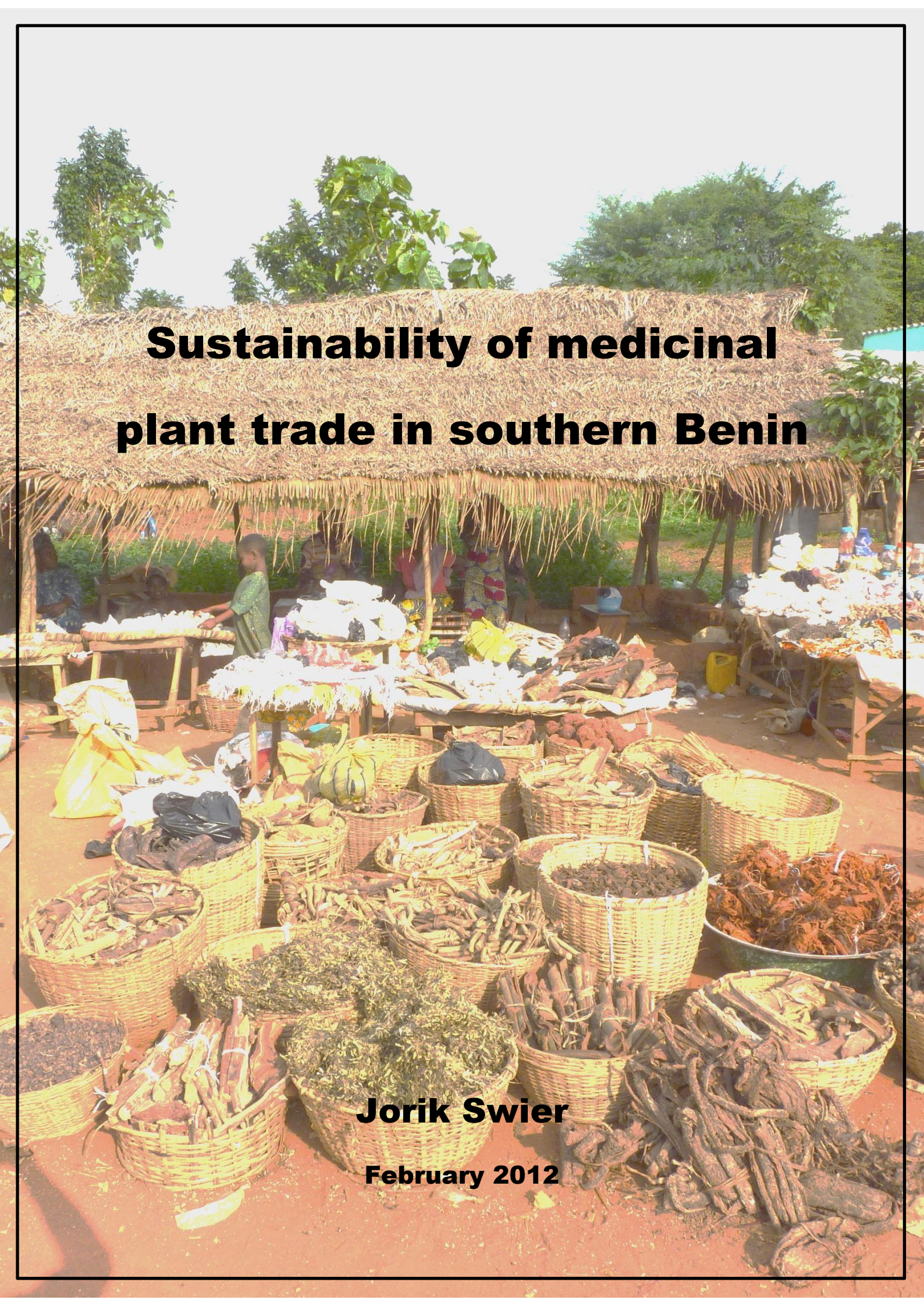

Sustainability of medicinal plant trade in southern Benin

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February 2012

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An analysis of the sustainable harvest and trade of medicinal and magical barks, woods and roots in southern Benin.

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Minor thesis MSc Plant Biotechnology

870202-819-070

February 2012

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Contents

Abstract

The vast majority of Africans rely on traditional medicines for their healthcare. Wild plants are the number one source of medicines for these people (Cunningham, 1993). The collection of wild plants for traditional healthcare puts great pressure on natural resources. Although roots and barks are generally harvested in lower quantities than leaves and fruits, the harvest is considered more destructive with less chance of recovery for the plant. Hence, the sustainability of medicinal roots and barks is investigated in this research. This was achieved by performing market surveys and interviews, and collecting both field- and market samples in the research area: south Benin, West-Africa. Fieldwork resulted in the collection and identification of sixty-four plant species with medicinal bark or roots. An assessment of the sustainability of these species was performed, based on literature study accompanied by observations made on markets, interviews with plant sellers and traditional healers, and field observations. The majority of species collected were typical savannah- and woodland-species (n=±45), with very few primary forest-species. A few primary forest-species collected on the markets, generally didn't even originate from Benin. Primarily savannah- and woodland-species are expected to require immediate protection due to overharvesting. Threatened species include *Carissa spinarum* (Apocynaceae), *Pterocarpus erinaceus* (Fabaceae), *Acridocarpus smeathmannii* (Malpighiaceae), *Sphenocentrum jollyanum* (Mennispermaceae), *Carpolobia lutea* (Polygalaceae) and *Securidaca longepedunculata* (Polygalaceae). Several other species require further research on the current status in Benin, but are expected to be under pressure: *Mondia whitei* (Apocynaceae), *Curculigo pilosa* (Hypoxidaceae) and *Raphiostylis beninensis* (Icacinaceae). Remarkably, species with medicinal roots appear to be more threatened than species with medicinal bark.

A more detailed investigation on the aforementioned threatened species is recommended, as well as research in plants harvested for their medicinal leaves, fruits and seeds.

Keywords: ethnobotany, medicinal plants, West-Africa, sustainability, NTFP, biodiversity

1. Introduction

In large parts of the developing world, local communities depend largely on plant derived products for their daily needs. Wood is used for construction and as fuel, plants are grown for food, trees and shrubs offer fencing and shade, fodder for feeding livestock, ornamental plants are seen throughout villages, certain plants have a religious or ritual meaning and plants provide most of their medicines. The use of plants as medicine is not a recent development. One of the oldest fossil finds of human use of medicinal plants dates back to the Middle Paleolithic age some 60,000 years ago (Solecki, 1975). Even today, plants continue being used for both conventional and traditional medicine. Examples of conventional medicines developed or derived from plants include aspirin (first obtained from willow), taxol® (extracted from yew) and digitoxin (obtained from foxglove).

The term traditional medicine can be described as the use of indigenous medicinal and aromatic plants, animal parts, or organic and inorganic materials for preventive and therapeutic purposes (WHO, 2004). Traditional medicine is highly dependent upon plants. In Viet Nam, approximately ten times more plant than animal species are recorded to be used (Van and Tap, 2008). This illustrates the relative importance of plants in traditional healthcare. The World Health Organization (WHO) has estimated that about 70% of the population of Benin relies on traditional medicine and even up to 90% is some other African countries (WHO, 2001). This high demand of medicinal plants makes them excellent trade goods. Commercially valuable wild natural resources, being intensively harvested, provide a source of money for unemployed people to fall back upon (Cunningham, 1994). But the continuous collection of valuable natural resources puts high pressure on plant species.

1.1 Geography of Benin

The Republic of Benin is located in West Africa. It spreads out between the latitudes 6°10'N and 12°25'N and longitudes 0°45'E and 3°55'E. It is bordered by Togo in the west, Nigeria in the east, the Atlantic Ocean in the south, and Burkina Faso and Niger in the north. It covers a land area of 112,622 km^2, approximately 2.7 times the surface of the Netherlands. The population in Benin is estimated to be around 6,75 million (INSAE, 2002), with the majority of the inhabitants living in the south. The country is characterised by varied climatological and geographical conditions. In general, the country is a plateau with altitudes up to 650 meters in the north. The most common soil type is the tropical ferruginous soil. The mean annual rainfall is between 900 mm in the north and far south-west, and 1300 mm in the south-east (Diederich & Simmer, '08).

Unlike most countries in tropical west Africa, rainforest is not abundant in Benin. A savannah corridor which reaches the coast of southern Ghana, Togo and Benin interrupts the West African rainforest. This corridor, deprived of rainforest, is called the Dahomey gap (figure 1). The Dahomey gap is not the result of human activity, but of an abrupt climatic change some 4000 years ago (Salzmann and Hoelzmann, 2005). The relatively low rainfall has given rise to the typical forest-savannah mosaic found in Southern Benin, combined with fallows and farmland.

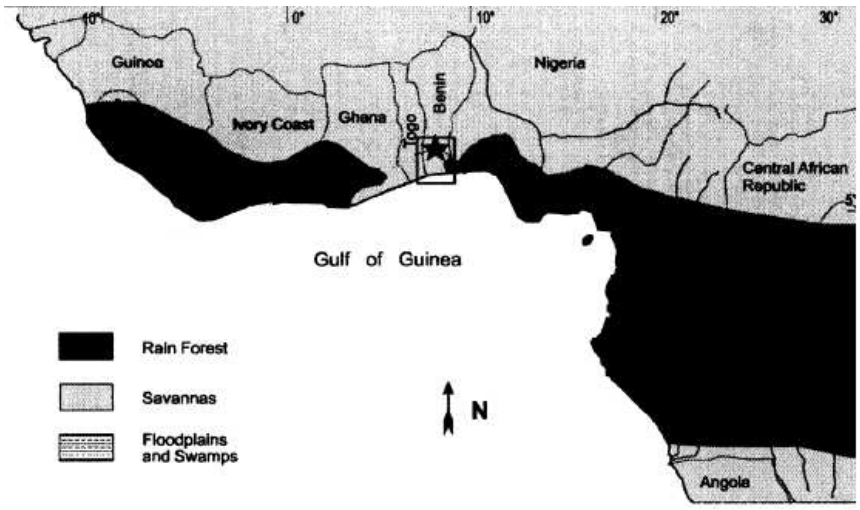

Figure 1 The location of Benin in the Dahomey gap. Image taken from Salzmann and Hoelzmann, 2005, adapted without permission.

