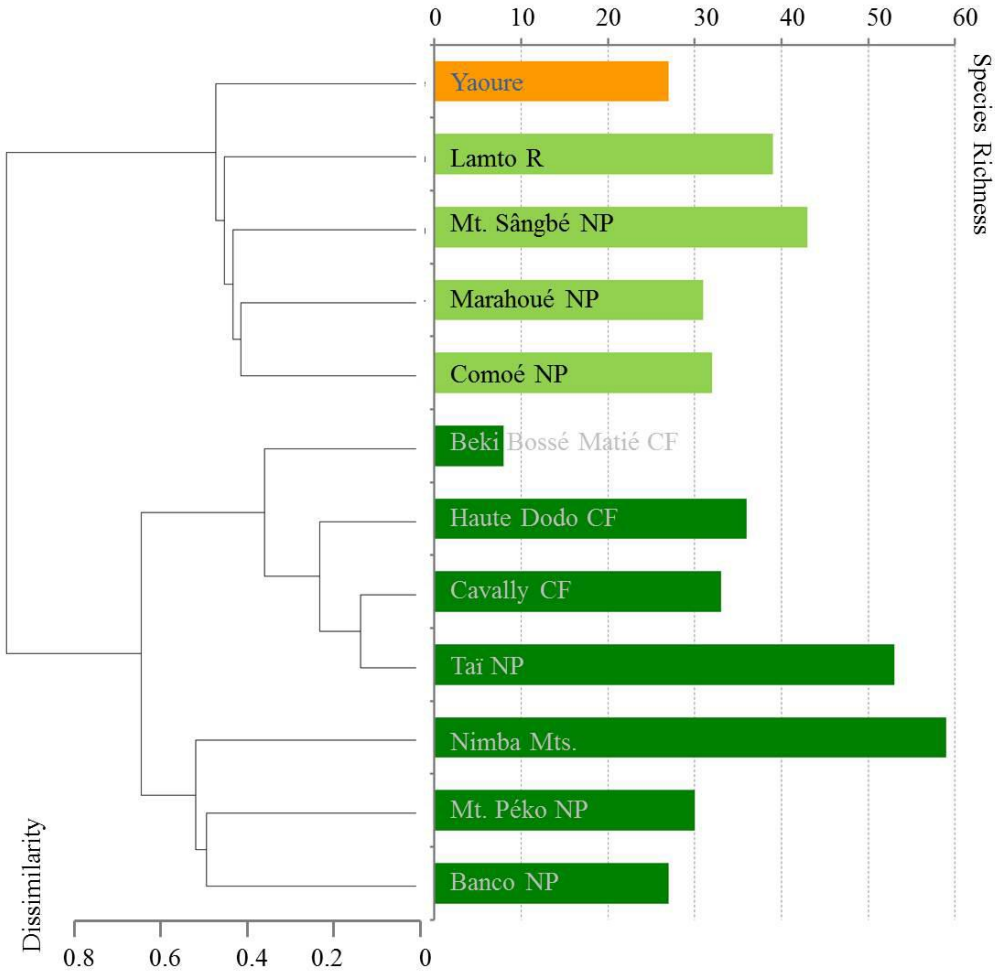
## 3.4 Comparison to other assemblages

Table 3.1 and Table 3.2 detail not only which species were recorded but also which species might be found in the study area. In general, for reptiles it is impossible to gain a near complete species list with such survey techniques (short period of time, opportunistic search in suitable habitats; see also chapter 3.5). However, for amphibians these methods are well suited. A number of well-defined areas exist where the majority of amphibian species is known, called assemblages. We compared the amphibian assemblage recorded during the present survey with historical data from 11 sites in Côte d'Ivoire. The Nimba Mountains have been included, even though most of their surface is located in neighbouring Guinea, because the site holds the highest amphibian species richness in West Africa (Penner et al. 2011).

In order to reveal which sites are similar to each other in terms of their amphibian assemblages, we calculated a consensus cluster based on 15 single clusters. The 15 clusters were gained by using three dissimilarity indices (utilising presence-absence data; Jaccard, Raup-Crick & Mountford) and five clustering algorithms (ward, single, complete, average & mcquitty; see Penner et al. 2011).

Results are shown in Figure 3.8. Assemblages of savannah regions group together and can be clearly distinguished from assemblages from the forest region. Thus despite being located at an ecotone, Yaoure contains predominantly savannah species and most forest species were missing. The most similar sites in terms of amphibian assemblages are located at Lamto and Marahoué. Mt. Sangbé is faunistically similar but different because of its altitude profile. Comoé is further to the north and in general much drier.

**Figure 3.8 Consensus cluster of amphibian assemblages of Côte d'Ivoire**




Legend: The sites located in the savannah biome group at the top (light green) with the Yaoure site (orange), whereas the forest assemblages group at the bottom (dark green). Species richness (number of recorded species) is shown by the length of the bars (see Penner et al. 2011 for more details).

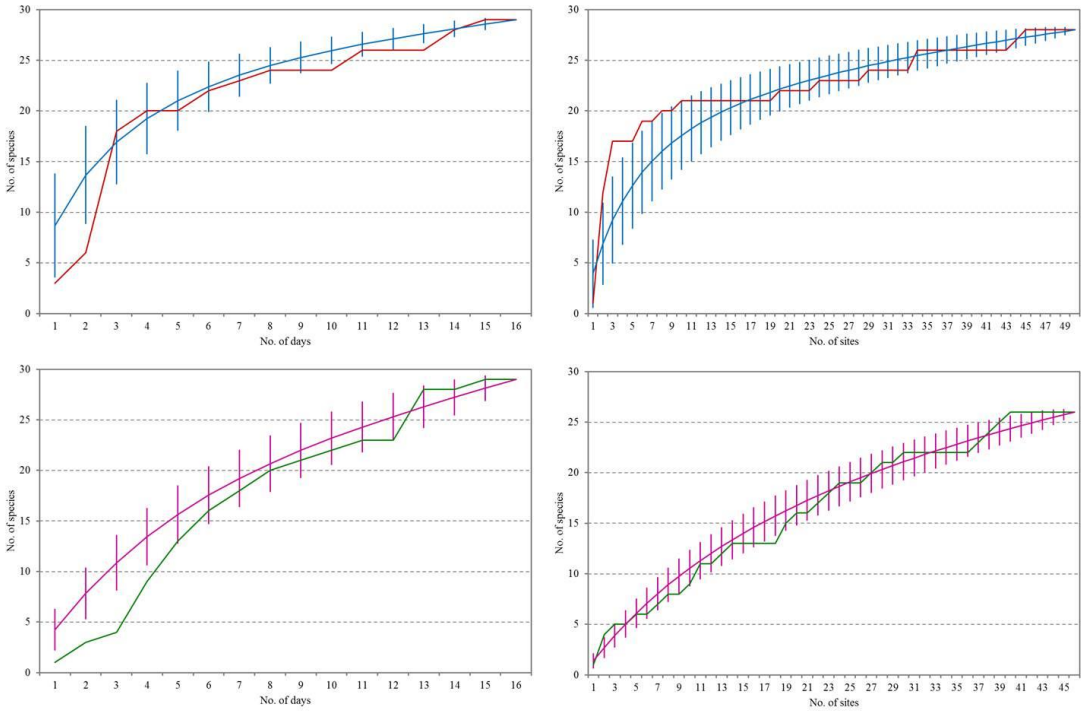
## 3.5 Sampling effort and timing of survey

In general, it is difficult to judge whether sampling effort and timing of the survey have been well suited. One indication is given by the comparison to other known assemblages. Unfortunately data exists only for amphibians and not for reptiles. For

amphibians, Table 3.2 and Figure 3.9 clearly show that more species can be expected for the site. Some species depend on forest habitats (see section 3.3) and therefore might be missing from the site. Others might have been still hard to find due to little rainfall.

