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Review

Threats and conservation strategies for the African cherry (*Prunus africana*) in its natural range- A review

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The world's *Prunus africana* bark demand used to be satisfied by exports, approximately 4000 tonnes per year from a few African countries, led by Cameroon exporting 62%, Madagascar, 20% and Uganda and Equatorial Guinea, 7% each. This coupled with unsustainable bark harvesting methods created pressure on the natural resource which suffered population decline and resulted in the species listing in Appendix II of CITES and EU's bark export ban. In other range countries where no commercial harvesting has taken place, the species is under threat from other anthropogenic threats which include local use, deforestation and habitat fragmentation which is affecting populations in Ethiopia, Madagascar, Zimbabwe and South Africa as well as Cameroon, Uganda and Equatorial Guinea. Wildfires burn *P. africana* seedlings, saplings and mature trees throughout the species' range every year. Invasive alien species have mainly affected *P. africana* populations in Zimbabwe and South Africa. Climate change is projected to affect populations in southern Africa and Madagascar than those in East and West Africa. The fact that the threats vary or are common among countries calls for different or similar *P. africana* conservation strategies respectively. Strategies may vary from country to country or region to region depending on the type and magnitude of threats. These strategies include *in situ, circa situ* and *ex situ* conservation. In this paper, the various threats to *P. africana* populations across the species' natural range are investigated together with the conservation strategies which can be put in place to ensure sustainability.

Key words: Threat, climate change, habitat fragmentation, endangered species, conservation strategies, commercial harvesting, forest management, international regulation.

INTRODUCTION

The African cherry, *Prunus africana* (Hook. f.) Kalkman (Rosaceae) is a geographically widespread tree restricted to Afromontane forest habitats of the African continent (Stewart, 2003a). The species is popular for its bark whose extract is used to treat benign prostate hyperplasia (BPH) which is a non-cancerous enlargement of the prostate common in men over the age of 50 (Stewart, 2003a). The bark contains phytosterols (β-sitosterol, β-sitostenone) which inhibit the production of prostaglandins in the prostate, thereby suppressing the inflammatory symptoms associated with BPH and chronic prostatitis; pentacyclic triterpenes (oleanolic and ursolic acids) which inhibit the activity of glucosyl-transferase, an enzyme involved in the inflammation process; ferulic esters (*n*-docosanol and *n*-tetracosanol) which reportedly lower blood levels of cholesterol, from which testosterone is produced (Stewart, 2003a). In this regard, raw bark, macerated bark, or bark extracts were shipped to Europe and to the United States of America where they were sold in herbal formulations under the species' synonym, *Pygeum africanum* before the bark export ban (Stewart, 2003b; Nsawir and Ingram, 2007).

Traditional healers across Africa use *P. africana* as a medicine to treat diarrhoea, dysmenorrhoea, epilepsy, impotence, infertility, irregular menstruation, kidney disease, mental illness, eye disorders, fevers, obesity, pneumonia, arthritis, haemorrhage, haemorrhoids, hyper-menorrhea, hypertension, prostate gland enlargement and as an antibiotic, antigonorrheic, antihelmentic, anti-inflammatory, antimalarial, antiparasiticide, antirheumatic and antitussive (Stewart, 2003b). Additional to the medicinal value, the high strength and durability of *P. africana* timber makes it a useful tree throughout its natural range. In Uganda, the timber is used to make mortars, pestles, and bee hive supports (Cunningham, 1996) whilst large trees are hollowed out to make ‘‘beer boats’’ and banana beer (Cunningham and Mbenkum, 1993; Stewart, 2003b). In Cameroon, the timber is used to produce window and door frames whilst in West Africa; it is used for truck bodies, chopping blocks, bridge decks, cabinets and furniture (Stewart, 2003b). In South Africa, the wood is used for making wagons (Stewart, 2003b). In Zimbabwe, it is used as a general purpose timber.

P. africana like any valuable natural resource is under pressure from overutilization through commercial harvesting of bark, local use, invasive alien species, wildfires, habitat degradation and fragmentation, as well as climate change which is projected to affect the whole of the African continent through climatic zone shifts. Human action is to blame for the mentioned threats to the species abundance, distribution and survival. This therefore calls for conservation efforts before the species is wiped out.

SPECIES DESCRIPTION AND DISTRIBUTION

P. africana is an evergreen hardwood tree; over 30 m in height, with a straight bowl up to 1.5 m diameter; thick, fissured and dark-brown bark (Nsawir and Ingram, 2007; Betti, 2008). The leaves are simple and alternately arranged. The flowers are small, androgynous, 10 to 20 stamens, insect-pollinated, creamy white, fragrant and distributed in 70 mm axillary racemes (Nsawir and Ingram, 2007). Fruits are 11 mm x 9 to 10 mm, ellipsoid or transversely ellipsoid, indehiscent bilobed drupe, deep red to purple-black, 0.5 g, intensely bitter and resemble a cherry when ripe (Betti, 2008). The epicarp squeezes off in fingers revealing a green mesocarp surrounding a bony endocarp (Betti, 2008). Seeds have the same shape as the fruit and the cotyledons are white with a thin papery, dry and pale yellow-brown testa (Betti, 2008).