1.2 Plant trade

Non-timber forest products (NTFPs) are biological materials other than timber, which are extracted from forests for human use. NTFPs have a long history of being used by rural communities in the tropics for their subsistence and trade (Sinha and Brault, 2005; Ticktin, 2004). Extractions of marketable NTFPs, if done sustainably, may create a reliable and permanent source of income for local people. However, chronic harvest of medicinal plants and other NTFPs poses a serious threat for species diversity and can cause resource repletion (Geldenhuys and Williams, 2005; Silvertown, 2004; Djossa *et al.*, 2008; Cunningham, 1993 and others). Wild species that are sold frequently and in high quantities are at greater risk of overharvesting (Cunningham, 1993).

Market surveys and interviews are a valuable strategy in performing conservation analyses and plant trade researches. In the case of Benin, although medicinal plants are marketed for a long time, no study has yet assessed the impact of medicinal plant organ sales on their sustainable uses (Vodouhê, 2008). Learning which species are sold, their prices, and the volumes marketed are the first steps in identifying species with conservation or resource management priorities (van Andel *et al.*, 2012).

1.3 Aim and objective

The aim of this research can be defined as follows: to assess and qualify the sustainability of commercially harvested roots, barks and woods with medicinal or magical purposes in southern Benin.

In order to investigate this aim, a number of research questions was formed:

- Which plant species are used for magical and medicinal purposes in Benin?
- What growth forms do these plants have and in what vegetation type do they grow?
- Which part is harvested for which magical or medicinal purpose?
- How and where are these plants harvested? Are less damaging harvesting techniques applied or can they be developed?
- Which plant species are threatened due to overharvesting in an unsustainable manner?

2. Materials and methods

Plant material was collected in southern Benin. Local people, including traditional healers and market sellers, were questioned about medicinal and magical plants and their uses (*2.1 Collection of data*). Next, these plants were identified as much as possible (*2.2 Identification of plants*). This was done in Benin and the Netherlands. Once the plants were identified to species-level, the sustainability for each species was investigated based on literature, personal observations and interviews (*2.3 Establishing sustainability*). This resulted in the characterization of the sustainability of medicinal and magical plant trade in southern Benin, with a number of threatened species.

2.1 Collection of data

This study formed part of the research project "Plant Use of the Motherland: Linking Afro-Caribbean and West African Ethnobotany", carried out by the Netherlands Center for Biodiversity Naturalis, in collaboration with the Université d'Abomey-Calavi in Benin. Field research in southern Benin was carried out in six weeks, between mid-June to July 2011. Nine markets (Dantokpa, Calavi, Godomey, Adjarra, Avrankou – Porto-Novo, Grand Marché – Porto-Novo, Dassa, Golo and Savalou) were visited at least once (figure 2). There, medicinal plants were monitored, interviews were held and

Figure 2 Typical small medicinal market stall in Benin. Photo: Jorik Swier

plants were bought. As explained in paragraph *1.4 Sustainability of medical plants*, the plant parts which appear to be under the highest pressure regarding sustainability, are usually roots, barks and woods. Therefore, only these plant parts, purchased at markets, or obtained from traditional healers and vendors, are considered in this research. Several interviews were held with traditional healers and other people involved in medicinal plant trade. Field samples were collected in these areas surrounding Agonli, Golo, Dan and Savi. For a map with the geographic location of these locations, please see figure 3.

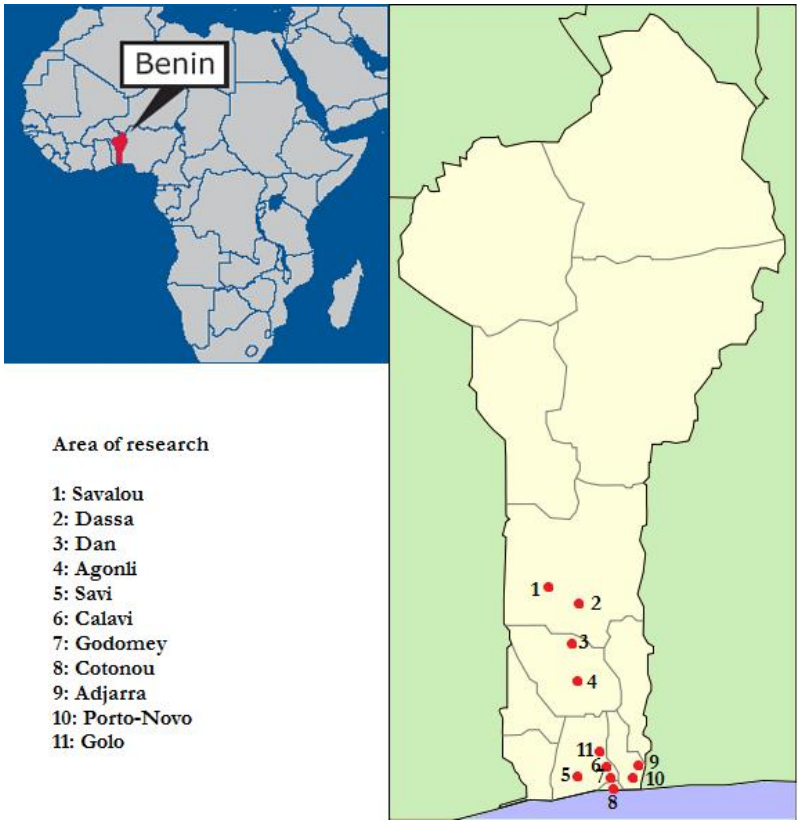

Figure 3 Map of Benin with cities where data is collected highlighted.

2.1.1 Interviews

In order to collect plants and gather information regarding the use and trade of medicinal plants, a number of semi-structured, qualitative interviews were held with traditional healers ('guérisseurs' in French), plant sellers on markets and harvesters of plants in the field. Guidelines as proposed by the Food and Agriculture Organization (FAO) were followed as closely as possible (Davis Case, 1990). During these interviews, the respondents were questioned about the use of a particular plant, how and when to harvest the desired plant part, what plant species they use and how they recognize these species and what species they consider to be vulnerable or disappearing. *Appendix 1* shows a list of questions asked to most interviewees.

Additionally, the Office National du Bois (ONAB, Cotonou) was interviewed in order to obtain information regarding the use and trade of timber species. Since timber species can potentially also provide medicinal bark, this indicates a possible source for medicinal plant collectors to obtain their material from. Accompanied with observations done at sawmills and lumberyards, we assessed the potential of bark collection from these sites as a by-product from lumber production.

2.1.2 Market sampling

Medicinal and magical plant samples were obtained on markets. In principle, every type of bark, root or wood was purchased from the first visit onwards. This meant that nearly every plant stall on a market was visited and quickly scanned for the available bark, root and wood specimens. Fresh leaves, fruits and seeds were usually ignored, as the focus in this research lies on woody plant parts. After some time, the bulk of the material present at plant stalls was quickly recognized and the search for new plant material was getting increasingly more challenging. The person selling the material on the market was asked for the local name of the material (and in which language), its use and preparation method. DNA samples were taken from samples

whenever possible. These samples consisted of a piece of fresh material, preserved in a sealed zip-lock bag with silica gel. DNA samples were labelled with database numbers for reference and stored at room temperature. The obtained plant material was processed into herbarium vouchers by pressing (if possible) and drying in a stove. Samples were split in two; one part of the voucher was kept in the Herbier National du Bénin, Abomey-Calavi, the other part was sent to the Nationaal Herbarium Nederland. Vouchers were labelled with a number which is to be found in the Botanical Research And Herbarium Management System (BRAHMS) database. Details for each collected voucher will be made available through BRAHMS and Global Biodiversity Information Facility (http://www.gbif.org/) by the end of 2012.

2.1.3 Field sampling

Medicinal and magical plant samples were also obtained in the field. This meant we accompanied rural plant collectors during participant observations (Jorgensen, 1989) and went into the fields to collect plants and monitor how plant collection was performed. Field informants were asked to show plants which have medicinal or magical roots and barks. Additionally, market samples of yet unidentified roots and barks were taken into the field, and the informant was asked to show us the plant where the material came from. This way, leaves and sometimes also flowers and fruits, could be matched with hard to identify roots or barks. Complete sets of herbarium vouchers, including bark, root and leaves, were created from a single plant in the field. Further processing, labelling and storage of the samples was performed as described in paragraph *2.1.2 Market sampling*.

2.2 Data analysis

The collected samples were identified (paragraph *2.2.1 Identification of plants*) and their sustainability was judged (paragraph *2.2.2 Establishing sustainability*). A characterization of all species collected gave rise to a number of species with key sustainability issues.

2.2.1 Identification of plants

Identification of the collected plant parts was performed at the Herbier National du Bénin, Nationaal Herbarium Nederland Wageningen branch and at the African wood collection of Nationaal Herbarium Nederland Leiden branch. Vernacular names supplied by sellers and field informants often matched those names found in literature (Burkill, 2004; de Souza, 2008; Plant Resources of Tropical Africa (PROTA) (http://database.prota.org/); JSTOR Plant Science (http://plants.jstor.org/)). The use of the plants was also asked to the person providing the material. Again, this use was often found in various forms of literature. Samples that were collected in the field along with leaves, could be identified with confidence to species level. Market samples of roots or bark were often 'identified' solely by matching the vernacular name supplied by the informant. The species suggested by literature was then checked in the herbaria. Sometimes information of the herbarium sheets matched the information supplied by the informant. A number of samples was checked with comparative material in the wood collection in Leiden. Although the species suggested by literature was often not available in the collection, certain samples of other species within the same genus were sometimes present. All together, these pieces of information contributed to a correct identification. Plant species names were checked for correctness using The Plant List (http://www.theplantlist.org/) which filtered out synonyms and provided the most recent author.

2.2.2 Establishing sustainability

The sustainability of medicinal plant species was judged based on several factors. Cunningham (1994 and 1997), as well as Ticktin (2004), suggest a number of criteria for selecting priority species. These criteria help in determining which species are vulnerable to overexploitation. Based on these factors, key species for protection are filtered out. A list of these factors involves:

- *Growth form:* the category of the plant. Usually expressed as herb, shrub, liana, tree, fern etc. Since this research deals with primarily woody plant parts, the most common growth forms are shrubs and trees. The growth form indicates the size of the plant, which is relevant for the amount of medicinal material present. A small shrub is easily killed if the roots are to be harvested, while a big tree may survive the removal of some roots. Accordingly, bark removal from a small tree will more often kill the individual than bark removal from a big tree (Schumann *et al.*, 2010). However, even big trees can be killed when bark is removed from the entire circumference of the tree (ring barking) as opposed to partial debarking from one side only (Geldenhuys, 2005; Delvaux, 2009).
- *Vegetation type:* indicates the natural habitat of the species. Divided in four types for the African species considered in this research, namely primary forest, secondary forest, weedy vegetation and shrubland, and savannah. The vegetation type of the species provides information on the amount of habitat in Benin. Primary forest is patchy, rare and often endangered in Benin (Adomou, 2005; Nansen, 2001), so any species exclusively growing in primary forest can be considered under pressure. Accordingly, savannah and weedy vegetation and shrubland are much more common in Benin, so species occurring in those two regions are not in immediate threat of habitat loss, although overexploitation may still occur. Vegetation type was taken from literature (Hawthorne and Jongkind, 2008; Burkill, 2004; de Souza, 2009) and others. The classification into four vegetation types is a simplification; more detailed classification is

beyond the scope of this research. The four categories used in this research are divided as follows:

Primary forest: dense, moist evergreen or semi-deciduous forest. Mangrove.