There are several ways of estimating how many species might occur in a particular area. In species accumulation curves, species richness is plotted cumulatively over time using observed or estimated mean species richness (after Ugland et al. 2003, Colwell et al. 2004, Kindt et al. 2006). A line reaching asymptotically a horizontal plateau indicates that most species have been recorded. This plateau line cannot be extrapolated. To do that a different method has to be employed, so called estimators (e.g. see short summary in Oksanen et al. 2013).

**Figure 3.9 Species accumulation curves**

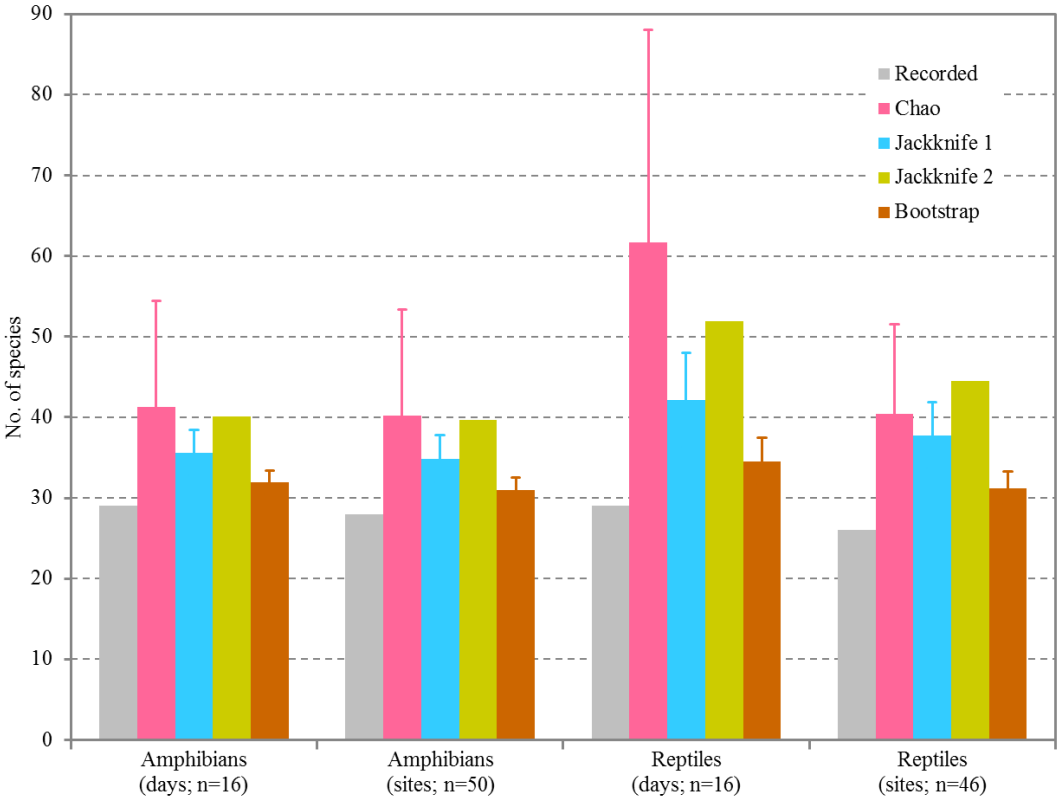



Legend: Top row: amphibians in blue (estimate + standard deviation) and red (cumulative), and bottom row: reptiles in pink (estimate + standard deviation) and green (cumulative); per successful sampling days (left column) and recorded sites (right column).

The species accumulation curves show that in order to detect more amphibian species, a longer survey, meaning more field days, would have yielded more species. Though sampling effort in terms of number of sites visited seems to be relatively well off. For reptiles the curves confirm previous knowledge that the survey was not ideal for this group and a different methodology and much more effort has to be allocated to record reptile biodiversity. Please note that reptiles were not the main focus of the survey but a convenient side product.

Extrapolating what more effort in terms of field days and sites visited could have yielded is shown in Figure 3.10. Employing different estimators, using only the records from the current survey, suggests that around 40 amphibian species and up to 60 reptile species could occur in the study area. Error bars (standard deviation) can be quite high but the overall picture given by four differently calculated estimators is similar.

**Figure 3.10 Estimators of species richness for the study area**




Legend: The grey bar shows the actual number of recorded species and the error bars the standard deviation. For the estimations per days, all records have been taken into account, including records by locals and the traps. For estimates in terms of number of sites visited the records by locals and the traps were left out. Estimators for amphibian richness are shown on the left, for reptiles on the right.

The drift fence and funnel traps were an appropriate method to supplement habitat searches and interviews. Three species were only detected with the traps: *Phrynobatrachus calcaratus* (Amphibia), *Lycophidion* sp. and *Trachylepis perroteti* (both reptiles). Especially secretive snakes such as *Lycophidion* are rarely caught which is the reason why so little is known and why taxonomic assignment is still pending.

## 3.6 Ecosystem services

The value of biodiversity is difficult to measure. Principally biodiversity values can be divided into two large groups: direct and indirect values. These can be further distinguished into consumable and productive use values (direct) and social/cultural,

ethical, aesthetic, option values and environmental services. Not all values can be quantified in monetary terms. However, another way of quantifying the positive effects of biodiversity are co called ecosystem services (ESS). These are one important aspect of biodiversity.

ESS are intuitive if whole systems are considered, but may also apply to the benefit or role a single species or groups of species can have. Herewith we do not summarise the position of the amphibians and reptiles within their respective ecosystems but give few examples on the ESS they provide for humans.

For example, many snake species focus on rodents as food source (Greene et al. 1999) and thereby control rodent populations (Lawson 1993, Lawson & Clemens 2001). Rodents in turn can cause severe damage to harvests, stored food (Sánchez-Cordero & Martínez-Meyer 2000, Stenseth et al. 2004) and may transmit deadly diseases (e.g. plague (see WHO 2006), Leptospirosis (Kounde 1999) & Lassa fever, which can cause high mortality rates (up to 80%) in Western Africa and may cause 30.000 deaths per year (Birmingham & Kenyon 2001)).

Another prominent example is provided by amphibians. Most species lay eggs in temporary waters, where tadpoles hatch and develop. Depending on the species, tadpoles have different feeding strategies. Some filter the water for phyto- and zooplankton, thereby keeping the water clean and relatively safe to drink, e.g. for humans and cattle. Others are carnivorous and feed also on mosquito larvae, thus controlling their numbers and the diseases they can transmit (e.g. malaria) (Mohneke & Rödel 2009). In consequence, not only species of conservation concern are important but the general aim has to be to maintain a high (natural) diversity.