The African cherry is widely distributed (Figure 1) and is restricted to montane and afromontane forest habitats of west, east, and southern Africa (White, 1983; Stewart, 2003a; Stewart, 2009). Range countries include Angola (Bailundu Highlands and Mt. Moco), Lesotho, Malawi (Mt. Mulanje, Zomba and Vipya plateaus), Mozambique (Mt. Chiperone, Chimanimani Mountains and Mt. Gorongosa), South Africa (Mpumalanga through KwaZulu/Natal to the Knysna Forest), Swaziland (Forest patches near Malolotja and Mbabane), Zambia and Zimbabwe (Chimanimani, Nyanga and Chirinda Forest Reserve) in South Tropical Africa (Betti, 2008). In East Tropical Africa, *P. africana* is found in Burundi (Albertine Rift, Mt Heha/Ijenda, Mt. Bururi and Teza Forest), DR. Congo (Kivu Region, Rwenzori and Virunga mountains and Kahuzi-Biega National Park), Ethiopia (northwest Highlands to Lake Tana and southeast Highlands to Horar, Harerge, Illubador, Kefa, Arsi and Wolega), Kenya (Kakamega Forest, Mt. Kenya, Mt. Elgon, Mau Forest), Rwanda (Virunga mountains, Mukura and Nyungwe Forests), Sudan (Imatong mountains), Tanzania (northeast of the country including Mt Kilimanjaro) and Uganda (Kalinzu, Bwindi, Mgahinga, Mt.Elgon and Imatong mountains) (Farwig et al., 2007; Betti, 2008). The species also occurs in Cameroon (Bamenda Highlands, Mt. Kilum, Mt. Manenguba, Ademawa plateau and Mt. Cameroon), Equatorial Guinea (Pico Basile and Grand Caldera de Luba on the island of Bioko) and Nigeria (Mambila plateau, Gashaka Gumti National Park and southeast of the country) of West Tropical Africa, as well as in Madagascar (Zahamena Strict Nature Reserve, Montadia, Antsevable and Manakumbahiny-Est, Tsaratanana mountains, Ambatondrazaka and Moramanga, Tampoketsan Ankazobe and Ankaratra mountains), Sao Tome e Principe (central Principe, near the volcanic plugs of Joao Dias Pai e Filho and montane Sao Tome) and Grand Comore (Dawson et al., 2001; Betti, 2008). Before the EU ban, commercial bark harvesting (Figure 1) used to take place in Cameroon, particularly Mt Cameroon, Mt Kupe, Bamenda Highlands including Mt Oku and Nso, Kenya, Mau and western parts of the country; Uganda, Bushenyi District; DRC, Mt Kivu and in eastern parts of the country; eastern montane forests of Madagascar (Cunningham and Mbenkum, 1993).

THREATS TO THE DISTRIBUTION AND ABUNDANCE OF *P. AFRICANA*

Climate change

Climate change is a complex biophysical process caused by the rising global land and sea temperatures originating from increasing concentrations of greenhouse gases, principally CO_2 whose emission has increased by 80% since 1970, emanating largely from industrial activities of developed countries in Europe, North America and Japan together with burgeoning economies of Brazil, China, India and South Africa (Ziervogel et al., 2008). The impact of climate change in Africa is poorly understood because of lack of knowledge on the drivers of the continent’s climate, highly diverse and variable climates (encompassing the extreme aridity of the Saharan deserts at one end of the range and the extreme humidity of the Congo rainforest at the other) and severe lack of local weather data which makes it difficult to validate climate models to predict the impacts of climate change on *P. africana* distribution and abundance (Conway, 2009). However, it is predicted that many regions of Africa will suffer from temperature increases and droughts caused by range shifts along altitudinal and

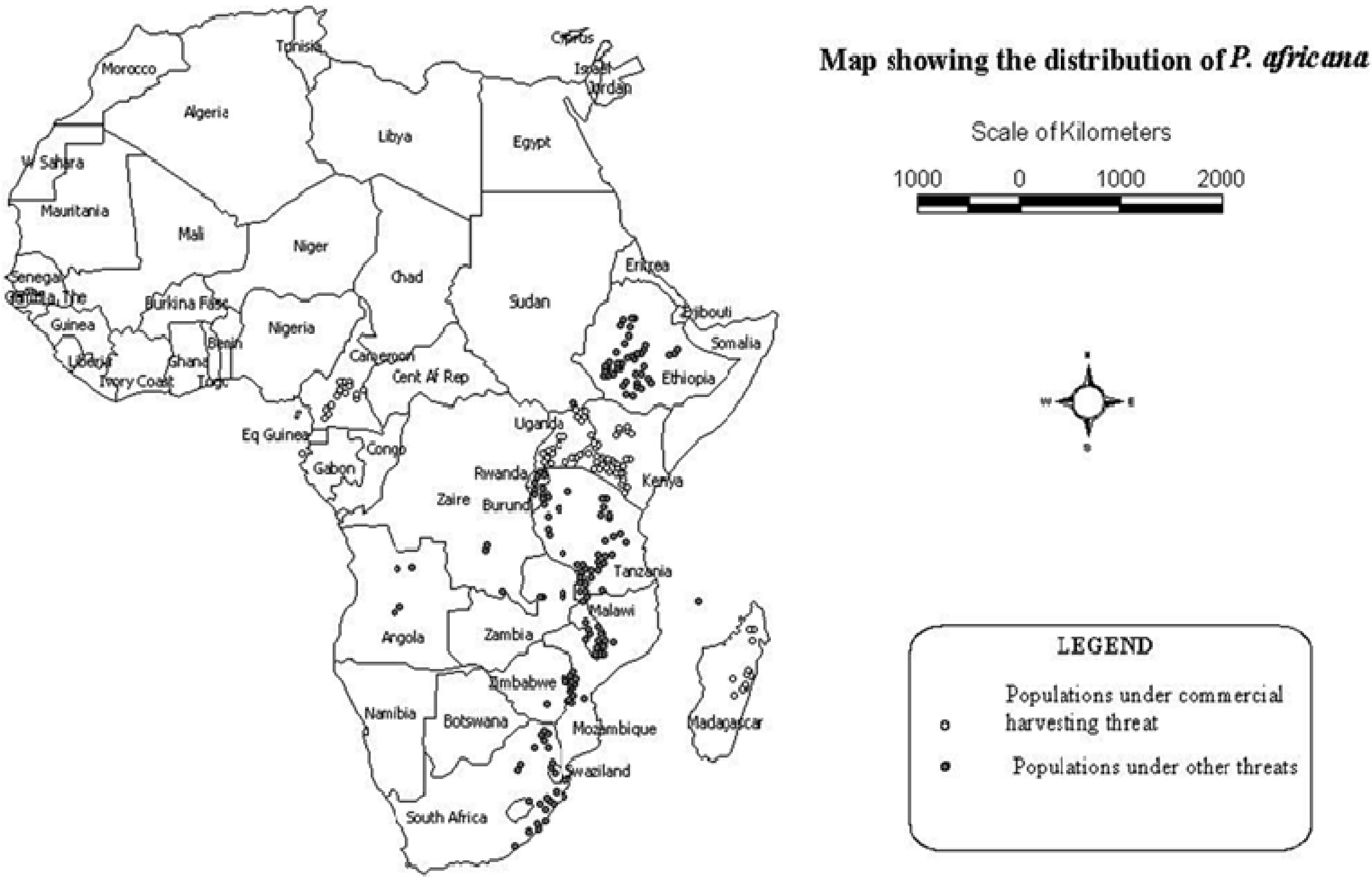

Figure 1. A map showing the distribution of *P. africana* as well as populations threatened by commercial harvesting.

moisture gradients (Hulme et al., 2000; Hannah et al., 2008; Conway, 2009).