Secondary forest: dry (often disturbed) semi-deciduous forest. Associated riparian forest. Disturbed gallery forest.

Weedy vegetation and shrubland: (abandoned) farmland. Fallows. Along roads. Disturbed grassland. Around villages.

Savannah: dry savannah. Woody savannah. Woodland. Associated riparian forest.

More information on vegetation types and associated plant species can be found in Adomou (2005).

- *Survives harvest:* the medicinal plant part to be harvested, together with the growth form of the species, yields information on the chances of plant survival. Certain species may be considered valuable by plant traders, so they may uproot a plant to extract all its roots, or fell a tree to strip off all its bark. Other harvesting techniques can be less destructive. Most trees will survive if part of its bark is removed, as long as the tree is not ring-barked or girdled (Botha *et al.*, 2007). Pruning and coppicing are also options for sustainable harvest of wood and bark. Some secondary roots can be removed, without uprooting the plant. Methods of extracting medicinal plant parts sustainably are often available and can be considered here.
- *Resprouting ability:* damaging of plants may lead to resprouting. As a response to physical damage, a plant may create shoots or roots (Midgley, 1996; Ky-Dembele *et al.*, 2007). Some species react very well to removal of branches and coppicing, while others do not. Trees that do respond well to coppicing, could be good candidates for cutting of branches for the harvest of bark. Regular cutting of shoots is possible in those cases, without killing the individual tree. Resprouting is only relevant in cases where bark or

wood is harvested, since it does not involve regeneration through roots. Information on the resprouting abilities is often scarce, especially for species without global commercial interest.

- *Cultivation status:* many medicinal plants are harvested from the wild. However, certain species are naturalized or cultivated, which puts less stress on wild populations. If a species is currently only growing in the wild but can also be cultivated, that may indicate possibilities to relieve pressure on wild populations in the future. Other species may be difficult, undesirable or even impossible to grow in cultivation. This holds true in particular for primary forest species, but also for large trees with medicinal bark/roots as their only use. These large trees take years to grow, before one can harvest bark or roots for medicinal purposes.
- *Rarity:* an important factor in the sustainability of a species is the frequency in which the species can be found in the wild. If it is very common, there is less chance of overexploitation. The most vulnerable species are those which are listed as threatened by the IUCN red list (http://www.iucnredlist.org/); (Neuenschwander *et al.*, 2011), but this list is far from complete. Information on the rarity of species is sometimes lacking or out-dated. In those cases, field observations combined with data gathered from interviews, are used to investigate the current rarity of a particular species in Benin.
- *Other uses:* plants have many uses, not only medicinal uses. Depending on the uses of a species, the plant is either endangered or actually protected. Many trees provide valuable timber, which renders those species vulnerable to overexploitation because of (illegal) logging. Other species may provide fodder for livestock or edible fruits. In those cases, trees are often protected by local people, since it is beneficial for them to maintain those species. It is not uncommon to see cultivated fields where multipurpose trees such as *Vitellaria paradoxa* are kept in the field, because they are considered too valuable to cut down. At the same time, you can find dead tree stumps in otherwise virgin forest,

because these trees provide highly valuable timber. The other use(s) of a species may indicate the species is either in danger or actually protected by local people. Conflicting uses which put extra pressure of resources include timber, fuelwood and dyes, since these uses make use of the same plant parts and can therefore deprive resources as well. Some plant species are considered sacred by local people. These sacred species are often highly protected by locals which prevents overharvesting.

- *Market quantity:* a species can only become vulnerable if it is being harvested. Small scale harvest can be done sustainably, even for endangered species. Large scale, destructive harvest may even hurt a species that is not yet threatened according to the red list. The amount of harvested material is a good indication for the level of threat to a species. Therefore, the relative market quantity of a plant medicine is weighted in. Based on the preliminary results of our market survey, we estimated the volumes of these species on the market. A detailed quantification of market volumes is in preparation (Quiroz *et al.*). This quantitative market survey information is helpful in determining which species are very common or rare on the market and which species are highly prized. Species with high quantities being traded are more likely to be threatened. At the same time, species that are considered rare and precious, might be very scarce in the wild.

This data is taken from various sources including World Agroforestry Centre (http://www.worldagroforestry.org/), Plant Resources of Tropical Africa (PROTA) (http://database.prota.org/), JSTOR Plant Science (http://plants.jstor.org/), Flore Analytique du Bénin (Akoègninou, 2006) and others.

3. Results

Approximately fifteen interviews were held in total, including nine traditional healers and six market sellers. These interviews provided good insights in the use and sustainability of medicinal plants (*3.1 Information gained from interviews*).

Most markets generally exhibited an array of products including vegetables, fruits, household products, animals and livestock, fish and meat, construction materials, fetish/voodoo items and medicinal and magical plants. An estimated 5 to 10% of all market stalls is devoted to medicinal and magical plants, but more detailed data will be published at a later stage (Quiroz *et al.*, in preparation). Most plant parts are typically sold in bundles or bunches with between two and ten pieces of root/bark in a bundle. Prices are highly dependent on the species, but prices per bundle typically range between 50 to 200 CFA (0.10-0.40 US$) for green leaves/branches, and 200 to 400 CFA (0.40-0.80 US$) for barks and roots.

Matching all the separate elements of identification (vernacular name, therapeutic use, macroscopic features) eventually gave rise to the confident identification of an estimated 90 to 95 percent of all woody samples collected. In total, sixty-four plant species were found, mainly on markets. These sixty-four species comprise 27 families. A small number of species (n=3 to 7) is expected to be still in the unidentified samples. Paragraph *3.2 List of collected species* provides a detailed list of the species collected from the research area. Botanical information and details regarding the sustainability of the harvest of those plant parts are listed.

The sustainability of the collected plant species is judged based on several factors involving supply and demand, plant recovery postharvest and occurrence in the wild. Recommendations on the protection of certain species are made based on this information. A vulnerable species is highly sought after, rare, only grows in the wild and is killed upon harvest. Based on these

requirements, a list of key species has been compiled (paragraph *3.3 Key species*). This list provides a more detailed overview of species

3.1 Information gained from interviews

In southern Benin, the languages most commonly spoken are Fon, Goun (closely related to Fon) and Yoruba (particularly near the Nigerian border). The language most often used in interviews was Fon, with the help of a local interpreter. Interviewees explained the use of local plants and provided names of plant (parts) bought on the markets. It quickly became apparent that many medicine plant parts have suffixes in Fon and Goun. These suffixes indicate the specific part that is used of give indications on the use of the plant. Suffixes in Fon and Goun include, but may not be limited to, "-mansi"=medicine, "-tin"=tree, "-goto"=bark, "-do"=root, "-kwin"=seed, "-ma"=leaves. This gives rise to vernacular names such as "adjikwindo", which means "roots of the plant with seeds used in adji" (adji is a common board game in West Africa). Many more suffixes and prefixes are used to describe the plant in question. Characteristics often described in vernacular names include a certain use, color, size, taste et cetera.

Harvest of plants often occurs whenever and wherever people need. However, especially barks are said to be harvested during the dry season, as they will easily deteriorate e.g. by fungus, in the rainy season. Once dried though, they can be preserved for a long time. Many harvesters store their plants after drying, so plants are also available in the wet season. Harvest occurs in regions where the needed plant species grows. This can be any location, preferably close by, but sometimes rare plants are taken from further away. Interviewees responded they do not go into sacred forests since this is forbidden. One respondent replied he got into trouble with the owner after going into a sacred forest. Places where the desired species grows are found by asking local people and village chiefs. They can inform the harvesters on the exact location of a plant.

Barks and roots were said to be more expensive than leaves. That is because those plant parts are more difficult to acquire. At the same time, barks and roots should not be mixed when preparing a remedy for a certain illness. Drinks or concoctions that require several ingredients are nearly always composed of several root species or several bark species, but roots and barks are never mixed together.

When asked for rare or extinct plant species, respondents provided various species. Plant species mentioned as rare include *Caesalpinia bonduc*, *Parkia biglobosa, Carissa spinarum*, *Clausena anisata* and *Prosopis africana* (while another respondent said this species was very prevalent). Species said to be extinct include *Garcinia kola*, *Cola nitida, Picralima nitida* and *Panax ginseng*. However, these species have all been collected on the market more than once. This indicates that these species might either originate from abroad, or might not be extinct in Benin after all. It should also be noted that the species mentioned by interviewees varied. Local availability, or the lack thereof, can result in interviewees mentioning a species as common or rare.

Timber species were also said to be disappearing. Specifically mentioned are iroko (*Milicia excelsa*) and *Khaya senegalensis*. Because it is known that several other timber species also have medicinal bark, approximately five sawmills were visited. Bark of species collected on the market, with valuable timber as well, include *Pterocarpus erinaceus, Afzelia africana, Prosopis africana, Vitex doniana, Pseudocedrela kotschyi* and *Lophira lanceolata*. To investigate if the bark of those species on the market was taken from logs designates as lumber, the sawmills were visited. It was evident that the logs at those sawmills were cants, which means they were squared and their bark removed. Upon questioning, people working at the sawmills replied that the logs are canted with a chainsaw in the forest. The bark therefore remains in the forest and bark collectors do not go to lumberyards or sawmills to collect bark.

Figure 4 Typical harvest of medicinal bark. Photo: Diana Quiroz

Interviewees were questioned about the method of bark and root harvest. The extracting of both plant parts occurs in a crude manner with machete or axe (figure 4). Care is taken as to not kill a plant (this holds true for bark taken from big trees), but root removal is said to often kill smaller plants.