## 3.7 Conclusion

Most reptile and amphibian species are likely to be widespread in the study and surrounding areas, and thus are not of conservation concern. However, it is predicted that proposed mining activities will exacerbate already existing threats to their populations within the concession. Therefore, close monitoring of their populations is needed to anticipate sudden decline and ensure that mitigation measures are successful. In relation to the proposed and current infrastructures, conservation measures should focus on protecting remaining intact landscapes, especially forested fragments. A particular attention should also be made to monitor water quality and to reduce potential water pollution risks in the study area, on which amphibian and reptile communities are reliant for their survival.

The tentative new amphibian species *Hyperolius* sp. was recorded inside a previously considered TMF infrastructure location. Further research is required to establish its taxonomic status and distribution within the concession. As mitigation measures are difficult to implement with open cast mining because habitat destruction is the biggest threat to biodiversity, offset planning should be implemented as soon as possible to compensate habitat loss.

# 4.0 IMPACT ASSESSMENT

## 4.1 Impact Description

The Amara mining concession, where mining exploration and exploitation activities have been ongoing for decades, is an important area for herpetofaunal diversity, given its location in the transitional zone between forest and savannah, and the remaining natural habitats are thus of significant ecological importance. The preservation of the amphibian and reptile assemblages in the region will require careful management and maintenance of a variety of special habitat types in the concession.

The main threats to amphibians and reptiles communities related to the proposed mining activities from the Project are:

- Habitat alteration and destruction through mining activities (present and past exploitation especially around the indicated infrastructures; see Figure 2.5). This can lead to the local extinction of most species, except a few disturbance tolerant ones. One important concern is the unknown requirements (e.g. total area needed or number of individuals) of populations to remain at viable levels.
- The removal of complete hill tops during the exploitation phase will increase erosion, can alter stream flows and, in this process, can lead to the loss of reproductive sites for some reptiles and amphibians species. The recent removal of the river bank by illegal Chinese miners along the Bandama River has already destroyed the gallery forests and its associated herpetofauna.
- New roads and/or improved roads, constructed by the Project, can facilitate access to remote areas resulting in further habitat modification, increased killing of edible reptiles and mortality from vehicular traffic. During the exploitation phase, increased vehicles movements as well as drilling will generate noise and ground vibration. In addition to potentially altering behavioural and reproductive activities, these mining activities can also increase the direct rate of reptile and amphibian mortalities through collision with machineries and habitat clearance. All will have serious impacts on the environment with obvious adverse effects on amphibians and reptiles.
- Potential for wastewater pollution from exploitation activities and/or accidental spills from chemicals as well as pollution through sediments can have a direct impact on the aquatic and fossorial biodiversity of the surrounding area if not well managed. Of particular concern is water pollution at sites where amphibians breed or fossorial species live. Potential drainage of contaminated water into the immediate environment (swamps and water ponds) is likely to affect the suitable aquatic habitats where amphibians and reptiles live.

The cumulative impacts have already led to a heavily disturbed site. Past and present explorations, as well as ongoing artisanal mining activities, have drastically modified the area which left no pristine habitats. Furthermore, illegal Chinese miners were also present along the Bandama River and recently completely destroyed an important part of

the river bank, along with its gallery forests and its associated herpetofauna. These activities have left numerous abandoned deep holes which can be found all over the concession. Almost all these holes remain uncover with some of them deeper than 20m with the risk of human accident, as well as being death traps for the herpetofauna.

Further development of the mine and its associated infrastructures, as well as a further increase of the local human population, will increase the pressure on the remaining semi-natural habitats, especially the savannah areas along the lake and the remaining forest patches.

## 4.2 Impact Assessment

A well planned exploitation plan can help to keep the project's negative impacts on biodiversity at a minimum. Of particular importance for rehabilitation are the restoration of altered habitats which requires monitoring to verify that the activities have the desired effects. As in our opinion open cast mining per se can never lead to positive environmental impacts, offsetting of previously unprotected sites is the most important aspect for biodiversity to compensate for the negative losses (see section 6.2). The main negative impacts are summarized as follows:

a) Direct habitat loss

- Vegetation clearance on the land required for the mine and its infrastructures (e.g. drilling pads, camp sites, and roads). Some areas have already been altered; some will be altered in the future to allow the development of the mine.

- Habitat for amphibians and reptiles will be lost (by alteration or removal of mature forest and savannahs, micro-habitats such as streams, ponds, swamps, rivers and lakes) which leads to reduced number of populations and might lead to local extinction.

- Considering the wide distribution and abundance in other areas, the impact will be low for most species. The range restricted species, especially the two gecko species, will experience a larger impact. Most threatening is the impact for the tentative *Hyperolius* sp. because it is currently only known from two sites within the concession.

b) Indirect habitat loss

- The population in Côte d'Ivoire in general and in the area in particular will increase in the near future. In addition, an active mining site will encourage people to move into the area in order to gain work at the mine or to make their living by providing commodities to the mining personnel and their families (e.g. food). This will lead to an increasing demand for land, especially for agriculture, which is already very high in the area. Cattle grazing is already quite intense in some areas, alters habitats and also likely to increase in the near future.

Furthermore, water pollution (e.g. destruction of gallery forest, disposal of waste) is a severe problem and modifies aquatic habitats in a negative way.

- The consequences and the significance of the impacts are the same as for the direct habitat loss.

c) Increase in the number of access roads

- The further development of the infrastructure will also lead to the construction of further roads or to major improvement of existing roads.
- As shown by numerous examples throughout the world, this is directly correlated with a decrease in natural habitats and biodiversity, because exploitation of natural resources (e.g. hunting, establishment of new fields) will be facilitated due to improve access to the area.
- Côte d'Ivoire is already well developed and natural areas outside protected areas are very rare. Though no unique habitats were found in the area by us, as with all other impacts, an increase in the number of access roads will increase threats to biodiversity.

d) Increased bush meat demand

- As mentioned above, the mine and its associated infrastructures will create an increase in the local population. This will lead to a further increase in demand for bush meat.
- Bush meat hunting for the species mentioned above (see section 3.1.1) is already ongoing in the area and having a severe impact on their populations. In an unsustainable manner, it reduces populations, especially of larger reptiles and leads to local extinctions.
- All species of conservation concern and listed as bush meat species are vulnerable to this trade and might become locally extinct. Although some species are widespread and not unique to the area, they still might become locally extinct.

e) Accidental deaths of amphibians and reptiles

- Construction activities, associated noise, traffic, presence of people, vibrations from blasting and vehicles will cause accidental deaths of amphibians and reptiles.
- Results are direct deaths and migration of some species away from disturbed habitats.
- Local significance can be very high. In combination with the above mentioned factors, the population of larger reptile species will further decrease. Species vulnerability in the wider context depends on the species. Most widespread

species will not suffer but might become locally extinct, which is especially worrying for the species listed under conservation concern.

f) Risk of snake bites

- Snakebite belongs to a list of "neglected tropical diseases" compiled by the United Nations World Health Organisation (e.g. Guitiérrez et al. 2006, Harrison et al. 2009, Warrell 2010) with sometimes extreme consequences. In nearly all case there are fatal consequences for the snakes that is killed on sight, but also in many instances with grave consequences for the people being bitten (Brown 2012). Every year a large number of people (including workers at mining sites) are bitten by venomous snakes (e.g. see Chippaux 2011 for a summary for sub-Saharan Africa). It is standard to train people, who work on remote sites in such mining projects like the Yaoure project, on: (i) How to avoid snake bites, (ii) How to distinguish between dangerous and harmless snake species and (iii) How to treat snake bites (first aid procedures). Our offer of training was not met during the time we were present at the mine site (see also section 6.1).