There is evidence that Africa is warmer than it was 100 years ago; with warming through the twentieth century having been at the rate of about 0.5°C per century (Hulme et al., 2000). The six warmest years in Africa have all occurred since 1987, with 1998 being the warmest (Hulme et al., 2000). Hernes et al. (1995) and Ringius et al. (1996) (cited in Hulme et al., 2000) constructed climate change scenarios for the African continent, that predicted the Sahara and semi-arid parts of southern Africa which is habitat to *P. africana* in South Africa, Mozambique, Zimbabwe, Lesotho, Swaziland and Zambia, warming by about 1.6°C and the equatorial African countries warming to about 1.4°C by the 2050s. The Atmosphere-Ocean General Circulation Models analysed by the intergovernmental Panel on Climate Change (IPCC), predicts that over the next 100 years, northern and southern Africa will be warmer by as much as 4°C (Conway, 2009; Hulme et al., 2000). Warming is likely to be higher than the global annual mean throughout the continent and in all seasons, with drier subtropical regions warming more than the moister tropics (Ziervogel et al., 2008; Conway, 2009). While warming is seen to dominate the continent, areas around Nigeria and Cameroon, the largest *P. africana* bark exporter in West Africa and along the coastal margins of Senegal/ Mauritania and South Africa are projected to cool (Hulme et al., 2000).

Different regions in Africa currently exhibit contrasting rainfall variability characteristics, with the Sahel region displaying large multi-decadal variability characterised by recent drying; East Africa, a relatively stable regime with some evidence of long-term wetting, and southeast Africa, a stable regime marked with inter-decadal variability (Hulme et al., 2000). According to Joubert and Hewitson (1997) (cited in Hulme et al., 2000), precipitation is simulated to increase over much of the African continent by the year 2050. Parts of the Sahel could experience precipitation increases of as much as 15% over the 1961 to 1990 average by 2050 (Hulme et al., 2000). However, according to Conway (2009), in the next century, northern and southern Africa is projected to become drier with precipitation falling by 15% or more. More moderate drying of 5 to 15% /century is noted along the Mediterranean coast and over large parts of Botswana and Zimbabwe and the Transvaal in southeast South Africa. Thus, the *P. africana* habitat in South Tropical Africa particularly in South Africa and Zimbabwe will be affected, leading to possible population decline or even extinction. A study of *P. africana* in South Africa, found that 47% of the standing stems ≥10 cm Diameter at Breast Height (DBH) were dead due to increasing aridity in the Southern Cape region (Geldenhuys, 1981). In eastern and parts of central Africa, including the Horn of Africa average rainfall is likely to increase (Ziervogel et al., 2008; Conway, 2009), a scenario which may/may not affect *P. africana* survival. The modest wetting trend noted over East Africa is seen to be part of a more coherent zone of wetting across most of equatorial Africa, in some areas of up to 10% or more per century (Hulme et al., 2000).

Pronounced climate change is also expected in Madagascar with projections indicating mean temperature increases of 1.1 to 2.6°C throughout the island with greatest warming in the south and least along the coast and in the north (Hannah et al., 2008). Rainfall is projected to increase in summer (January to April), and winter (July to September) and the southeast coast will be drier by 2050 but wetter elsewhere. The dynamic global vegetation model (BIOME and MAPPS) projects Madagascar to lose 11 to 27% of its current habitat due to climate change if range migrations are possible (perfect dispersal) and 17 to 50% if not (Malcolm et al., 2006 cited in Hannah et al., 2008). 18% of species were projected to expand in range and 45% to contract, even under the optimistic full dispersal assumption (Hannah et al., 2008). The mentioned climate change scenarios indicate that, montane ecosystems (in highland areas below the subalpine zone) which are habitat to *P. africana* are not going to be spared by increasing temperatures and aridity in some parts of Africa. We can expect a decrease in the area suitable for *P. africana* in southern African countries, for example in Zimbabwe where the length and severity of the drier periods is increasing. Afromontane forests are at risk because quite small changes in temperature and rainfall patterns can have deleterious impacts on the viability of plants (Conway, 2009).

Commercial harvesting

Unlike climate change whose impact on *P. africana* distribution and abundance is not clearly understood, the role of legal and illegal commercial overharvesting on the decline in populations has been clearly evident and was documented (Ewusi et al., 1992; Tchouto, 1996). Annually, approximately 4000 tonnes of bark used to be harvested primarily from Cameroon (62%), Equatorial Guinea (7%), Kenya (7%) and Madagascar (20%) and exported to France, Italy and Belgium (Cunningham and Mbenkum, 1993; Terry et al., 1999; Cunningham et al., 2002). In many countries, this over-exploitation was characterised by trees being girdled and left to die or felled to facilitate easier access to the bark (Cunningham and Mbenkum, 1993). Bark exploitation has caused serious damage to wild populations of African cherry including trees inside forests of high conservation value, leading to concerns on the long term sustainability of harvesting and conservation of this tree species. A study in Equatorial Guinea found that, 68% of exploited *P. africana* were either dead or experiencing canopy dieback (Fashing, 2004).

As a result of the high international demand for the bark, there was a recent ban on bark export to the EU and prior to this, *P. africana* had been listed as an endangered species in Appendix II of the Convention of International Trade in Endangered Species of wild fauna and flora (CITES) (Dawson et al., 2001; Stewart, 2003b). In theory, this means that countries of export have to issue export permits and countries of import have to check these permits upon entry (Cunningham et al., 1997). The species is also listed in the Tree Conservation Database (TCD) of the World Conservation Monitoring Centre (WCMC) (Dawson et al., 2001). The FAO Panel of Experts on Forest Gene Resources lists *P. africana* as one of the 18 top priority species for action in Africa (Dawson et al., 2001). Before the EU ban, these regulations had little impact in practice because some permit guidelines for sustainable harvesting were disregarded and most harvesters did not even know of their existence (Dailey and Fernandes, 2009). Furthermore, because of the scattered distribution of *P. africana* in most countries, monitoring is difficult or in some cases virtually impossible. As a consequence, there has been pressure to move *P. africana* from Appendix II to Appendix I of CITES, implying that there would be no-more trade of the species (Dailey and Fernandes, 2009).