3.2 List of collected species

Approximately one hundred samples were collected during fieldwork in southern Benin by Jorik Swier. About sixty samples were obtained on markets and forty in the field with the help of traditional healers. For a complete overview, we have taken data from Diana Quiroz and Alexandra Towns as well. These data included plant species with medicinal of magical bark, roots or wood which have not been collected by Jorik Swier. Data obtained from Quiroz and Towns resulted in an additional approximate ten species which had not yet been collected by Swier. This brought the total to sixty-four different species. These species are listed in *Table 1*. This table provides a complete overview of the species collected, combined with sustainability factors as explained in paragraph *2.3 Establishing sustainability*.

Table 1: A list of plant species providing medicinal roots, bark and wood collected in southern Benin, together with sustainability aspects for these species.

[FAMILY] *Botanical name*	Vernacular name (language)	Part(s) used	Therapeutic uses	Growth form	Vegetation type				Survives harvest[1]	Resprouts[2]	Cultivated/wild	Rare yes/possibly/no[3]	Other use(s)	Rel. market quantity[4]
					Primary forest	Secondary forest	weedy vegetation and shrubland	Savannah						
[ANAC.] *Anacardium occidentale*	Akachougoto (Fon)	Bark	Child cough	tree	n	n	y	y	y	y	c	n	seeds + fruits	+
[ANAC.] *Lannea acida*	Minameygoto (Fon); Aku (Tcha)	Roots+bark	Cold shivers, anaemia, child's growth	tree	n	n	y/n	y	p	?	w	n	food+dye	+
[ANAC.] *Lannea barteri* syn. *L. kerstingii*	Hounmansi (Fon); Akoe (Idatcha); Suzu (Fon)	Bark	Malaria, menstruation, promotes growth	tree	n	n	y	y	p	y	w	p	dye	+++
[ANAC.] *Mangifera indica*	Mangagoto (Fon)	Bark	Anaemia	tree	n	y	y	n	y	y	c	n	fruits+timber	++
[ANAC.] *Spondias mombin*	Akonkonman (Fon); Yeyache (Tcha)	Bark	Protection against weapons	tree	n	y	y	n	p	y	c+w	n	fruits	0
[ANNON.] *Annickia chlorantha / A. affinis*	Aworpka (Yoruba)	Bark	Malaria	tree	y	y	n	n	n	?	w	p	(timber)	0
[ANNON.] *Annickia polycarpa*	Ataigoto (Fon)	Bark	Malaria	tree	y	y/n	n	n	p	?	w	n	n	0
[ANNON.] *Annona senegalensis*	Otriboeboe (Idatcha); Wingli (Fon)	Roots	Snakebites	shrub/ small tree	n	n	y	y	p	y	w	n	fruits	+
[ANNON.] *Cleistopholis patens*	Hounsounsgoto (Fon)	Bark	Women infertility	tree	y	y	y/n	n	p	n	w+c	n	seeds	+
[ANNON.] *Xylopia aethiopica*	Kpedjerekougoto (Fon)	Bark	Haemorrhoids	tree	y	y	y/n	y/n	p	?	c+w	n	spice	0
[ANNON.] *Uvaria chamae*	Ayarahado (Fon), Yayado (Fon); Erunjuit (Yoruba)	Roots	Menstruation, anaemia and hernia	shrub/ small tree	n	y	y	y	p	?	w	n	fruits	+
[APOC.] *Carissa spinarum*	Ahanzo (Fon); Hanzo (Fon); Igbogobai (Yoruba); Gongo	Roots	Male aphrodisiac, infection and malaria	shrub	n	n	y	y	p	y	w	n	n	++
[APOC.] *Mondia whitei*	Tchigoun (Fon), Chirigoun (Fon)	Roots	Male aphrodisiac	liana	n	y	y	n	p	y	w	n	n	+++

[APOC.] *Rauvolfia vomitoria*	Fiofioma (Kota-Fon); Lewe (Fon)	Roots	Madness	shrub/ tree	n	y	y	n	p	y	w+c	n	n	+
[AREC.] *Cocos nucifera*	Agongèdo (Fon); Agodo (Goun)	Roots	Blood problems and jaundice	palm	n	n	y	y	y	n	c	n	fruits+timber	+
[BALAN.] *Thonningia sanguinea*	Atimawudo (Fon); Otchokumonku (Tcha)	Roots	Child cough and kidneys	parasite	y	y	y	y/n	n	-	w	n	n	+
[BIGN.] *Kigelia africana*	Gnanblikpogoto (Fon)	Bark	Cysts, myomas, fibromas	tree	y	y	y	y	p	?	w(+c)	n	(seeds+ wood)	++
[BIGN.] *Newbouldia laevis*	Adjamangoto (Fon); Akoko (Tcha+Yoruba)	Bark	Many incl. snakebites and intest. problems	shrub/ small tree	n	y/n	y	y	p	?	c(+w)	n	sacred tree	+
[BIGN.] *Spathodea campanulata*	Adadegoto (Goun)	Bark	Female aphrodisiac	tree	y	y	y	y	p	?	c+w	n	ornamental	0
[CLUS.] *Garcinia kola*	Ahoédo (Fon); Cola blanc (French)	Roots	Diabetes and male aphrodisiac	tree	y	y	n	n	p	?	w+c	n	chewsticks+ seeds	+
[COCHL.] *Cochlospermum planchonii*	Chori (Idatcha); Beton (Tcha); Gbetu (Tcha)	Roots	Snakebites	shrub	n	n	y/n	y	n	-	w	n	dye+fibre	0
[COMBR.] *Combretum collinum*	Susufu (Fon)	Roots	Dysentery and snakebites	small tree	n	n	y/n	y	p	y	w	n	n	0
[COMBR.] *Pteleopsis suberosa*	Kluklugoto (Fon); Okluklu (Idatcha); Kulikuligoto (Fon)	Bark	Children growth	shrub/ small tree	n	n	y	y	p	y	w	n	n	+++
[EUPH.] *Bridelia ferruginea*	Onseguiguido (Fon); Ira (Yoruba)	Bark+roots	Children walk, contra-ceptive, heartburn	shrub/ small tree	n	n	y	y	p	y	w	n	fuelwood	++
[EUPH.] *Mallotus oppositifolius*	Kisé kisé su (Fon); Ahinja (Idatcha)	Roots	Malaria	shrub/ small tree	n	y	y	y	p	y	w	n	chewsticks	+
[FAB.-CAES.] *Afzelia africana*	Aguakpogoto (Goun); Kpakpa (Yoruba + Fon)	Bark	Protection against weapons, anaemia, STDs	tree	n	y/n	y	y	p	y	w	n	timber+fodder	0
[FAB.-CAES.] *Caesalpinia bonduc*	Adjikwin (Fon); Inchao (Tcha)	Roots	Male aphrodisiac	liana/ herb	n	y	y	n	n	n	c	y	n	++
[FAB.-CAES.] *Cassia siamea*	Cassia (Fon)	Bark	Malaria	tree	n	n	y	y/n	p	y	c	n	timber + ornamental tree	+
[FAB.-CAES.] *Daniellia oliveri*	Ozagoto (Fon); Inya (Tcha)	Bark	Children walk and heartbeats	tree	n	n	y/n	y	p	y	w	n	fuelwood	+
[FAB.-CAES.] *Dialium guineense*	Asonsouingoto (Fon)	Bark+roots	Fatigue and anaemia	tree	n	y	y	y/n	p	y/n	w(+c)	n	fruits+timber	+
[FAB.-CAES.] *Erythrophleum africanum*	Ekpoyobo (Yoruba); Tagbitaé (Tcha)	Bark	Makes tongue fall out	tree	n	y/n	y/n	y	p	?	w(+c)	n	wood	0
[FAB.-MIM.] *Albizia adianthifolia*	Ayolé (Fon)	Roots	Intestinal problems and cough	tree	y/n	y	y	y/n	y	y/n	w	n	Wood and fruits	++

[FAB.-MIM.] *Parkia biglobosa*	Ahwatin (Fon)	Bark	Female aphrodisiac	tree	n	n	y/n	y	p	y	w+c	n	edible fruits	0
[FAB.-MIM.] *Prosopis africana*	Kaké (Fon); Akaki (Tcha)	Wood+bark	Male aphrodisiac	tree	n	n	n	y	p	y	w	p	timber+ fuelwood+food	++
[FAB.-PAP.] *Baphia nitida*	Sokpli (Fon); Supeypey (Fon)	Wood	Dye and coloring	shrub/ small tree	y	y	y/n	n	n	y	w+c	n	(fodder)	+
[FAB.-PAP.] *Erythrina senegalensis*	Kpaklesigoto (Fon); Ochite (Idatcha)	Bark	Asthma	tree	n	n	y	y	p	y	w+c	n	ornamental	+
[FAB.-PAP.] *Pterocarpus erinaceus*	Kochu (fon); Hongeragoto (Fon); Kosso (Goun)	Bark	Menstruation and anaemia	tree	n	n	y/n	y	p	y	w	n	timber	++
[HYPOX.] *Curculigo pilosa*	Ayoté (Fon); Ayoglin (Fon)	Roots	Increase breast milk and against painful menstr.	herb	n	n	y	y	n	-	w	p	n	+++
[ICAC.] *Raphiostylis beninensis*	Kplakplakan (Fon)	Stem	Intestinal problems	liana	n	y	y	n	n	-	w	?	n	++
[LAM.] *Vitex doniana*	Ori (Idatcha); Fontin (Fon)	Roots+bark	Haemorrhoids and children's skin	tree	n	y/n	y	y	p	y	w	n	fruits+wood	+
[LAM.] *Vitex madiensis*	Oriëgoe (Idatcha)	Roots	Cold shivers	shrub/ small tree	n	n	y/n	y	p	?	w	n	(fruits)	0
[LOGAN.] *Anthocleista vogelii*	Gotudo (Fon); Irakpo (Tcha)	Roots	Fat loss, contraceptive and protection	tree	y	y	n	n	p	?	w	n	n	++
[LOGAN.] *Strychnos spinosa*	Agogo (Idatcha)	Roots	Snakebites	shrub/ small tree	n	n	y	y	p	y	w	n	(timber+ fruits)	0
[MALP.] *Acridocarpus smeathmannii*	Gbanguina (Fon); Bangina (Fon); Gbangando (Aizo)	Roots	Male aphrodisiac	liana/ shrub	n	y	y	y/n	n	-	w	p	n	+++
[MALV.] *Adansonia digitata*	Alomainta (Fon); Baobab (French)	Bark	Children growth	tree	n	n	y	y	y	n	w(+c)	n	leaves and fruits	+
[MALV.] *Bombax costatum*	Kponkpolá (Yoruba)	Bark	Female aphrodisiac	tree	n	n	n	y	p	y	w	n	flowers	0
[MEL.] *Entandrophragma candollei*	Iginla (Yoruba)	Bark	Protection in rituals	tree	y	y/n	n	n	p	?	w	y	timber	0
[MEL.] *Khaya senegalensis*	Zounxa (Fon); Kasedral (French)	Bark	Anaemia, female aphrod. and vaginal problems	tree	n	n	y	y	y	y	c(+w)	n	timber+ ornamental	+++
[MEL.] *Pseudocedrela kotschyi*	Atindorokpo (Fon); Tchaguigui (Tcha)	Roots	Stomach problems	tree	n	n	n	y	p	y	w	n	timber	+
[MEL.] *Trichilia emetica* spp. *suberosa*	Ichikun (Idatcha); Itchikó (Tcha)	Roots	Snakebites	small tree	n	n	y	y	p	y	w(+c)	n	ornamental+ timber+fruits	+
[MENISP.] *Sphenocentrum jollyanum*	Hanso hanso vovo (Fon); Kpedo(Fon); Akerigibo(Yor)	Roots	Male aphrodisiac and female contraceptive	shrub	y	y	n	n	n	-	w	y	n	+