Assessment of the significance for each of the identified impacts was conducted separately, and is presented in the following sections.

### 4.2.1 Direct habitat loss

| **Impact** | **Direct habitat loss** | | | |
|---|---|---|---|---|
| Nature | Negative | | Positive | |
| | Habitat loss is a negative impact as it destroys the places where the species live and the resources they require to survive. | | | |
| Nature of Impact | Direct | | Indirect (Secondary) | Cumulative |
| | Open cast mining clears the vegetation and changes the landscape dramatically in a direct way. In combination with alterations of habitats for other purposes (indirect habitat losses), cumulative effect will emerge. | | | |
| Likelihood / Probability | 1 = Unlikely | 2 = Possible | 3 = Likely | 4 = Definite likelihood |
| | 4 - Definite likelihood because the mine is already in place, thus habitat has already been lost and further developments of the mine will result in further habitat losses. | | | |
| Duration | 1 = Short term | 2 = Medium term | 3 = Long term | 4 = Permanent |
| | 4 - Most likely to be permanent because habitats (e.g. tropical forests) take more than 12 years to regenerate. Regeneration times for savannah habitats are unknown. | | | |
| Extent / Spatial | 1 = Localised | 2 = Site | 3 = Wider and Adjacent Region | 4 = National / International |
| | 2 - Direct effects will be confined to site.<br>3 - Indirect effects most likely influence a larger area.<br>4 - Cumulative effects in combination with other habitat losses in Côte d'Ivoire are of national and even international importance. | | | |
| Magnitude / Scale | 1 = Low | 2 = Minor | 3 = Moderate | 4 = High |
| | 4 - Most likely high because of duration (see above). | | | |

| **Impact** | **Direct habitat loss** | | | |
|---|---|---|---|---|
| Resource/Receptor Sensitivity/ Importance of Value | 2 = Low | 4 = Moderate Low | 6 = Moderate | 8 = High |
| | 2 - For most species because of their wide distribution.<br>4 - Moderate low for range restricted species of savannahs.<br>6 - Moderate for range restricted species of forests.<br>8 - High for *Hyperolius* sp. | | | |
| Significance of the impact | 1 – 20 = Negligible | 21 – 56 = Low | 57 – 92 = Medium | 93 – 128 = High |
| | 28 to 128 (Low to High)<br>Ranges so widely depending on the species under consideration, see sensitivity aspects mentioned above. | | | |

### 4.2.2 Indirect habitat loss

| **Impact** | **Indirect habitat loss** | | | |
|---|---|---|---|---|
| Nature | Negative | | Positive | |
| | Habitat loss is a negative impact as it destroys the places where the species live and the resources they require to survive. | | | |
| Nature of Impact | Direct | | Indirect (Secondary) | Cumulative |
| | Demand for more land to be used as agricultural sides will certainly increase in the near future and be fuelled by mining developments. | | | |
| Likelihood / Probability | 1 = Unlikely | 2 = Possible | 3 = Likely | 4 = Definite likelihood |
| | 4 - Definite likelihood because the mine is already in place, thus habitat has already been lost and further developments will result in further habitat losses. | | | |
| Duration | 1 = Short term | 2 = Medium term | 3 = Long term | 4 = Permanent |
| | 4 - Most likely to be permanent because habitats (e.g. tropical forests) take more than 12 years to regenerate. Regeneration times for savannah habitats are unknown. | | | |
| Extent / Spatial | 1 = Localised | 2 = Site | 3 = Wider and Adjacent Region | 4 = National / International |
| | 2 - Direct effects will be confined to site.<br>3 - Indirect effects most likely influence a larger area.<br>4 - Cumulative effects in combination with other habitat losses in Côte d'Ivoire are of national and even international importance. | | | |
| Magnitude / Scale | 1 = Low | 2 = Minor | 3 = Moderate | 4 = High |
| | 4 - Most likely high because of duration (see above). | | | |
| Resource/Receptor Sensitivity/ Importance of Value | 2 = Low | 4 = Moderate Low | 6 = Moderate | 8 = High |
| | 2 - For most species because of their wide distribution.<br>4 - Moderate low for range restricted species of savannahs.<br>6 Moderate for range restricted species of forests.<br>8 - High for *Hyperolius* sp. | | | |
| Significance of the impact | 1 – 20 = Negligible | 21 – 56 = Low | 57 – 92 = Medium | 93 – 128 = High |
| | 28 to 128 (Low to High)<br>Ranges so widely depending on the species under consideration, see sensitivity aspects mentioned above. | | | |
| Impact | Increase in number of access roads | | | |

| **Impact** | **Indirect habitat loss** | | | |
|---|---|---|---|---|
| Nature | Negative | | Positive | |
| | Negative for biodiversity as it allows easier access to remote areas and therefore their unsustainable exploitation. | | | |
| Nature of Impact | Direct | | Indirect (Secondary) | Cumulative |
| | Indirect and cumulative because it adds to the other impacts. | | | |
| Likelihood / Probability | 1 = Unlikely | 2 = Possible | 3 = Likely | 4 = Definite likelihood |
| | 4 - Definite because the mining activities need the roads and it is impossible to restrict their use. | | | |
| Duration | 1 = Short term | 2 = Medium term | 3 = Long term | 4 = Permanent |
| | 3 to 4 - because the state will have difficulties in maintaining roads in remote areas. Reduced or locally extinct populations may recover if suitable habitats remains and if neighbouring areas still contain the species. However, timelines are unknown. For habitats see table on direct habitat loss. | | | |
| Extent / Spatial | 1 = Localised | 2 = Site | 3 = Wider and Adjacent Region | 4 = National / International |
| | 2 - Confined to site. | | | |
| Magnitude / Scale | 1 = Low | 2 = Minor | 3 = Moderate | 4 = High |
| | 3 to 4 - reversible for populations (but see "duration" above) and high for habitats. | | | |
| Resource/Receptor Sensitivity/ Importance of Value | 2 = Low | 4 = Moderate Low | 6 = Moderate | 8 = High |
| | 2 - For most species because of their wide distribution.<br>4 - Moderate low for range restricted species of savannahs.<br>6 - Moderate for range restricted species of forests.<br>8 - High for *Hyperolius* sp. | | | |
| Significance of the impact | 1 – 20 = Negligible | 21 – 56 = Low | 57 – 92 = Medium | 93 – 128 = High |
| | 24 to 128 (Low to High)<br>Ranges so widely depending on the species under consideration, see sensitivity aspects mentioned above. | | | |