In Cameroon, *P. africana* is considered a vulnerable species mainly resulting from excessive commercial harvesting (Betti, 2008). The country was the biggest exporter of *P. africana* bark recording annual average exports of 1500 tons of fresh bark during the 1980s and 2000 tons in the early 1990s (Cunningham et al., 2002). Field observations in Cameroon suggested that, bark gatherers selectively harvested bark from the largest trees available and where over-exploitation of large trees occurred, there was a shift to trees with a smaller and smaller diameter at breast height (Cunningham and Mbenkum, 1993). Tako et al. (1996) (cited in Cunningham et al., 2002) surveyed five sites around Mt. Cameroon and indicated that 61% of *P. africana* trees were totally debarked, an additional 25% of tree trunks girdled, 1.6% felled and only 10% had not been exploited out of a sample of 127 trees. The harvest levels were considered unsustainable by Stewart (2001) (cited in Betti, 2008).

In DRC, bark harvesting was reported to be opportunistic and unregulated because controlled harvesting has not been possible due to civil wars (Betti, 2008). As for Madagascar, like Cameroon, *P. africana* is considered a vulnerable species because of poor compliance to Forest regulations. Although the *Direction des Eaux et Forêts (*1997) law of Madagascar requires harvesters to extract *P. africana* bark sustainably, harvesters usually cut down small trees because of resource scarcity (Dailey and Fernandes, 2009). As a result, the species is characterised by poor recruitment and a few young trees. In Equatorial Guinea, bark harvesting began in 1992/3 and was considered unsustainable. By 1999, only one company, *Aprovechamiento Agricola* (APRA), a subsidiary of NATRA, a Spanish conglomerate, exported *P. africana* bark from Bioko (Terry et al., 1999). In Burundi, no data is available on the effect of commercial trade. In Tanzania, research is required to determine the extent of harvest for export.

Local use

In most parts of Africa, *P. africana* bark, stem and branches, roots and leaves are used for various purposes by local people thereby threatening the few and small populations. In Ethiopia, the species is not threatened but local people harvest and use the bark, stem and branches for fuel wood, charcoal production and as timber (Betti, 2008). Recruitment is poor in Bale Mountains. The species is harvested for medicinal and other domestic purposes in Angola and Malawi, were it is listed in the IUCN Category status Vulnerable (*VUA1cd*) with Angola having small populations still remaining in Mt. Moco and the Bailundi Highlands with no effective control measures put in place yet (Betti, 2008).

It is listed in IUCN Category status Endangered (*C2Ad2*) in Swaziland where it is locally harvested for medicinal purposes and traded internally and across border to markets in Johannesburg, South Africa (Betti, 2008). In South Africa, there is exploitation of the remaining small, vulnerable populations and there is internal commercial trade of *P. africana* bark for medicinal purposes (Betti, 2008). The traditionally dominant tribal group on Bioko, Equatorial Guinea, the Bubi, harvest the bark of the tree for a number of medicinal uses (Terry et al., 1999).

Habitat fragmentation and degradation

Habitat fragmentation and degradation are important drivers of biodiversity loss and can influence the life cycle of tropical tree species by lowering pollination, limiting seed dispersal, increasing seed predation and therefore affect population sizes and distribution (Farwig et al., 2007). In Madagascar, deforestation has claimed about 90% of the island's natural forest leaving fragments which provide a poor template for large-scale species range shifts (Hannah et al., 2008). According to Dailey and Fernandes (2009) deforestation is rampant in Madagascar with only 18% of the original forest cover still remaining. Habitat destruction and fragmentation are also considered the biggest threats to *P. africana* in Sao Tome e Principe and Zimbabwe.

The clearance of vegetation to create space for pine (*Pinus patula, Pinus taeda* and *Pinus elliotii*), Eucalyptus (*Eucalyptus cloeziana, Eucalyptus grandis* and *Eucalyptus camaldulensis*) and *Acacia mearnsii* plantations in Nyanga and Chimanimani mountains was characterised by the destruction and fragmentation of the *P. africana* afromontane habitat leaving small and rare patches. In Ethiopia, *P. africana* habitat is destroyed by livestock, as well as clearance by the local inhabitants. Habitat loss through forest clearance for subsistence farming is considered a threat in Nigeria, Mozambique, Rwanda and Zambia (Betti, 2008). In DRC, fuel wood harvesting by 0.5 million Rwandan refugees has been an issue near Kahuzi-Biega.

Invasive species

Linked to habitat fragmentation and destruction through the establishment of forest plantations is the invasion by the established exotic tree species. Alien plants can alter the structure of native plant communities (Brooks, 2000) through competition with native plants and modification of fire regimes (Higgins et al., 1999; DiTomaso, 2000). Invasive plants can out-compete native annual (Inouye et al., 1980; Pake, 1993; Brooks, 2000) and perennial plants (Eissenstat and Caldwell, 1988; Melgoza and Nowak, 1991). Some deplete soil water faster and at greater soil depths, others utilize increased levels of soil nutrients faster than native species and thus, reduce their growth rates (Brooks, 1998). These can significantly reduce native seedling biomass and species richness (Brooks, 2000). Invasive alien species are generally known to negatively impact on native species diversity. Invasive alien species are known to be a threat to *P. africana* habitats in South Africa and Zimbabwe.

Zimbabwe's afromontane phyto-region is scattered along the eastern highlands, where most of the exotic pine, gum and wattle plantations were established. The commercial forest plantations cover an area of 118 000 ha, of which 68% is planted with pines, *P. patula* constituting 61%; *P. taeda*, 22.8%; *P. elliottii*, 10%; *Pinus kesiya*, 2% and *Pinus oocarpa*, 0.2%. The remainder represents *E. grandis*, *E. cloeziana* and *A. mearnsii*. Among the pines, *P. patula* is the most aggressive invader of afromontane forests where *P. africana* and other important species occur, in localities above 1600 m asl. In the Eastern Highlands of Zimbabwe, *P. patula* was estimated to have invaded more than 100 000 hectares of land. *A. mearnsii* and *Acacia melanoxylon* are aggressive invaders of montane grasslands. *A. mearnsii* (Figure 2) was estimated to have invaded more than 200 000 hectares mainly in the mist belts of the Eastern Highlands.