[MOR.] *Milicia excelsa*	Iroko (Fon); Loko (Fon)	Bark	Protection	tree	y	y	n	n	y	n	w	y	timber + sacred tree	0
[MYRT.] *Syzygium guineense* var. *guineense*	Bagrusoe (Idatcha); Alégoussoko (Tcha)	Roots	Cold shivers	tree	n	n	y	y	y	y	w(+c)	n	fruits+ timber	0
[OCHN.] *Lophira lanceolata*	Banhô (*unknown*); Oguan (Yoruba)	Bark	Malaria and anaemia	tree	n	n	y	y	p	y	w	n	timber+ seeds	+
[OLAC.] *Olax subscorpioidea*	Métindo (Fon); Mintindo (Fon); Achokpongi (Tcha)	Roots	Many incl. fat loss and menstruation	shrub/ tree	y	y	y	y/n	p	?	w	n	n	++
[POLYG.] *Carpolobia lutea*	Avia (Fon and others)	Roots	Male aphrodisiac	shrub/ small tree	y	y	y/n	n	n	-	w	y	fruits	++
[POLYG.] *Securidaca longipedunculata*	Kpela (Fon); Kpaktalé (Idatcha); Kpèkado (Fon)	Rootbark	Malaria, caries and wash brain (incense)	shrub/ small tree	n	y	y	y	n	-	w	n	ornamental	++
[RUB.] *Gardenia ternifolia*	Kakrambo (Idatcha); Dakpla (Fon); Tatakplando (Fon)	Roots	Male aphrodisiac and grow babies	shrub/ small tree	n	n	y/n	y	p	?	w	n	n	++
[RUB.] *Morinda lucida*	Kwèswé (Fon); Wèdo (Fon); Kwensido (Fon); Huensi (F)	Roots	(Female) aphrodisiac and intest. problems	tree	n	y	y	y/n	p	y	w(+c)	n	(dye)	++
[RUB.] *Sarcocephalus latifolius*	Kodo (Fon); Oegoekbessi (Idatcha); Kudo (fon)	Roots	Contraceptive and vaginal cleanser	shrub/ small tree	n	n	y	y	p	y	w	n	fruits + fuel wood	+++
[RUT.] *Clausena anisata*	Gbossou azoué (Fon); Magbevudey (Fon)	Roots	Infection	shrub/ small tree	n	y	y	y/n	p	y	w(+c)	n	n	+
[RUT.] *Zanthoxylum zanthoxyloides*	Xetin (Fon)	Roots	Male aphrodisiac and toothache	tree (/shrub)	n	y/n	y	y	p	?	w	n	n	++
[SAPOT.] *Vitellaria paradoxa*	Limagoto (Fon); Wugo (Fon), Hagoto (Fon)	Bark	Intestinal and lung problems	tree	n	n	y	y	p	y	w(+c)	n	timber+ fruits	++
[VIT.] *Cissus populnea*	Tchakúbala (Tchá); Dèdo (Fon)	Roots	(Female) aphrodisiac	liana	n	n	y	y	n	-	w?	n	food gum	++

Remarks: species listed **in bold** are considered key species in sustainability. The next chapter will comment on these species in relation to a potential threat

"?" indicates the value is unknown, since too little information exists.

[1] indicates if the plant is suspected to survive harvest of plant part. "p"=possibly; the plant is expected to survive, but no definite answer could be given. "y"=yes, plant usually survives harvest. "n"=no, plant does not survive harvest.

[2] indicates if the plant resprouts upon removal plant parts. Some plants form sprouts upon the removal of a branch (coppicing). Others respond to physical damage such as cutting of roots, by forming young shoots. "y"=yes, plant resprouts easily. "n"=no, plant does not resprout, or with great difficulty.

[3] indicates rarity of the species in Benin. Rarity is based on literature, personal observations and answers from interviewees.

[4] indicates the relative market quantity (weight) of the species. Based on the preliminary results of our market survey, we estimated the volumes of these species on the market. "0"=rarely seen on the market, always in low quantities. "+"=sometimes seen on the market, but in below average quantities. "++"=frequently seen on the market, sold in fair quantities. "+++"=often seen on the market, sold in great volume and often available in big bags.

3.3 Key species

Based on *Table 1*, a list of key species is compiled here. While the sustainability of all species is considered in the table, it is not possible to provide more information for every species. Instead, the species with a more complex sustainability story, or those species which are suspected to be threatened, are discussed in this overview. Species listed in *Table 1* but not indicated as a key species, can be considered not in need of protection. In practice, species with a relative market quantity of "++" or "+++", species which are rare, species that are killed upon harvest or species with interesting or unique sustainability aspects are discussed here. For each key species some recommendations are provided to conclude with. These recommendations can help in the protection of vulnerable plant species.

Lannea barteri (Oliv.) Engl. (syn. *L. kerstingii* Engl. & K.Krause) [Anacardiaceae]

Tree up to 12 metres. Found in woody savannah and forest edges. The bark, grey and slightly scaly on the outside, is pounded. This yields a fibrous material which is orange to brownish red. Bundles of this pounded and shredded bark are sold on local markets in high quantities. Observed to be possibly one of the most common species on southern Beninese markets. The bark is used for dyeing and against various illnesses including malaria. The species is widespread, scattered, nowhere very common or even scarce, yet not rare (Arbonnier, 2004; Jansen, 2005). *L. barteri* shows very good bark recovery by edge growth, but the exposed wood is susceptible to insect damage (Delvaux *et al.*, 2009). Since the bark is exceptionally common on the market, yet the tree is not abundant in the wild, it is expected there could be a sustainability issue regarding this species. The high local demand in Benin may decrease the population in this area, while on global scale *L. barteri* may not be threatened. However, no destructive harvest such as dead trees, were observed in the field. It is not in cultivation and it coppices relatively easily.

Recommendations: quantify population in Benin. Protect existing trees by promoting sustainable harvest through partial debarking or coppicing.

Carissa spinarum L. (syn. *C. edulis* (Forssk.) Vahl) [Apocynaceae]

Shrub up to 2 metres. Growing in evergreen to semi-deciduous woodlands, slopes and savannah. The aromatic roots are used for several illnesses and as male aphrodisiac. Fairly common on markets and also used as ingredient for alcoholic bitters. Sought after by local people, and sometimes mentioned as becoming rare and hard to find by traditional healers and market stall owners. The species is considered vulnerable by the Red List book of Benin, and endangered by Adomou (2005). However, data from other parts of Africa is lacking. Considering the fair size of the plant and the root diameter observed on the market (usually 0.5 to 2 centimetres diameter), it is expected the plant is sometimes, but not always, killed upon harvest. The species is only found in the wild.

Recommendations: distribution is not well-known. Protection of natural habitat recommended. Propagation by local people as well as sustainable harvest, by not uprooting the plant but only removing a few secondary roots, should be promoted.

Mondia whitei (Hook.f.) Skeels [Apocynaceae]

Climbing liana up to 8 metres. The species occurs in a variety of habitats, ranging from humid forest, riverine forest, swamp forest and forest margins to humid or semi-dry savannah, sometimes along river banks (Lamidi & Bourobou Bourobou, 2010). Highly prized and commercialized root used as male aphrodisiac. The single root/rhizome, usually ½ to 2 centimetres in diameter and one to one and a half metres in length, grows horizontally just

Figure 5 Freshly harvested *Mondia whitei* root. Note thick root and thin and short vine. Photo: Jorik Swier

beneath the soil surface. It is harvested by following the vine to its base and digging up the root, which can be longer than the aboveground vine (figure 5). The plant is killed by the harvest, although small pieces of root left behind, may sprout again (Deguenonvo, 2011). The root with aromatic, vanilla-scented root bark, is sold on every market in Benin in high quantities, either fresh or dried. *M. whitei* is considered vulnerable in Benin (Neuenschwander *et al.*, 2011) or endangered (Adomou, 2005), although it is not listed on the global red list. Within its area of distribution in Benin, it may be not so rare locally, or even fairly common (Deguenonvo, 2011). However, *Mondia whitei* has become rare in many parts of its distribution area in Africa because of overexploitation and habitat loss. There is therefore a real danger of genetic erosion. Cultivation of the species is currently in an experimental phase in Congo, Guinea and Kenya (Lamidi & Bourobou Bourobou, 2010), but has not been observed in Benin during this research.

Recommendations: overexploitation is a real concern. Possibilities for sustainable harvest i.e. through harvest quotas, need to be investigated. Cultivation of the species may be a possibility, but methods of propagation need further research.

Garcinia kola Heckel [Clusiaceae]

Tree up to 25 metres. Naturally growing in primary and secondary forests. Sometimes planted near (cacao) plantations. Seeds ('bitter kola nuts') are highly commercialized on local and even international markets (Adeyeye and Ayejuyo, 1994). Also an important source of chew sticks, as are other *Garcinia* species. This has led to a decline in the population of *Garcinia* trees. The roots are also used in Benin as remedy against diabetes and as male aphrodisiac. The harvest of roots could be done on a sustainable basis, since big trees will not suffer from the loss of a few roots. However, due to overexploitation for the fabrication of chew sticks, the species has a global status of vulnerable on the IUCN red list. In Benin the species is actually extinct in the wild (Neuenschwander *et al.*, 2011). Since market sellers responded the seeds come from Nigeria, it is most likely the medicinal roots and chew sticks also originate from Nigeria.

Recommendations: in Benin, most of the species natural habitat is lost. Protection of primary rainforest and cultivation of trees in those areas are the only conceivable recommendations, since the species is extinct in the wild in Benin. A more sustainable alternative to *Garcinia* chew sticks should be found.