### 4.2.3 Increased bush meat demand

| **Impact** | **Increased bush meat demand** | | | |
|---|---|---|---|---|
| Nature | Negative | | Positive | |
| | Negative if conducted in an unsustainable manner. Sustainable quotas for the species inside the concession are unknown. | | | |
| Nature of Impact | Direct | | Indirect (Secondary) | Cumulative |
| | Direct because it reduces populations. Indirect because it alters the food web. Cumulative because it adds to other impacts. | | | |
| Likelihood / Probability | 1 = Unlikely | 2 = Possible | 3 = Likely | 4 = Definite likelihood |
| | 3 to 4 - Likely to definite because effects can be managed but will take very large efforts and resources which are unlikely to be allocated. | | | |
| Duration | 1 = Short term | 2 = Medium term | 3 = Long term | 4 = Permanent |

| **Impact** | **Increased bush meat demand** | | | |
|---|---|---|---|---|
| | 2 to 4 - Depending on the species and the surrounding areas (allowing easy re-populations). | | | |
| Extent / Spatial | 1 = Localised | 2 = Site | 3 = Wider and Adjacent Region | 4 = National / International |
| | 3 - Wider and adjacent region. | | | |
| Magnitude / Scale | 1 = Low | 2 = Minor | 3 = Moderate | 4 = High |
| | 3 to 4 - reversible for populations (but depends heavily degree of impact and surrounding areas). | | | |
| Resource/Receptor Sensitivity/ Importance of Value | 2 = Low | 4 = Moderate Low | 6 = Moderate | 8 = High |
| | 2 - For most species because of their wide distribution. | | | |
| Significance of the impact | 1 – 20 = Negligible | 21 – 56 = Low | 57 – 92 = Medium | 93 – 128 = High |
| | 22 to 30 (Low) | | | |

### 4.2.4 Accidental deaths of amphibians and reptiles

| **Impact** | **Accidental deaths of amphibians and reptiles** | | | |
|---|---|---|---|---|
| Nature | Negative | | Positive | |
| | Negative. | | | |
| Nature of Impact | Direct | | Indirect (Secondary) | Cumulative |
| | Direct. | | | |
| Likelihood / Probability | 1 = Unlikely | 2 = Possible | 3 = Likely | 4 = Definite likelihood |
| | 4 - Definite because the mining activities need the roads and it is very difficult to restrict their use and avoid accidental deaths. | | | |
| Duration | 1 = Short term | 2 = Medium term | 3 = Long term | 4 = Permanent |
| | 3 to 4 - because it is possible to manage partially but only at substantial costs. | | | |
| Extent / Spatial | 1 = Localised | 2 = Site | 3 = Wider and Adjacent Region | 4 = National / International |
| | 2 - Confined to site. | | | |
| Magnitude / Scale | 1 = Low | 2 = Minor | 3 = Moderate | 4 = High |
| | 1 to 3 - depending on the scale of the mine and the relevant management actions. | | | |
| Resource/Receptor Sensitivity/ Importance of Value | 2 = Low | 4 = Moderate Low | 6 = Moderate | 8 = High |
| | 2 - For most species because of their wide distribution.<br>4 - Moderate low for range restricted species of savannahs.<br>6 - Moderate for range restricted species of forests.<br>8 - High for *Hyperolius* sp. | | | |
| Significance of the impact | 1 – 20 = Negligible | 21 – 56 = Low | 57 – 92 = Medium | 93 – 128 = High |
| | 20 to 104 (Negligible to High)<br>Ranges so widely depending on the species under consideration, see sensitivity aspects mentioned above. | | | |

### 4.2.5 Risk of snake bites

| **Impact** | **Risk of snake bites** | | | |
|---|---|---|---|---|
| Nature | Negative | | Positive | |
| | Negative for biodiversity as well as for personnel. | | | |
| Nature of Impact | Direct | | Indirect (Secondary) | Cumulative |
| | Direct as snakes will be killed. Indirect and cumulative because it does not ameliorate the general notion that all snakes are venomous. | | | |
| Likelihood / Probability | 1 = Unlikely | 2 = Possible | 3 = Likely | 4 = Definite likelihood |
| | 1 - Though no management measures are currently in place. | | | |
| Duration | 1 = Short term | 2 = Medium term | 3 = Long term | 4 = Permanent |
| | 1 to 4 - depending on the species and the magnitude. | | | |
| Extent / Spatial | 1 = Localised | 2 = Site | 3 = Wider and Adjacent Region | 4 = National / International |
| | 2 - Confined to site. | | | |
| Magnitude / Scale | 1 = Low | 2 = Minor | 3 = Moderate | 4 = High |
| | 1 to 4 - depending on the species and magnitude. | | | |
| Resource/Receptor Sensitivity/ Importance of Value | 2 = Low | 4 = Moderate Low | 6 = Moderate | 8 = High |
| | 2 - For most species because of their wide distribution. | | | |
| Significance of the impact | 1 – 20 = Negligible | 21 – 56 = Low | 57 – 92 = Medium | 93 – 128 = High |
| | 10 to 22 (Negligible to Low)<br>Which is the impact in biodiversity but not on employed personnel. | | | |

Overall, previous exploitation already has, and future exploitation will continue to have a significant impact on the environment and its biodiversity. The main impact will be the alteration and loss of natural habitats. Mitigation measures presented in the following sections will help to minimise these impacts. These measures need to be included in a comprehensive environmental management plan, and offset planning need to start rapidly in order to compensate for any residual impacts, and to attain net gain in biodiversity.

## 4.3 Important Issues

- No species have been recorded which are currently listed as threatened by the IUCN Red List. Few species are considered to be of conservation concern. See sections 3.1.1 and 3.2.1 for more details.
- The only two areas of unique concern are the two sites where the tentative *Hyperolius* sp. was found (see also chapter 3.2.1). Other aspects are discussed in chapter 3.3.

# 5.0 MANAGEMENT AND MONITORING REQUIREMENTS

At the very onset of the project, measures have to be taken to eliminate, reduce, or remedy potential undesirable effects resulting from mining and its associated activities, e.g. removal of hill tops, road construction, clearing sites for drilling, excavating pits, dumping of tailings, and human population pressure on land. Thus, mitigation should be considered at all developmental stages of the project including, and not limited to, design and construction of facilities for exploitation. With a well-planned exploitation timetable, the project's negative impacts on the biodiversity of amphibians and reptiles could be minimal. The most important tool is offsetting which is not considered in the current report but in our opinion has to go hand in hand with the current survey and its results (see section 6.2). Mindful of the various impacts, the following guidelines are proposed with the aim of reducing the magnitude of the respective impacts.

## 5.1 Impact Mitigating and Management Requirements

- Protect the integrity of the ecological systems, i.e. remaining forest/savannah patches that still exist in the concession.
- Rehabilitate altered vegetation patches and allow migrating corridor by reforestation. Given the present state of the banks of the Bandama River, destroyed by the illegal Chinese mine, its restoration is of primary importance for all reasons previously mentioned.
- Hunting of edible reptiles should be controlled, which includes the prohibition of use and transportation of any hunting equipment (guns, spears etc.) and bush meat by all permanent or temporary staff members. Workers should be sensitized not to hunt in and around the concession area.
- Proper handling and discharge of contaminated water to keep all water bodies clean. All contaminants should be neutralised, solidified and disposed of in an environmentally sound way. This includes the proper disposal of substances containing toxins or contaminants, either mineral or bacterial.
- Measures should be taken to prevent littering in the study site and surrounding areas.
- Start a rehabilitation plan which aims at restoring natural habitats and considers all native floral and faunal elements. This should especially focus on heavily altered areas such as removed hill tops and the Bandama River banks.
- Start programmes to educate staff of the mining site, as well as local people, on the values of biodiversity in general and of conservation possibilities in their area in particular. Also as artisanal miners are driven out of the central part of the concession, and locals are advised not to conduct artisanal mining activities, then people start looking for alternatives. Most of the land is already occupied so one solution is to start agriculture in the savannahs along the lake. However, this area is also used as cattle grazing ground and classical conflicts between herdsmen and farmers are arising. Therefore, alternative livelihood programs should be proposed

and a dialogue has to be started between the farmers and cattle breeder of the area to reduce the tensions between these groups to avoid further conflicts. Apparently dialogues have started. This is a good start and we would like to emphasize that the process needs to be continued and extended.