Other important invasive alien species (IAS) are *P. taeda, P. elliottii, Pinus radiata, Lantana camara, Psidium guajava* and *Eucalyptus spp*. In South Africa, the area under *P. patula* constituted 337 000 hectares in 2001and the species had invaded an area of about 17 600 hectares in surrounding afromontane forests in cool mist belts and wet high altitudes of 1 500 to 1 900 m asl in Kwazulu-Natal and Mpumalanga which are *P. africana* habitats. *A. mearnsii* is considered to be the major invader in South Africa and was estimated to have invaded about 2 500 000 hectares in Kwazulu-Natal and Mpumalanga. Plant invasions often involve the establishment of new life forms which may have intrinsic fuel properties that differ from those of native species (Brooks et al., 2004). The invasion of the afromontane habitat by invasive alien species like Pinus*,* Eucalyptus*,* Acacia and *L. camara* in the Eastern Highlands of Zimbabwe fuel wildfires not thought to have been prevalent before invasion. These wildfires kill long-lived *P. africana* and other native afromontane plants.

According to Brooks and Berry (1999), thick layers of invasive alien plant litter often develop where alien species are abundant. These accumulations lead to hot temperatures, long flame residency times and continuous burn patterns (Brooks, 1999). Besides alien species there are indigenous species which threaten the survival of *P. africana*. Photos (Figure 3) which I took in Nyanga National Park, Zimbabwe show *P. africana* trees under threat from *Ficus ingens* which in this case, completely enveloped the *P. africana* butts, threatening the trees' survival.

Wildfires

Fire is problematic in forests throughout Africa. In Sudan, Angola, DRC, Lesotho, Zambia, and Zimbabwe, the afromontane forests were reported to be vulnerable to fire (Betti, 2008). Wildfires mainly interfere with regeneration, as it wipes out seedlings and saplings which cannot withstand the damage. Figure 4 shows part of a *P. africana* stem with a large scar (class 4 damage-51 to 75%) caused by fire in Nyanga National Park, Zimbabwe.

THE WAY FORWARD

Conservation

According to ICRAF, *P. africana* conservation strategies are based on biological and ecological (genetic variation, reproductive biology and ecosystem function) and policy and regulation determinants (Dawson et al., 2001). Given the wide but disjunct distribution of *P. africana* across Africa, genetic variation could have diverged accordingly. Genetic experiments done by Dawson and Powell (1999) revealed genetic variation (66%, $P<0.001$) among Cameroon, Kenya, Uganda and Madagascar populations. This emphasizes the need to develop regional conservation programmes. Variation within the same population and between populations within the same country, shows the importance of developing conservation strategies at country level. Besides genetic variation, there is need to consider the reproductive biology of *P. africana,* as it affects *ex-situ* and *circa situ* conservation strategies. According to Dawson et al. (2001), *P. africana* seed is

Figure 2. Invasive alien species in Nyanga, Zimbabwe.

intermediate in nature and therefore limits long term *ex-situ* seed storage.

However, short term seed storage across planting seasons is possible. Usually, it is noble to consider the ecosystem where the species occur rather than conservation of *P. africana* only. The afromontane forests are not habitat to *P. africana* only but are rather considered to be important conservation targets. Typical cases are Mt. Cameroon with 42 strictly endemic plant species (Thomas and Cheek, 1992); Bwindi Impenetrable Forest, Uganda, containing 50% of the world's endangered mountain gorilla, *Gorilla beringei* (Cunningham, 1996); Kakamega Forest, Kenya, considered of high conservation value (Kokwaro, 1988); Chimanimani Mountains and Chirinda Forest in the Eastern Highlands of Zimbabwe considered high value conservation areas with several endemic, rare and endangered species; Chimanimani Mountains in western Mozambique. Madagascar is one of the most important biodiversity hotspots, with 80% of the 10,000 to 12,000 flowering plants species endemic (Dailey and Fernandes, 2009). Bioko is unique in terms of its fauna, with species like the drill (*Mandrillus leucophaeus poensis*), Pennant's red colobus (*Piliocolobus pennanti*), the red-eared monkey (*Cercopithecus erythrotis erythrotis*) and Preuss's monkey, (*Cercopithecus preussii insularis*), all of which are endemic together with more widespread, but still rare species such as the black colobus (*Colobus satanus satanus*) and the crowned monkey (*Cercopithecus mona pogonias*) (Terry et al., 1999). Most of these forests are under threat from agricultural clearance and therefore need to be conserved. In Bioko, access routes opened in Pico Basile Forest to harvest *P. africana* gave meat hunters easier access routes to the habitat of a seriously threatened endemic subspecies of the primate Preuss's guenon (*C. pruessi insularis*), which has contributed to its endangered status (BPPP, 1999). Therefore, by conserving the whole ecosystem, a number of endemic, endangered species will be protected.

The sole regulation of international significance in influencing *P. africana* conservation strategy is CITES, in which the species is listed in Appendix II becoming effective in 1995, implying that trade must be licensed at export and import (Dawson et al., 2001). This means that exporting countries issue export permits and importing countries check these permits upon entry. The scientific