Pteleopsis suberosa Engl. & Diels [Combretaceae]

Shrub up to 10 metres, but more often much lower. Grows on woody savannah. Bark, which can be peeled off the stem in long strips, is coiled and made into bundles. One of the most common plant medicines on the markets in Southern Benin. Highly commercialized. Easily recognized by the long but narrow strips with a brown, warty, corky, surface. Used for the development and growth of children, as well as various internal problems. The species is not listed in the Red List book of Benin, but data on the rarity of the species is lacking. Interviewees responded that the plant was common, which was fortified by the field observations made in woody savannahs. The

species was frequently seen in savannah woodlands, with no observed evidence for destructive harvesting. The harvest of the bark from the stems, which were observed to be mostly between two and six centimetres across, can be considered detrimental for the species. It is expected the harvest can kill the plant, although regeneration from root suckering is possible (Bognounou *et al.*, 2009). The species is only known in the wild, without cultivation.

Recommendations: no immediate action to be taken. The species appears to be very common, although hard evidence is lacking. Further research on the local population densities may be useful for finding areas depleted of the species due to overharvesting.

Caesalpinia bonduc (L.) Roxb. [Fabaceae – Caes.]

Herby liana up to 15 metres. Found in disturbed woodland and secondary forest. Roots are highly prized male aphrodisiacs, while the seeds are used for board games. Leaves and stems are also sold on markets for medicinal purposes. The plant is one the most well-known species. The seeds are sold in large quantities on every market, although the roots and leaves are more scarce. The roots are one of the most expensive plant medicines available on markets, often costing $1.- or even $2.- a bundle of less than 50 grams. The species is actually extinct in the wild in Benin (Neuenschwander *et al.*, 2011). However, it is widely planted and cultivated throughout villages in gardens and along roads. *Caesalpinia bonduc* is common in other countries, hence there is no danger for genetic erosion (Oudhia, 2007).

Recommendations: all parts of the plants are considered valuable. Given the fact that the plant is only cultivated, yet nowhere common on the market, it is recommended to cultivate this plant more often. Not in need of protection due to extensive and successful cultivation.

Prosopis africana (Guill. & Perr.) Taub. [Fabaceae – Mimos.]

Tree up to 15 metres. Grows in savannahs and inselbergs. A multipurpose tree with valuable wood, leaves for fodder, edible seeds and several medicinal purposes (Agboola, 2004). The wood is sold on markets as male aphrodisiac in fair quantities, while the bark is also used sometimes. Leaves can be found on the market as well. It is remarkable that the wood sold on markets comes in weathered, irregular chunks without sapwood. This could be explained if the medicinal wood is a by-product from the production of wooden mortars, utensils and tools, where small piece are of no use. It could also be true that the wood is taken from dead tree stumps, which would explain the lack of sapwood and grey, weathered surface. Both possibilities can be regarded as a more sustainable harvest than felling a tree for its wood. Due to extensive overexploitation, *Prosopis africana* has disappeared from extensive parts of the southern Sahel and the adjacent Sudan savannahs (Orwa *et al.*, 2009). It is not on the Red List of Benin, however, there are indications that the species is overharvested for its wood. The species is not cultivated, partly because the seeds are hard to germinate (World Agroforestry Centre; Niang-Diop *et al.*, 2010). This puts extra pressure on the existing resources.

Recommendations: habitat protection. Investigate opportunities for planting of seeds and seedling protection. Promote coppicing, to which the tree responds well (Weber *et al.*, 2008), as sustainable method of harvest.

Pterocarpus erinaceus Poir. [Fabaceae – Pap.]

Small tree up to 15(-25) metres. Grows widespread in woody savannah and open forest throughout West and Central Africa. It is a multipurpose tree, with valuable timber, medicinal bark and fodder. The tree also produces a red exudate when the bark is cut. This sap is used in medicine and for providing clothing with a glaze (Duvall, 2008). The bark is fairly frequent on

the market and is used against anaemia and painful menstruation. The species is endangered in Benin (Neuenschwander *et al.*, 2011; Adomou, 2005), although not globally. Overexploitation of the species by collecting fodder material or timber is a serious concern in certain parts of Africa, but in many parts of its distribution range it is even abundant (Duvall, 2008). The tree is not necessarily killed upon harvest of bark. Some bark regeneration is observed and the underlying wood shows high resistance to insect damage (Delvaux *et al.*, 2009). The species also readily coppices, which provides a sustainable method for bark- and fodder collection. Cultivation of the tree has not yet been tried on a large scale (Duvall, 2008), but may prove a useful remedy against depletion of the wild population.

Recommendations: Promote protection of wild trees through habitat protection and coppicing techniques as sustainable harvest method. Investigate prospect of cultivation.

Curculigo pilosa (Schumach. & Thonn.) Engl. [Hypoxidaceae]

Small herb <40 cm with a single, thick, black tuber. Typical savannah plant; survives dry season in dormant state. Sprouts quickly in rainy season, when it comes to flower. The root, usually ~2½ x 10 cm, is used for breastfeeding women to increase milk production. The root is very common on markets; stalls with a big bag full of this particular root are not uncommon. The plant is always killed by harvesters, since the entire root is dug up. Although the species is not listed in the red list book of Benin, it remains unknown how common the species is. During our field trips in the rainy season, the plant was not observed. Herbarium sheets offer no information on the degree of rarity of the species. It is therefore assumed the plant may be relatively rare, or at least under pressure, since it must be harvested in the rainy season when it is above ground and thus visible. This means the plant is probably killed before it can set seed. Propagation may therefore be compromised, leading to a decline in the species.

Recommendations: determine and quantify the population in Benin. Immediate protection of the species may be required. No sustainable harvest on individual level is possible, therefore the cultivation of the species must be considered. Establishing harvest quotas may also prove useful.

Raphiostylis beninensis Hook F. ex Planch [Icacinaceae]

Woody liana up to 12 meters or straggling shrub. Found in semi-deciduous secondary forests and disturbed shrubland. It is one of the lesser known species of the genus (Lasisi *et al.*, 2011). The stems, but also the roots, are used for various intestinal problems. It is fairly common to find on the markets. Stems are cut in equal pieces and tied to bundles. Vendors did not know where it came from, but it is not mentioned as becoming rare by interviewees. Cutting the stems of *Icacinaceae* typically kills the plant (Parren and Bongers, 2001), although it is unknown if this species regenerates from its roots. Data on the rarity is completely lacking. It is not listed on the red list, but information is exceptionally scarce. During our field research in Benin, the plant was not collected from the wild. Data obtained from herbarium specimens in Wageningen does not supply more information. The origin of the fairly large supply of market plants remains to be solved but might be originating from Nigeria or other neighbouring countries.

Recommendations: investigations on plant ecology and scarcity. Establishing origin of market supplies. It would be safe to suspect sustainability to be an issue with this species, because it is fairly common on the market, yet it does not appear common in the wild.

Acridocarpus smeathmannii (DC) Guill. & Perr. [Malpighiaceae]

Woody liana or scandent shrub up to 6 metres. Found in fringing or riverine forest, scrubland and secondary forest or moist savannah. Highly commercialized root used as male aphrodisiac.

Found on every market, often in high quantities. Possibly *A. alternifolius* is also used for the same purposes. Both species are considered endangered by the Red List book of Benin (Neuenschwander, 2011) and Adomou (2005). This is fortified by the fact that of 98 African herbarium specimens known in Wageningen, only four are from Benin (Jan Wieringa, personal comm.). That is remarkably few, considering the fact that plants from Benin are generally well documented. The roots sold on markets are usually two to five centimetres in diameter. Given the high price of the product and plant size, it is suspected plants are uprooted by harvesters, thereby killing the plant. So far, the plant is not recorded to be in cultivation.

Recommendations: research on distribution in the wild, impact of the exploitation on the species and possibilities of cultivating the species. Immediate protection of the species may be required.

Khaya senegalensis (Desv.) A.Juss. [Meliaceae]

Tree up to 25 metres. Grows in gallery forests and moist savannah woodlands in the wild, but is often planted along roads and in cities. Plantations have been made in the past, sometimes with success. The bark is one of the most common medicines found on local markets and used for a variety of illnesses including anaemia, intestinal and vaginal problems. The bark is even commercialized to such an extent, that powdered bark can be found in packages in supermarkets. However, the plant's primary use is the wood, which is a highly valued timber. Due to overexploitation and illegal logging, the species has become endangered in Benin according to the Red List book of Benin (Neuenschwander *et al.*, 2011). The remaining wild trees are usually stunted and/or too small to provide timber. The wild population of the species has declined for many years, but is reported to be recovering. The tree is also planted increasingly frequent in villages and along road (Lopez Essou, personal communication). Most bark appears to be harvested from planted tree. Hardly a single tree with DBH>20 cm can be found in Cotonou which is not damaged by bark removal (figure 6), even if these trees are located in areas

with prohibited access. It is very common to see trees with severely malformed trunks, with mostly scar tissue for the first few metres. Patches of younger and older scars are often to be found on the same tree, indicating frequent removal of bark. Despite the extensive removal of bark from *Khaya senegalensis* trees, this activity does not seem to hurt the tree much. Not a single tree could be found that was killed by excessive debarking. It appears people are harvesting bark consciously as to not ringbark the tree. Furthermore, bark recovery of *Khaya senegalensis* is reported to be very good (Delvaux *et al.*, 2010).

Figure 6 *Khaya senegalensis* tree in Cotonou. Note scars from frequent bark harvest. Photo: Jorik Swier

Recommendations: habitat protection within area of distribution. Increase in planting of trees. No immediate actions needs to be taken, since the high number of cultivated tree provides a sustainable source of bark.

Entandrophragma candollei Harms [Meliaceae]

Annickia polycarpa (DC.) Setten & Maas [Annonaceae]

Annickia chlorantha (Oliv.) Setten & Maas /*A. affinis* (Exell) Versteegh & Sosef [Annonaceae]

These species are trees from primary evergreen forests. Although different species with different uses, they can be put in one group since they share a common sustainability. *A. chlorantha* and *A. affinis* are two highly similar species which are often confused in the field and in literature

(Kémeuzé and Nkongmeneck, 2011). *E. candollei* is a prized timber species, while the wood of *Annickia* species is only used locally. These four species are not indigenous to Benin and are hence imported from neighbouring countries, primarily Nigeria. The bark is used against malaria (*Annickia* sp.) or in rituals (*E. candollei*). Since it comes from far away, it is relatively expensive and sought after. These species are rarely found on Beninese markets. Surprisingly, these true primary rainforest species sold on markets in Southern Benin, don't grow in Benin (Akoègninou *et al.*, 2006). Apparently it is worth the effort to take the plant from far away and transport it over long distances. High prices of these medicines put great pressure on populations in neighbouring countries.