- Conduct courses for staff on how to avoid snake bites, how to distinguish between dangerous and harmless snake species and how to treat snake bites (first aid procedures) (see section 6.1).

## 5.2 Monitoring Requirements

Long term monitoring and maintenance of forests and savannahs in the concession will help to safeguard the site, its biological diversity and ecosystem services. A detailed monitoring plan for environmental activities, including protection measures for the remaining forests and savannahs in the area, need to be implemented as soon as possible and followed during all phases of the Project life. To achieve this goal, collaboration with conservation biologist and the Ivorian Government is needed to guarantee effective implementation of the proposed mitigating measures.

We propose the establishment of a long term monitoring programme for selected amphibian and reptile species inside the concession. This should include selected sites (e.g. forest patch south of the dam, selected savannahs at the lake) and selected species (e.g. *Phrynobatrachus calcaratus* in the forest or *Phrynomantis microps*, *Kassina schioetzi*, Kassina senegelensis, *Hyperolius igbettensis, Hyperolius* sp., *Psammophis elegans* and *Philothamnus irregularis* in the savannahs, which have an indicator function). Monitoring should also accompany the restoration of habitats (e.g. on hill tops and along the Bandama River banks). Individuals need to be captured and marked, to establish measures of abundances, and this process repeated at regular time intervals. This should continue for several years so that natural population fluctuations can be distinguished from unnatural impacts.

Furthermore, additional research is required to verify the taxonomic and distribution status of *Hyperolius* sp. and *Lycophidion* sp., as well as to disentangle the species complexes of *Hemidactylus* cf. *muriceus* and *Philothamnus carinatus*. This requires mostly laboratory work to conduct wider comparisons with already existing material in museum collections and conducting further analyses (e.g. Computer-tomography scanning of the skulls of the two snake species) but might also include further field work to assess distributional range extent (especially for *Hyperolius* sp.).

# 6.0 SUMMARY AND CONCLUSION

Maintaining (and monitoring) the remaining semi-natural forest and savannah patches in the concession will help to safeguard the ecological integrity of the site and its biological diversity. Environmental monitoring assists in the systematic and prompt recognition of problems, leading to effective corrective actions.

## 6.1 Gap Analysis

Survey design - As expected beforehand, the survey design was not ideally suited for reptiles. In order to asses this group really well, a dedicated long-term survey with much more resources is needed. For reptiles, two different approaches are needed whether the aim is to detect most lizard and snake species, or if it is directed towards recording crocodile species. Dedicated lizard and snake surveys need the active participation of the local population over a longer period of time (ideally at least 1 year) with regular visits by the experts to assure correct data collection. Crocodile surveys require a much more detailed habitat assessment along suitable sites (e.g. Bandama River), night surveys on the water and more interviews with fishermen and other people living and working along these sites. Certainly the timing of the survey was not optimal for amphibians. There were too little rains and a few more species can be expected to occur in the area. Ideally surveys are conducted twice, once at the beginning and once at the end of the rainy season because not all amphibian species have the same activity throughout the season.

“Snake training” - We offered training on how to recognise dangerous snakes, how to avoid snake bites and what first aid measures should be taken in case of a snake bite, several times while on site. Unfortunately, the course never took place. Herewith, we would like to renew our offer and emphasize its necessity again. Consequences of dangerous snake encounters for the workers can be fatal and can potentially paint an unfavourable picture of the mining company if no adequate measures were taken in advance to prevent these accidents. Course length and content can be adapted to the local conditions. Ideally a small “emergency response team” should be formed and be properly equipped to deal with all situations arising by the presence of dangerous snakes. We recorded a number of species which are well known to cause fatalities upon unfortunate encounters with humans.

Habitat maps - There is a need to improve the existing habitat maps. A useful idea of which habitats are found in the area was gained from driving around the concession as well as looking at satellite and other maps provided by the Project and Amec Foster Wheeler. However, a land-cover classification derived from satellite data was received after one third of the survey and was not considered to be highly accurate. It is extremely helpful for such surveys if land-cover maps would be provided well in advance of the actual field trip. In addition to such classification gained from high resolution satellite images, LiDAR (Light Detection and Ranging) provides a useful state of the art alternative which would also immensely facilitate other surveys as well as detailed planning of the mining sites.

Export permits - Export permit procedures need to be revised and verified if the current process is correct. The process of obtaining export permits ("certificate d'origine") took a long time and prices appeared higher than in neighbouring countries. This might be connected to the fact that CITES forms were used despite the fact that not CITES relevant species were exported. Further clarifications should be sought with the relevant authorities.

## 6.2 Offsetting

The most important tool to attain a potential net gain in biodiversity is through offsetting, which was unfortunately not included in the scope of the current report, but in our opinion should go hand in hand with the current survey and its results. Therefore, we present here a few suggestions to be included in offset planning.

As mentioned before, offsetting is urgently required. The concession harbours a dense human population and it appears difficult to select and put aside a forest or savannah area as an offset site. All habitats are already used and altered by humans (e.g. farming, grazing cattle, timber extraction, non-timber forest products and or for artisanal mining). Therefore, we suggest that conservation efforts should be implemented in more distant areas where the habitats and biodiversity are still intact and human population less dense, to offset for any residual negative impacts of the proposed Project mining activities inside the concession. These sites have to be well chosen and biodiversity surveys need to assure that a comparable fauna is preserved. On the other hand, already ongoing conservation efforts in other areas could be enhanced. Furthermore, restoration of the Bandama River banks can provide beneficial impacts for the local biodiversity and would help to attain a net gain in biodiversity.

In Côte d'Ivoire it is especially important to do this in strong collaboration with international experts, NGOs and governmental organisations because the country has many protected areas but the vast majority of them have an unclear management status. This means that only 13 (out of more than 200 protected areas) are assigned to an IUCN management status (Mallon et al. 2015). As the decline in biodiversity is tightly linked to habitats loss, actions are needed not only to create more protected areas but also to significantly improve the status of existing ones. This is exemplified by the status of nearby Marahoué National Park where most of the forests have recently disappeared from inside the protected area (see Figure 2.3).

## 6.3 Conclusion

The site falls within the transitional zone between forest and savannah, harbouring important herpetofaunal communities of both ecoregions. A total of 35 species of reptiles and 29 species of amphibians were recorded in the concession. A number of species which were expected for this area were not recorded within the Project area. The Project area is similar to but has a slightly lower species richness than other sites in Côte d'Ivoire. Additional field work would be required to get a more complete species list.