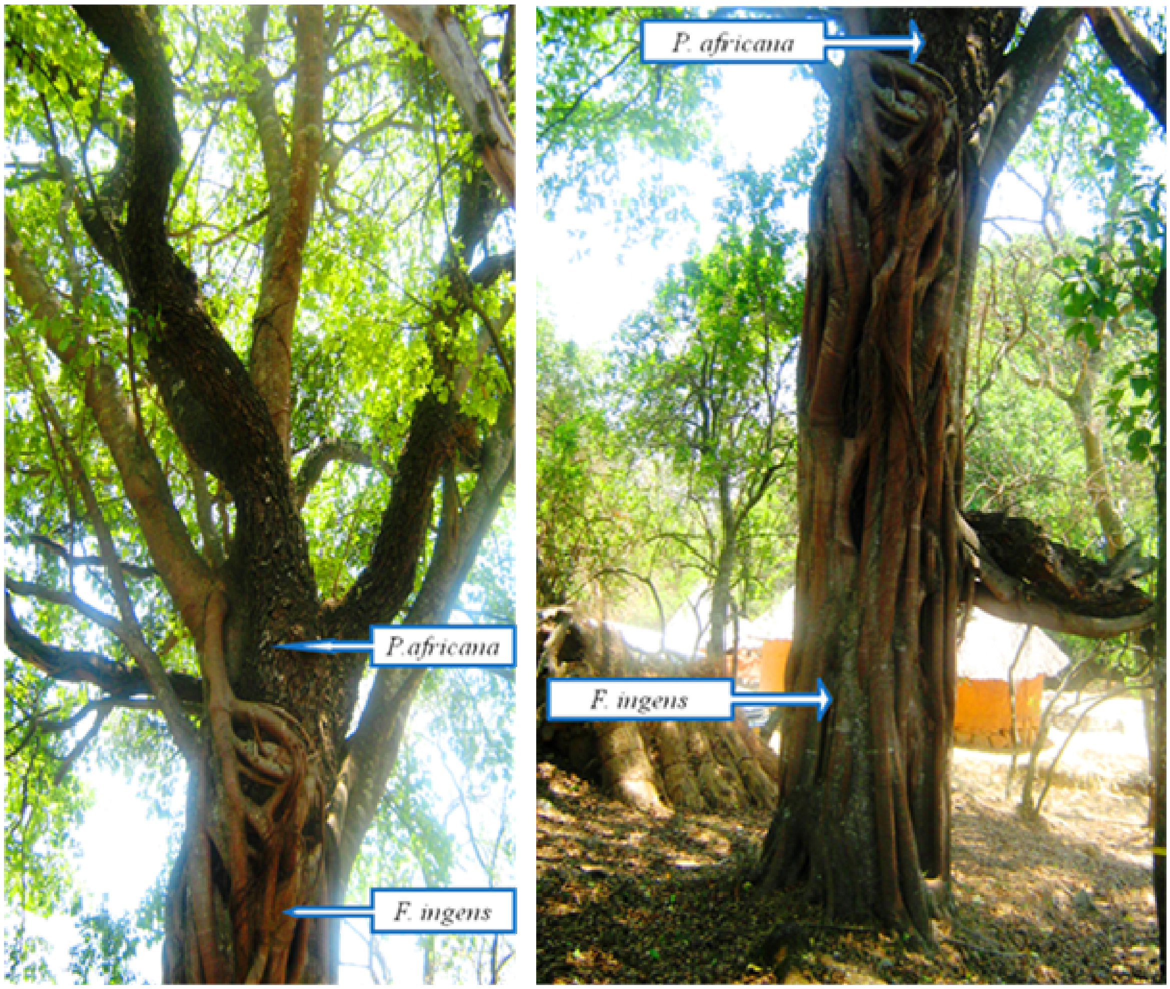

Figure 3. *P. africana* trees under threat from *F. ingens* in Nyanga National Park, Zimbabwe.

authority of the country exporting advises its management authority on the sustainability of a consignment and the export permit would be based on a sound inventory and management information (Terry et al., 1999). All exporting countries are signatories to CITES and this should mean that, the *P. africana* bark entering the EU is harvested from a sustainable source. However, this is usually not the case because quotas and permits are being issued without reference to adequate biological baseline information. In addition to CITES, many countries have their national policies and regulations which govern conservation of *P. africana*. The Forestry Law (1995) of Equatorial Guinea (Reglamento de Aplicacion de la Ley Sobre el Uso y Manejo de los Bosques EQG/96/002) seeks to ensure sustainable management of commercially exploited non-timber forest products (NTFP) like *P. africana* (Articulo 62) (Terry et al., 1999).

Local people are important in any conservation scheme because they are the ones directly involved with the resources and use them on a day to day bases. Many countries have adopted collaborative and community based forest management methods and have been found to be successful because it overcomes regulation enforcement problems and institutional weaknesses. A typical example is Mt. Cameroon where two villages signed an agreement with a *P. africana* bark exporting company to promote sustainability by avoiding tree cutting and monitored by the villagers themselves (Dawson et al., 2001).

In-situ conservation

In situ conservation refers to conservation of *P. africana* diversity in its natural habitats (Kjaer et al., 2001). It can be a success where it is possible to establish protected areas like forest reserves and national parks, as is the case of Zimbabwe's Chirinda Forest or where there is full community participation. In Bioko, Pico Basilé was proposed to be afforded National Park status and the southern end of the island, including the Caldera de

Figure 4. A *P. africana* stem showing a scar caused by fire in Nyanga National Park, Zimbabwe.

Luba, Lago Biao and the settlement of Moca were to be protected as a scientific reserve (Terry et al., 1999).

According to Cunningham and Mbenkum (1993), community beliefs can be a strong base for *in-situ* conservation. In Kenya's Embu District, over 250 sacred groves many of which are containing *P. africana,* have been spared from clearance for agricultural purposes (Dawson et al., 2001). The problem with such a scenario, depending on the size of the grove is reproductive isolation which may lead to inbreeding.

Ex-situ and circa situ conservation

Ex situ conservation involves the protection of a species' outside its natural habitat and is usually applied as a supplement to *in situ* conservation and involves techniques like establishment of *P. africana* clonal archives, *in vitro* conservation and conservation plantings (Kjaer et al., 2001). *P. africana* cannot be conserved in seed banks because of the intermediate nature of the seed, which can rapidly lose viability. *Ex situ* conservation can be categorised into static and evolutionary where the former maintains the original genotypes, whilst the later supports natural selection in order to respond to new or changing environments (Kjaer et al., 2001). Static conservation can be of importance when the objective is intensive breeding of *P. africana,* where clones are grafted and kept in clonal archives (Kjaer et al., 2001). Evolutionary or dynamic conservation can therefore be a solution to climate change, as it allows species adaptation through continuous 'selection of the fittest' (Kjaer et al., 2001). *P. africana* enrichment plantings have been established in Kenya and Cameroon (Dawson et al., 2001).

Considering the commercial value of *P. africana*, the species is suited for "conservation through increased utilisation" strategy (Kjaer et al., 2001). This is because the species can be easily cultivated on-farm and bark harvesting can be done in a sustainable manner.