Recommendations: since these species are not indigenous to Benin, no specific recommendations could be made. It is expected the population in neighbouring countries is declining, because of overexploitation for Beninese markets, and/or because of general habitat destruction as observed in most West African primary rainforests.

Sphenocentrum jollyanum Pierre [Menispermaceae]

Shrub up to 1.5 metres. Grows mainly in the undergrowth of rainforest, often in deep shade, also in gallery forest. The thin taproot, which is easily recognized by its bright yellow colour and slightly scaly bark, is used as male aphrodisiac. It is seen on most markets, yet not in high quantities. It is quite expensive, which could partly be because of the small amount of roots per plant. The shrub remains small, so does not produce many roots. *S. jollyanum* is widely distributed but not very common in the forest, yet it is not rare on a global scale (Mosango, 2008). However, due to the fact that it grows in a very specific habitat (shady rainforest undergrowth) which is rare in Benin, it is likely the species is threatened in Benin. Its common use as an aphrodisiac may lead to genetic erosion. In Benin and Nigeria the plant is considered locally vulnerable or

even endangered and in need of protection (Mosango, 2008; Adomou, 2005). The plant is often harvested as small sapling, before reaching maturity, and is thereby killed (Tinde van Andel, personal communication). It only occurs in the wild, with no recordings of cultivation. However, it is recommended to promote the plant as candidate for cultivation in home gardens (Schmelzer *et al.*, 2010).

Recommendations: habitat protection. Determine population density and distribution in Benin. No sustainable harvest on individual level can be reached, but harvest quotas, based on population size and regeneration, can prove useful. Immediate protection of the species may be required in at least Benin. Cultivation can be a sustainable alternative to wild resources.

Carpolobia lutea G. Don [Polygalaceae]

A shrub or small tree up to 5 m. high. It is widely found in tropical Africa in secondary and primary forest, dense shrublands and even moist littoral savannahs although it prefers the shady understory of moist forests. The plant is widely known in Benin, with a similar vernacular name in many languages, namely "avia" or variations thereof (de Souza, 2008). This may indicate the name (and thus the plant) is derived from possibly another country and could be introduced. It is fairly common to find on the markets, although it is not to be found in large quantities. The species is widespread in tropical Africa, but data on its occurrence in Benin is completely deficient. Since the plant prefers dense forests, it can be expected the species is not common in Benin because this habitat is not prevalent in this area. The fruits are sometimes eaten but its main use in Africa is very specialized: it produces twigs to control cows with: cattle sticks. In mainly Nigeria and adjacent countries the plant is used by herdsmen for its extremely hard, strong and termite-resistant wood. The harvest of these cattle sticks is done in an extremely unsustainable manner in Cameroon, while the vast majority of the harvest is transported to

Nigeria where it is being traded, and probably also transported to Benin and even as far as Chad. This harvest in Cameroon is dominated by non-indigenes, with little benefit for local people. The plant is nearly always killed upon harvest, since the entire plant is used for cattle sticks and all its roots removed for medicinal purposes. This unsustainable harvest is also emphasized by the fact that relatively young plants are preferred for cattle sticks, resulting in a loss of reproductive specimens. Local depletion of the species has already been reported in Cameroon (Sunderland *et al.*, 2002). The plant is typically collected from the wild, with no cultivation known.

Recommendations: although the medicinal roots may be considered a by-product from the harvest of cattle sticks, the species is in serious danger of overharvesting. The current population in Benin needs to be characterized, as well as the origin of the medicinal roots established. Immediate protection of the species is expected to be required.

Securidaca longipedunculata Fresen. [Polygalaceae]

Shrub or small tree up to 6 (-12) metres. Found widely throughout Africa in a variety of climates, both in moist secondary equatorial forests as well as semi-arid savannahs. The medicinal part is the (toxic) root-bark, which is used for a variety of ailments such as malaria and caries. When fresh, it is very aromatic with a sharp taste. Once dried, it loses some of its aroma. The highly commercialized root-bark is greyish yellow, often shredded to small pieces and sold in bags on many markets. Best identified by its unique taste, resembling mouthwash and wintergreen oil. The roots are targeted by harvesters, but the plant does not respond well to the regular removal of roots. *S. longipedunculata* is sought after by local people, which has made this species threatened in at least South Africa (Ndou, 2006) and increasingly scarce in Ghana (van Andel *et al.*, 2012). However, it is reported to be common in savannah woodland from Senegal to South Nigeria (Burkill, 1985), but threatened in Burkina Faso (Ouedraogo, 2003). Data on the population in

Benin is lacking, but we suggest the species in under pressure in Benin as well. The seeds germinate with difficulty, seedlings grow slowly and do not tolerate transplanting well. This makes the species difficult to propagate and cultivate (Zulu *et al.*, 2011). Hence, the species is only found in the wild, with little prospect for cultivation.

Recommendations: the species is presumed to be overharvested with little possibilities for non-destructive harvest. Natural regeneration is poor, so a more sustainable source (e.g. through planting of seedlings) needs further research.

Sarcocephalus latifolius (Sm.) E.A.Bruce [Rubiaceae]

Small tree up to 10 metres, but more often a stout shrub of a few metres. Found on woody savannah and sometimes in fringing forests. Roots, easily recognized by their bright yellow colour and fibrous bark, are sold in high quantities on every market. Possibly one of the most commercial species in Benin. These roots are used for various genital issues. The species is very common in Benin and can be seen growing in most savannahs and even along roads. The plant responds well to coppicing (World Agroforestry Centre), indicating a good recovery to physical damage. The harvest of roots could be done on a sustainable basis, since the stout shrub does not necessarily die from the removal of part of its root system. However, the huge demand for the species may deplete local resources around areas of high demand such as cities. Cultivation could be a possibility in those cases, partly because the plant has multiple purposes including fuel wood and edible fruits, although the plant is currently not being cultivated.

Recommendations: no immediate measures need to be taken. Promote sustainable harvest by selective removal of roots and investigate possibilities for cultivation of the species, if local depletion is to be expected.

Morinda lucida Benth. [Rubiaceae]

Evergreen shrub to medium sized tree up to 15 m high. Found in a variety of environments such as woodland, savannah, secondary forests, hill slopes and gardens. It has many medicinal uses for its leaves, bark, wood and roots. The yellow colour of the woody parts, which is typical for many *Rubiaceae,* is extracted and used as dye and in alcoholic beverages (aphrodisiacs) to give it colour. The roots are fairly common on the market, where they are easily recognized by their yellow colour, although easily confused with *Sarcocephalus latifolius* or *Zanthoxylum zanthoxyloides.* The species is fairly common in Benin (Aschfalk *et al.*, 2000) and it is not considered rare, but hard data is lacking. It can be found cultivated in villages and gardens sometimes, which provide a reliable and sustainable source of medicinal material as well as fodder. The species is widespread in Africa with no danger for genetic erosion (Zimudzi & Cardon, 2005). However, since the demand of this species is high for both leaves and roots, overharvesting may be expected.

Recommendations: investigate population size in Benin. Encourage planting of the species in villages and gardens to alleviate the pressure on wild populations.

Vitellaria paradoxa C.F.Gaertn. [Sapotaceae]

Small to medium sized tree up to 20 metres. A typical savannah tree, often protected by local people and even conserved in farm fields. Bark, used for various internal problems, is fairly common on markets. It is dark brown, very rough and scaly on the outside, and with reddish streaks on the inside. Small drops of white latex are sometimes present. The tree is considered highly valuable because of the seeds, which provide shea butter. Its hard and heavy wood is also of many uses. The commercial status has designated *Vitellaria paradoxa* as one of the African forest genetic resource priorities. It is the subject of *in situ* conservation and germplasm exploration (Nikiema & Umali, 2007). The species is considered vulnerable in Benin

(Neuenschwander *et al.*, 2011), yet it is not rare or even common (Adomou, 2005). It recovers well from pruning and coppicing, which may provide a sustainable method of bark harvest. The species is primarily found in the wild, although small scale cultivation is observed in parts of West Africa.

Recommendations: *in situ* conservation. Planting of trees around farm fields should be encouraged. Coppicing should be promoted as sustainable bark harvest technique.

4. Discussion

4.1 Identification of plants

Most plant parts collected in this research were either roots or barks. The identification of these plant parts was very difficult, especially when these parts were kept in plant stalls at markets for a long time, so they had dried, turned mouldy or otherwise deteriorated. Very little accurate descriptions of these plant parts are available, and intraspecific variation in especially bark can be great depending on the tree's age. A lot of botanical information of leaves, fruits and flowers is available, but many botanists failed to collect or even describe the bark or the roots of a plant. Therefore, very little comparative material is available in herbaria. This makes identification exceptionally difficult, since clues for the species cannot be checked with identified, existing material.

Bark can be notoriously difficult to identify. The bark from a young tree can look completely different from the bark from an old tree, which often has a courser texture. Furthermore, harvesters can theoretically return to the same individual tree from which bark has been harvested before. This has been confirmed by interviewees. The second batch of harvested bark can be scar tissue, which is visually different from bark from virgin trees. Harvesters can also take a superficial slice of bark, not taking the cambium with it. The inside of the bark and its cambium can often show very clear patterns of cells or coloured streaks. If bark is harvested without cambium, these key features for identification are lost.

Roots can also be extremely difficult to identify, because virtually no woody root samples are present in herbaria or wood collections. Hence, most of the roots collected from the markets are identified based on literature. The local name provided by the informant was often found in literature. The species suggested by this reference, was then checked in the herbarium, to find out if the species had been listed with similar therapeutic uses before. If the therapeutic use listed

by the informant matches the use found in literature, there is an extra piece of evidence for correct identification.

Macroscopic features of wood samples were also checked, if comparative material was present in the herbarium. However, not all species could be found in the African wood collection of the Nationaal Herbarium Nederland, Leiden branch. This shows that this wood collection, amongst the largest and most comprehensive collections in the world, is still far from complete. Most wood samples in this collection consist of only a piece of heartwood, without bark, sapwood or roots. Moreover, samples from trees, primarily, are included. Very few specimens from bushes or small shrubs exist. Roots, even of highly commercial medicinal species, are completely lacking in this collection. This lack of comparative material is making positive identification of market samples very difficult. Other species within the same genus are sometimes present in the Leiden wood collection, making identification slightly easier but not conclusive.