In summary, it remains unknown to which extent past and ongoing exploration practices as well as artisanal mining activities around the Amara concession, have already affected amphibians and reptiles. A true baseline cannot be verified but derived from published data from comparable sites. It seems that many forest dependent species have been lost but most savannah species are still occurring in the area.

Four amphibian species of conservation concern were recorded during the present survey. Three have restricted ranges *Afrixalus vittiger*, *Hyperolius igbettensis* and *Kassina schioetzi*. A fourth species (*Hyperolius* sp.) cannot be assigned to any known species yet and further analyses are pending. Two species of reptiles have restricted ranges: *Hemidactylus fasciatus* and *Hemidactylus* cf. *muriceus*.

Nine species of reptiles are listed as being of conservation concern because they are regularly harvested: *Bitis arietans*, *Bitis rhinoceros*, *Chamaeleo gracilis*, *Pelusios castaneus*, *Python sebae*, *Python regius* and *Varanus niloticus*. The last four species are listed in CITES Appendix II.

Due to increasing impacts on amphibians and reptiles in the area, a further decrease in their population is foreseen if no proper mitigation measures are implemented. One might think that this is not a problem because most species are widespread and are able to tolerate some degrees of disturbance. However, a recent report shows a very sad future for biodiversity of the whole region, including the study area and the species found there (Mallon et al. 2015). As a result, some populations of these species might become locally extinct.

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# APPENDICES

# APPENDIX A

Daily activity reports; names abbreviated as follows: Johannes Penner=JP, Nono LeGrand Gonwouo=NLG, Koffi Kouamé=KK, Maxime Ouadio Lokou=MOL, Mathieu Konan Yao=MKY, Gustave Kouadio Alla=GKA

| Dates | Team members | Activities carried out | Observations/Issues |
|---|---|---|---|
| 01.05.2015 | JP & NLG | Transfer from Abidjan to site; introduction at site; organising field logistics and sort equipment; discuss security issues (night work); tour by car through the inner license | Site heavily disturbed, lots of new fields, displaced people, baseline in inner license difficult |
| 02.05.2015 | JP, NLG, KK & MOL | Prepared drift fence; constructed traps; searched via maps, discussions and field visit for trapping site; introduction for assistants | Old trapping sites not usable because of new fields; other sites contained no water |
| 03.05.2015 | JP, NLG, KK & MOL | Prepared specimens; searched sites to put up traps and conduct night work | Scarcity of water, amount of cows and people is an issue for site (for trapping) selection |
| 04.05.2015 | JP, NLG, KK & MOL | Prepared specimens; put up traps, night search in savannah between Angovia and lake (west) | Nice heavy rains in the previous night; current estimate: 17 amphibian species |
| 05.05.2015 | JP, NLG, KK & MOL | Checked traps; prepared specimens; day search south of dam; night search in savannah between Angovia and lake (further west) | Update: 19 amphibian species |
| 06.05.2015 | JP, NLG, KK & MOL | Checked traps; prepared specimens; day and night search near Akokro | Apparently numerous new fields |
| 07.05.2015 | JP, NLG, MKY, GKA | Checked traps; prepared specimens; introduction for new assistants; day and night search near Bokassou | Update: 20 amphibian species |
| 08.05.2015 | JP, NLG, MKY, GKA | Checked traps; prepared specimens, day and night work between Patizia and Akokro | Good forest patches (though very small), revisit needed after rains, update: 21 amphibian species; environments are getting very dry again |
| 09.05.2015 | JP, NLG, MKY, GKA | Checked traps, prepared specimens, day work in savannah at lake east of Angovia, night work in forest south of lake | River in savannah fallen dry, forest good, update 22 amphibian species, joined by Michel Yao and Genevieve Campbell |
| 10.05.2015 | JP & NLG | Checked traps, prepared specimens | |
| 11.05.2015 | JP, NLG, KK & MOL | Checked traps, prepared specimens, day work close to Bandama river (south of Alley), night work in and around pit | Gallery forest south of Alley completely destroyed (illegal mining), probably until Bozi (thus no forest on west side of river) |
| 12.05.2015 | JP, NLG, KK & MOL | Checked traps, moved traps and drift fence, prepared specimens, day and night work around Benou | Update: 24 amphibian species, everything is very dry, most temporary ponds contained no water |

| Dates | Team members | Activities carried out | Observations/Issues |
|---|---|---|---|
| 13.05.2015 | JP, NLG, KK & MOL | Prepared specimens, installed traps in forest near dam at Bandama river, night work north-west of Angovia | Vast majority of temporary ponds and streams were dry |
| 14.05.2015 | JP, NLG, KK & MOL | Checked traps, prepared specimens, day work at Dioulabougou, night work near lake Kossou | Tiny amount of rain, not sufficient for amphibians |
| 15.05.2015 | JP, NLG, MKY, GKA | Checked traps, prepared specimens, worked near Lotanzia, stayed there for the night | Update: 25 amphibian species, caught a spitting cobra (*Naja nigricollis*) from a kitchen in Angovia |
| 16.05.2015 | JP, NLG, MKY, GKA | Return from Lotanzia, checked traps, prepared specimens | Update: minimum 28 amphibian species |
| 17.05.2015 | JP, NLG, MOL, MKY, GKA | Checked traps, prepared specimens, worked near Dioulabougou | Few rains, update: minimum 29 amphibian species |
| 18.05.2015 | JP, NLG, MKY, GKA | Checked traps, prepared specimens, night work revisit to forest patch near Patizia | Discussed further permit issues with Michel Yao |
| 19.05.2015 | JP, NLG, KK & MOL | Prepared specimens, sorting material, packing specimens | Parts of the permits are ready |
| 20.05.2015 | JP, NLG, KK & MOL | Packing luggage, returning material, returning chemicals, short presentation to Amara on main findings (JP), interviews in villages along Bandama river for remaining crocodile populations (NLG) | Parts of the permits received, departure JP |
| 21.05.2015 | NLG | Packing luggage | Departure NLG |

# APPENDIX B

List of sites where amphibians and reptiles were recorded and the description of the habitats encountered.