Figure 5. *P. africana* intercropped with maize in the Western Region of Cameroon.

Therefore, bark harvesting can provide the much needed income, releasing pressure on the few remaining natural populations and at the same time protecting the genetic diversity of *P. africana* on-farm. *P. africana* domestication can be done by promoting its cultivation in farmers' fields, community nurseries and fields. There is need to have information on the origin and genetic variation of the reproductive material. On-farm conservation becomes increasingly important in areas where natural forests are contracting, for example through agricultural expansion. On-farm planting of *P. africana* has been practiced in Cameroon (Dawson et al., 2001). Figure 5 shows an agroforestry system in which *P. africana* was intercropped with maize in Cameroon.

In Northwest and Southwest Cameroon, 1.5 million *P. africana* trees, about 625 ha have been planted between 1976 and 2008 (Lodoen, 2010). The Kilum Mountain Forestry Project has been assisting farmers in the Oku area to manage *P. africana* nurseries and plant the species in their farms since 1989 (Cunningham et al., 2002). As a consequence, by 1994 there were 35 functional nursery groups, ranging in size from 5 to over 100 farmers. Members distribute seedlings amongst them-selves to plant in their farms and sell and sometimes give relatives and friends. In the Kom area of Boyo Division, Cunningham et al. (2002) reports that, the Ijim Mountain Forestry Project houses about 60 nursery groups, each with 10 farmers and have planted about 9 600 *P. africana* seedlings. Additionally, the Trees for the Future project, based in Kumbo, Bui division, consist of 63 groups and a total of 1 950 members and was started in 1991 and by 1994 had planted 275,000 trees, 9% of these being *P. africana* (Cunningham et al., 2002). Other groups are MESG, Shishong; VCP, Bafut; PAPSEC, Bamenda in northwest Cameroon; Greenfield Common Initiative Group, Bova and the Mosake Common Initiative Group in southwest Cameroon (Cunningham et al., 2002).

In Madagascar, three organisations, the United States Agency for International Development -Landscape Development Initiative (USAID-LDI), Pronatex, a Madagascar exporting company, and Phelps Dodge, an American mining corporation are putting effort to initiate and promote the propagation and planting of *P. africana* (Dailey and Fernandes, 2009). Other organisations working on the conservation of *P. africana* in Madagascar include Conservation International; Fanamby, an NGO working on community forest management; Silo National des Graines Forestieres (SNGF), a national forestry organisation; the national pharmaceutical laboratory Centre National Appliqué à la Recherche Pharmaceutique (CNARP) and the German development organization Deutsche Gesellschaft fuer Technische Zusammenarbeit (GTZ) (Dailey and Fernandes, 2009).

Dealing with climate change-Copenhagen climate change summit 2009

An agreement at 2009's UN Climate Change talks in Copenhagen, to cut carbon emissions by paying developing countries to maintain their forests has the potential to reverse the deforestation in the world's forests particularly in Africa and therefore, may help in the conservation of endangered species, among them *P. africana* (Clarke, 2009). This will involve the considera-tion of national policy changes required to implement a global mechanism to pay countries for reducing emissions from reduced deforestation and forest degradation (REDD) (Clarke, 2009).

National management plans

Governments in the natural range of *P. africana* need to develop management plans for sustainable bark harvesting. These plans consist of the current resource situation, objectives for sustainable harvest, organisa-tions responsible for management, management areas and description of the target species. The government of Cameroon has approved a National Management Plan for *P. africana* (Lodoen, 2010). The management plan balances conservation needs with local livelihoods and international health needs, and it addresses all of CITES' concerns and recommendations. The adoption of the plan is aimed at bringing back international trade in the valuable *P. africana* bark.

This follows the CITES 2006 ban in *P. africana* bark trade until exporting countries could develop management plans and carry out tree inventories, to ensure that the species is sustainably grown and harvested (Lodoen, 2010). The European Union (EU), the largest market for Cameroon, suspended *P. africana* bark import as a way of encouraging the major exporting country (with bark export accounting for about 48% of gross of exports before the ban) to ensure the species sustainability (Lodoen, 2010). The 150 paged management plan was developed by CIFOR, FAO, the Netherlands Development Organisation and the World Agroforestry Centre (WAC) over a period of 2 years and was part of the larger Community-Based Forest Enterprise project funded by the EU (Lodoen, 2010). The management plan was initiated in late 2008, when the Cameroonian Minister of Forestry and Wildlife asked the EU to fund this initiative. The Cameroon government aims to present the plan to CITES in Geneva, Switzerland by the end of 2010 and once approved, Cameroon can begin the plan implementation phase and hopefully bark export will follow soon afterwards (Lodoen, 2010).

Sustainable harvesting

P. africana was reported to withstand complete bark removal and this has offered the opportunity for sustainable harvesting (Cunningham and Mbenkum, 1993). One of the ways to conserve *P. africana* is to ensure sustainable harvesting where harvesters remove two opposite panels of the trunk, starting above ground level and avoiding debarking above the level of the first branch and then wait eight years for the bark to regenerate before harvesting the other two quarters (Cunnigham and Mbenkum, 1993; Ladoen, 2010). Research is under way at CIFOR, to verify the sustainability of this system (Lodoen, 2010). The problem for example in Cameroon has been that in many cases these guidelines were not followed, resulting in unsustainable harvesting (Cunningham and Mbenkum, 1993).

Invasive species control

In South Africa and Zimbabwe, invasive alien species are controlled through mechanical and chemical methods. Mechanical methods include the use of heavy duty rotary slashers to control young *A. mearnsii* plants. Large trees are usually ring barked or sprayed with trichlorophenoxy-acetic acid (2, 4, 5-T). Another herbicide commonly used is glyphosate (Roundup). In Zimbabwe, some companies like Border Timbers Limited are already trying non-invasive species like *Pinus tecunumanii* whilst in South Africa; research is under way to develop sterile clones of *P. patula.* Biological control methods used to control *A. mearnsii* include the use of the seed-feeding weevil, *Melanterius macalatus*; two gall-forming midge species, *Dasinuera* sp., and *Asphondylia* sp as well as a locally occurring fungus, Cylindrobasidium larvae which kills freshly cut stumps.