In the Herbier National du Benin, no woody plant parts were present at all. Although there is a fairly comprehensive collection of herbarium sheets of local plants, there is no wood collection available. This meant that all woody plant parts collected could not be confirmed with the aid of the only local herbarium near the research area.

The majority (estimated 90-95%) of roots and barks collected during the research is presumed to be correctly identified. Species which could not be identified with confidence, were labelled "cf." in the BRAHMS plant database. Only a small number of samples (estimated to comprise 3 to 7 species) could not be identified at all. DNA analysis and wood anatomy analysis will be performed in the near future to identify these species. Two remarkable unidentified root samples are 'koromi' and 'ahwalinguin' (both in the language Fon). These species were found on the market more than once. Macroscopic comparison to identified samples gives the impression that these two species are in fact species not yet described in the list of collected species provided in paragraph *3.2 List of collected species*. 'Koromi' is a small root with a diameter up to 2 cm. It has

dark brown, smooth root bark and ivory coloured wood with a medium density. 'Ahwalinguin' is a fair sized root. The bark is thin and irregularly coloured, as is the wood. It is also used as male aphrodisiac. The vernacular names for these two species were not found in literature. However, due to their significant market value and therefore suspected overharvest, these species should be given an identification priority.

In this research, woody plant parts of many species were vouchered for the very first time. This has, at least partially, filled the substantial gap regarding African roots and barks in the wood collection in Leiden Nationaal Herbarium.

4.2 Available information regarding sustainability aspects

The sustainability of the collected species was assessed in paragraph *3.2 List of collected species*. As explained there, the sustainability was based on literature, combined with personal observations and information obtained from informant interviews. The available information for assessing the sustainability was highly dependent on the plant species. Certain species have high international economic interest, which leads to a lot of available sources of information. Other species may not be important on the international market, which means these species lack detailed information regarding rarity, population ecology and destructive extraction of plant material. An effort was made to accurately judge the sixty-four collected plant species on the level of threat caused by unsustainable harvest of plant material. However, data was sometimes insufficient. This was the case for shrubs without global interest such as *R. beninensis, A. vogelii, S. jollyanum, C. spinarum, T. sanguinea, C. pilosa, O. subscorpioidea* and *C. populnea.* Tree species, often with global interest because of timber purposes, had sufficient data available to evaluate sustainability upon. However, also of the shrubs with insufficient data we made an evaluation of their sustainability to the best of our abilities. Certain plants are not of global interest, but their economic value is so great regionally in (parts of) Africa, that available data were sufficient. This was the case for *S.*

longipedunculata, C. lutea, A. senegalensis, B. ferruginea and *G. ternifolia.* Data for these species was often found in species-specific scientific reports or databases such as PROTA.

4.3 Locating commercial harvesters

This research has been focussing on establishing the sustainability of medicinal plants. As explained earlier in paragraph 2.3, it is vital to identify harvesting techniques for specific plant parts. It is nearly impossible to judge the way a certain bark or root has been commercially harvested without witnessing it yourself, while this aspect is important in sustainability assessment. A harvester may destroy a certain species, while he or she does not hurt a second species based on the way the bark is being stripped off, or roots are being dug up. It is therefore critical to locate commercial harvesters. Observing their methods of harvestings can provide vital clues on the key species. Which species are killed upon harvest? How do these people locate the plant they need? Can we educate these people to harvest the plant parts more sustainably?

The procedure to get into contact with commercial harvesters was found to be very difficult. During the field research in Benin, a substantial amount of effort was put into locating harvesters, with actually very little result. The plant trade appears to be very local and is often on small scale. Collectors are usually farmers who harvest plant parts and sell them to compensate for decreasing agricultural income (Vodouhê *et al.*, 2008). Requesting information on the origin of material found on the markets was not easy. Most medicinal plant stall owners did not want to share this information with anyone, especially a white man. They were reluctant to provide any insights in their contacts or their sources for buying barks/roots in wholesale. It is presumed the market chain is fairly long, with several small middle man in between. This could be achieved because woody plant parts can be stored for a relatively long time. Roots and barks might pass many intermediate traders before finally ending up in small plant stalls in villages. A large

number of important medicinal plants are harvested in current vegetation systems such as fallows and forests (Vodouhê *et al.*, 2008). This is fortified by observations done in the field. Only a small number of plant species is primarily harvested from home gardens or from cultivated trees in public areas.

During the weeks of fieldwork, small pieces of the plant trade puzzle were slowly gathered. It appears most plant stall owners follow two methods of obtaining their goods.

- They buy their goods at a wholesale market. Maybe once a week or every two weeks, they travel to a big wholesale market where they buy medicinal plants. These are usually dried parts, such as seeds and barks and appear to be coming from far away, or at least they are stored long enough to dry thoroughly.
- Plant stall owners get their plants delivered to them, at the market. Small cars loaded with big bags (rice bags) full of plants stop at markets. Plant stall owners buy a few bags of plant material, which appears to be very fresh. It is suspected the people bringing those bags are the actual harvesters as well, or they could be middle man with direct contacts with harvesters. They often bring only a few species, in high quantity, about once a week. Since the average plant stall has many plant species in stock, they require several deliveries a week, from different people. The vendors on the market often claim to not know these people, but instead these people "just bring the plants here." Delivery of plants doesn't occur at a specific time of day.

These two possible routes are in accordance with Vodouhê *et al.*, 2008. Surprisingly, vendors normally do not appear to collect any plant material themselves. An occasional traditional healer may collect a few roadside plants from around the village, but for woods, roots and bark they usually rely completely on other people harvesting for them.

4.4 Missing species

Despite the fact that a large number of medicinal roots and barks have been identified, there is still a number of samples that has not yet been identified. Furthermore, a small number of presumably important medicinal species has not been found during the research. The following species are listed in literature to provide important medicinal bark or roots, but were not physically encountered on markets during this research: *Uapaca togoensis, Burkea africana, Maranthes polyandra* and *Detarium microcarpum* (Delvaux *et al.*, 2009). There could be several reasons that these species are not found during this research:

- Some of the unidentified samples might be any of the aforementioned species, but because woody materials for physical comparison is lacking in the wood collection of the herbarium in Leiden, no match could be made.
- A certain species could be misidentified and actually be one of these missing species. As explained in *4.1 Identification of plants*, it was sometimes very difficult to identify a certain bark or root. It is possible that a mistake has been made and a missing species has been sampled but not correctly identified.
- The species listed in literature to be important in Benin, might not be so important after all, or at least not so important in the area or season investigated during this research.
- These missing species might not have been collected at all, but yet they were present. This could be because they greatly resemble other, previously collected, species. This may give the false impression that the species has already been collected.
- These species are threatened in Benin and becoming rare, or the populations are actually rapidly decreasing. Although the species are not listed as threatened on the national red list, it could be there is insufficient data for that judgement.

Because these species appear to be important in herbal medicine in Benin according to literature, it is recommended to specifically locate these species on the market. Perhaps they are no longer

frequent on the market, because of declining supply. Local names for these species could be found in literature. Market stall owners and traditional healers can then be asked specifically for these plants. This information will help in determining whether these species have a sustainability issue in southern Benin.

It should also be stressed that this research deals exclusively with woody plant parts. Green leaves, seeds and fruits were also plentiful on the markets and are of significant value as well (i.e. van Andel *et al.*, 2012). Due to constrains in time and money, no analysis of the sustainability of those plant parts could be made here. Although it is fair to assume that the harvest of green plant matter is in general less harmful to a plant species than the harvest of roots, plants that are harvested for their leaves, fruits or seeds should still be considered in an analysis. Especially herbs that are used entirely in medicinal recipes are of concern. Two examples of herbs seriously threatened in Benin due to overharvesting for medicinal purposes include *Acanthus montanus* (fam. Acanthaceae) and *Heliotropium sp.* (fam. Boraginaceae) (Peter Neuenschwander, personal communication). It is thus recommended to perform an assessment of other non-woody medicinal and magical plants as well.

4.5 Conclusions

Sixty-four medicinal and magical woody plant species were collected in southern Benin with economically important roots, bark or wood. Of these species, ten are predominantly found in primary forest according to literature, but four of these species are actually not indigenous to Benin. Only two primary forest species appear to be threatened, namely *Sphenocentrum jollyanum* (Menispermaceae) and *Carpolobia lutea* (Polygalaceae). The remaining fifty species are predominantly savannah and woodland species. Seven of these species appear to be under pressure, with *Carissa spinarum* (Apocynaceae), *Pterocarpus erinaceus* (Fabaceae), *Acridocarpus smeathmannii* (Malpighiaceae) and *Securidaca longepedunculata* (Polygalaceae) being the most threatened species. No techniques for sustainable harvest are deliberately applied by people harvesting the plants, but partial debarking is often observed for trees. This may be a cause for the relatively low number of threatened species with medicinal bark, as opposed to medicinal roots. The vast majority of plants is harvested from the wild, with little cultivation. Patches of forest protected by local inhabitants are rare; instead most people harvest wherever and whenever they need. Techniques for a more sustainable harvest need to be addressed to local harvesters and could include cultivation of plants, partial debarking, not uprooting a plant and coppicing.

5. Acknowledgements

First and foremost I would like to thank the Alberta Mennega Foundation for their financial support. The financial contribution has been of great value for this fieldwork. Furthermore I would like to sincerely thank the Herbier National du Benin and its associated staff for providing the research group a good place to work in. The stove and office were of invaluable use. My gratitude also goes to Nicaise Deguenonvo for his guidance, both as a friend, fellow student and interpreter. Finally, I want to express my appreciation for Diana Quiroz, Tinde van Andel, Alexandra Towns and Solène Brière for being such nice company both during the fieldwork and afterwards in the Netherlands. They were very pleasant company and provided fruitful and stimulating discussions.

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Appendix 1: questions in interviews

The following questions were commonly asked in interviews, although not all interviewees were asked the same questions while new questions were developed during the interview:

- What is your age, name, gender and religion?
- What is your occupation?
- What is your relationship with medicinal and magic plants?
- What plant parts do you use?
- Do you collect these parts yourself, or do you buy them?
- When you collect plants yourself, which plants do you collect? How are those plants called in your own language (which language)?
- When and how do you collect those plants?
- Where do you collect them? In a (sacred) forest, farm field, garden etc.?
- What uses do those plants have?
- How do you identify those plants?
- Which plants are very common in the wild?
- And which plant species are rare?
- Are there any plants becoming more rare?
- Which species harvested for their roots or bark are most important to you?