| Site | Latitude | Longitude | Altitude | Habitat description |
|---|---|---|---|---|
| AM1 | 7.056695 | -5.528191 | 209.8 | Relatively closed tree savannah with plenty of mimosa spiny plants along a seasonal water bed |
| AM2 | 7.056526 | -5.527802 | 205.8 | Open tree savannah along a seasonal water bed |
| AM3 | 7.059431 | -5.52536 | 202.5 | Large seasonal savannah pond regularly used by cattle about 300m from Lake Kossou |
| AM4 | 7.081964 | -5.561813 | 206.3 | Large seasonal water pond with a small forest patch on one bank and open tree savannah on the other bank, regularly used by cattle |
| AM5 | 7.057500 | -5.527182 | 202.9 | Open tree savannah about 200m from a large seasonal savannah pond |
| AM6 | 7.059588 | -5.526335 | 201.2 | Open tree savannah 50m from a seasonal water bed |
| AM7 | 7.058826 | -5.52606 | 199.7 | Cattle path in open tree grassland savannah |
| AM8 | 7.050664 | -5.524892 | 189.7 | Thick bushy area along a permanent fast moving stream in open savannah |
| AM9 | 7.055777 | -5.524548 | 200.8 | Flooded grassland area after a heavy rain in open tree savannah |
| AM10 | 7.056391 | -5.526298 | 201.9 | Open tree savannah |
| AM11 | 7.029753 | -5.475981 | 172.7 | Rocky and muddy area with leaf litter in gallery forest along Bandama River |
| AM12 | 7.031034 | -5.479032 | 173.8 | Abandoned artisanal mining pit in the gallery forest along the Bandama River |
| AM13 | 7.082966 | -5.561295 | 204 | Small temporal water along a seasonal stream in open tree savannah |
| AM14 | 7.082430 | -5.560528 | 203.8 | Open tree savannah/secondary forests |
| AM15 | 7.082162 | -5.560003 | 203.2 | Flooded grassy area close to a bushy vegetation stratum in open tree savannah |
| AM16 | 7.079045 | -5.561925 | 205.4 | Grassy area in open tree savannah |
| AM17 | 7.001725 | -5.545634 | 452.3 | Leaf litter in relatively closed canopy young forest on a small hill top |
| AM18 | 7.002578 | -5.54686 | 427.6 | Relatively closed canopy young forest on small hill top |
| AM19 | 7.003428 | -5.546754 | 399.6 | Leaf litter in a cocoa plantation on a hill flank |
| AM20 | 7.009536 | -5.554824 | 363 | Pile of building blocks close to human habitation in Akakro |
| AM21 | 7.001267 | -5.569728 | 522 | Dry tree on hill top around newly created cocoa plantation |
| AM22 | 7.002173 | -5.569891 | 515.1 | Grassy area on hill top around newly created cocoa plantation |
| AM23 | 7.004208 | -5.576954 | 364.3 | Water pond along permanent running water in disturbed gallery forest mostly replaced by cocoa plantations |
| AM24 | 7.003510 | -5.57742 | 366.3 | Running water around swampy area in open rice farm with plenty shrubs bordering the stream |
| AM25 | 7.002125 | -5.579693 | 376.1 | Tree trunks in newly created cocoa plantation |
| AM26 | 7.002039 | -5.580673 | 373.3 | Thick pile of Bamboo about 10m from the stream in disturbed gallery forest |
| AM27 | 6.997736 | -5.547959 | 325.4 | Leave litter in young cocoa plantation near forest patch. |
| AM28 | 6.999500 | -5.552598 | 333.3 | Old cocoa plantation |
| AM29 | 6.998953 | -5.552054 | 325.3 | Shrubs and small trees in a swampy area close to a permanent running water bordered by cocoa plantations |
| AM30 | 6.998566 | -5.551295 | 331.3 | Leaf litter in closed canopy forest patch |
| AM31 | 6.996253 | -5.546491 | 316.8 | Standing dead log of wood in newly created plantation |
| AM32 | 6.993115 | -5.543929 | 311.4 | Fast running water around a large forest patch with close canopy trees and leaf litter |

| Site | Latitude | Longitude | Altitude | Habitat description |
|---|---|---|---|---|
| AM33 | 7.029809 | -5.475908 | 174.8 | Closed canopy gallery forest along Bandama River |
| AM34 | 7.030089 | -5.476746 | 182.8 | Closed canopy gallery forest along Bandama River |
| AM35 | 7.018795 | -5.524128 | 283.3 | Large water pond around mining pit with grassy and bushy borders |
| AM36 | 7.017560 | -5.52423 | NA | Water pond around old mining pit with several artisanal mining pits in open grassy area |
| AM37 | 7.021878 | -5.527635 | 227.9 | Open swampy area around old mining pit about 100m from a permanent water pond |
| AM38 | 7.100862 | -5.552274 | 199.7 | Temporal water pond in open tree savannah |
| AM39 | 7.099983 | -5.552387 | 197.8 | Open savannah |
| AM40 | 7.097581 | -5.558198 | 210.9 | Temporal water pond in open tree savannah near grassy areas and fields |
| AM41 | 7.071952 | -5.556365 | 213.2 | Gallery forest along a seasonal water bed with relatively closed canopy trees |
| AM42 | 7.071280 | -5.556324 | 210.6 | Gallery forest with leaf litter along a seasonal water bed |
| AM43 | 7.070666 | -5.556932 | 211.7 | Understory along gallery forest close to a seasonal water bed |
| AM44 | 7.070078 | -5.557682 | 211.5 | Closed canopy gallery forest |
| AM45 | 7.068766 | -5.557697 | 215.6 | Seasonal water bed in gallery forest |
| AM46 | 7.051278 | -5.524205 | 194.5 | Thick plants with mimosa plants along a permanent flowing water in open tree savannah |
| AM47 | 7.050569 | -5.525676 | 194.2 | Thick bushy plants along a permanent water in open tree savannah |
| AM48 | 6.981524 | -5.601918 | 562.6 | Closed canopy secondary forest |
| AM49 | 6.980080 | -5.600465 | 522 | Bushy shrubs along secondary forest patch |
| AM50 | 6.979915 | -5.600165 | 516.7 | Secondary forest patch |
| AM51 | 6.979222 | -5.59863 | 512.5 | Secondary forest close to an old cocoa plantation |
| AM52 | 6.977985 | -5.597921 | 489.5 | Secondary forest and cocoa plantation |
| AM53 | 7.030266 | -5.475366 | 168.1 | Closed canopy gallery forest along the Bandama River |
| AM54 | 7.095761 | -5.637261 | 203.4 | Temporal water pond about 50m from a permanent flowing water body in open tree savannah with several thick shrubs regularly used by cattle |
| AM55 | 7.094998 | -5.636268 | 203 | Thick shrubs in open tree savannah |
| AM56 | 7.092677 | -5.636049 | 207.1 | Bushy forest patch around open tree savannah |
| AM57 | 7.092361 | -5.635141 | 212.7 | Bushy forest patch around open tree savannah |
| AM58 | 7.093175 | -5.635556 | 207.2 | Bushy patch around open tree savannah |
| AM59 | 7.094346 | -5.635731 | 204.5 | Temporal water pond close to path in open tree savannah |
| AM60 | 7.094444 | -5.639319 | NA | Seasonal savannah water pond in open tree savannah |
| AM61 | 7.091172 | -5.641517 | 209.7 | Grassland savannah after a heavy rain |
| AM62 | 6.992688 | -5.543498 | 325.1 | Closed canopy forest patch |
| Angovia | 7.034080 | -5.535374 | NA | Settlement of Angovia |
| Bot | 7.029533 | -5.475794 | NA | GPS & species record provided by the botany team |
| Bot | 7.005569 | -5.567214 | NA | GPS & species record provided by the botany team |
| Kossou | 7.003486 | -5.477689 | 213.4 | Settlement of Kossou |
| Trap 1a | 7.023764 | -5.528638 | 228.5 | Grassy area close to a large permanent water in an old exploration pit |
| Trap 1b | 7.022285 | -5.528057 | 227.5 | Swampy grassland area in an old exploration pit with permanent water bodies |
| Trap 2 | 7.029809 | -5.475908 | 174.8 | Rocky area with about 50% leaf litter cover in gallery forest 50m from the Bandama River |