CONCLUSION

The *P. africana* natural range, from east to west and from central to southern Africa poses various threats to the species. *P. africana* populations in west (Cameroon and Equatorial Guinea) and east (Kenya, DRC, Uganda) as well as the island of Madagascar are threatened mainly by commercial harvesting, whilst those in southern Africa are under threat from habitat degradation and fragmentation, invasive alien species and traditional harvesting for medicinal purposes which are also common in west and east Africa. Climate change is likely to affect the species throughout its range, if no effort is put in place to ensure species adaptation. This calls for various conservation strategies depending on the country or region depending on the most important threat(s). In Cameroon, Kenya, Uganda, DRC and Madagascar where commercial harvesting is taking place, sustainable harvesting should be promoted together with other conservation strategies. In Zimbabwe, Mozambique and South Africa as well as Ethiopia, conservation strategies should aim to avoid/reduce habitat destruction and wildfires among other conservation methods like *in-situ*, *circa-situ* and *ex-situ*. Since *P. africana* occurs in ecological important habitat, the afromontane forests, rich with endemic, endangered and rare fauna and flora, the focus should be to conserve these ecosystems.

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REFERENCES

Betti JL (2008). Non-detriment findings report on *Prunus africana* (rosaceae) in Cameroon. NDF Workshop Case Studies WG1 – Trees Case Study 9.

BPPP (1999). http://bioko.beaver.edu/newsletter/preussext.html (November 1999).

Brooks ML (1998). Ecology of a biological invasion: alien annual plants in the Mojave Desert. Ph.D. Dissertation, University of California, Riverside. p. 186.

Brooks ML (1999). Alien annual grasses and fire in the Mojave Desert. Madrono, 46(1): 13 -19.

Brooks ML (2000). Competition between Alien Annual Grasses and Native. Annual Plants in the Mojave Desert. Am. Midl. Nat., 144: 92–108.

Brooks ML, Berry KH (1999). Ecology and management of alien annual plants in the CalEPPC News. California Exotic Pest Plant Council, 7(3/4): 4 – 6.

Brooks ML, Matchett J, Wallace C, Esque T (2004). Fuels mapping and fire hazard assessment in a desert ecosystem. Fire Ecol., 2(55): 1-5.

Clarke J (2009). Comprehensive global review of current research shows potential for REDD transformation if countries embrace long and short-term policy reforms while learning from past lessons. http://www.cifor.cgiar.org/Headlines/Realising+REDD.htm Retrieved 24. December.

Conway G (2009). The science of climate change in Africa: impacts and adaptation. Discussion paper No 1. Grantham Institute for Climate Change. London Imperial College, UK.

Cunningham AB (1996). People, park and plant use. Recommendations for multiple-use zones and development alternatives around Bwindi Impenetrable National Park, Uganda. People and Plants working paper 4. UNESCO, Paris.

Cunningham AB, Mbenkum FT (1993). Sustainability of harvesting *Prunus africana* bark in Cameroon: A medicinal plant in international trade. People and Plants Working Paper 2. Division of Ecological Sciences, UNESCO, 7 Place de Fontenoy, 75352 Paris CEDEX 07 SP, France.

Cunningham AB, Ayuk E, Franzel S, Duguma B, Asanga C (2002). An economic evaluation of medicinal tree cultivation *Prunus africana* in Cameroon. People and Plants Working Paper 10. Division of Ecological Sciences, UNESCO, 7 Place de Fontenoy, 75352 Paris CEDEX 07 SP, France.

Cunningham M, Cunningham AB, Schippmann U (1997). Trade in *Prunus africana* and the implementation of CITES. German Federal Agency for Nature Conservation.

Dailey BW, Fernandes ECM (2009). The effect of ecological conditions on density and growth of *Prunus africana* seed. http://www.css.cornell.edu/research/prunus/ Retrieved on 14 January 2010.

Dawson I, Were J, Lengkeek A (2001). Conservation of *Prunus africana*, an overexploited African medicinal tree. Forest Genetic Resources Bulletin 28 http://www.cifor.cgiar.org/Headlines/prunus-africana.htm Retrieved 02 January 2010.

Dawson IK, Powell W (1999). Genetic variation in the Afromontane tree *Prunus africana*, an endangered medicinal species. Molecular Ecology. 8: 151-156.

DiTomaso JM (2000). Invasive weeds in rangelands: species, impacts, and management. Weed Sci., 48: 255 –265.

Eissenstat DM, Caldwell MM (1988). Competitive ability is linked to rates of water extraction. Oecologia., 75: 1–7.

Ewusi BN, Eben-Ebai S, Asanga CA, Nkongo JBN (1992). An Evaluation of the Quantity and Distribution of *Pygeum africanum* on the Slopes of Mount Cameroon. Unpublished Report Prepared for Plantecam-Medicam.

Farwig N, Bleher B, Von-der GS, Böhning-Gaese K (2007). Does Forest Fragmentation and Selective Logging Affect Seed Predators and Seed Predation Rates of *Prunus africana* (Rosaceae)? Biotropica. 42(2): 218 - 224.

Fashing PJ (2004). Mortality trends in the African cherry (*Prunus africana*) and the implications for colobus monkeys (*Colobus guereza*) in Kakamega Forest, Kenya. Biological Conservation. 120: 449 – 459.

Geldenhuys CJ (1981). *Prunus africana* in the Bloukrans River Gorge, southern Cape. South Afr. For. J., 118: 61- 66.

Hannah L, Dave R, Lowry PP, Andelman S, Andrianarisata M, Cameron A, Hijmans R, Kremen C, MacKinnon J, Randrianasolo HH, Andriambololonera S, Razafimpahanana A, Randriamahazo H, Randrianarisoa J, Razafinjatovo P, Raxworthy C, Schatz GE, Tadross M, Wilmé L (2008). Climate change adaptation for conservation in Madagascar. Biol. Lett. 4: 590–594. (doi:10.1098/rsbl.2008.0270).

Hernes H, Dalfelt A, BerntsenT, Holtsmark B, Otto NL, Selrod R, Aaheim A (1995). Climate strategy for Africa CICERO Report 1995:3, University of Oslo, Norway.p. 83.

Higgins SI, Richardson DM, Cowling RM, Trinder-Smith TH (1999). Predicting the landscape-scale distribution of alien plants and their threat to plant diversity. Conserv. Biol., 13, 303–313.

Hulme M, Doherty R, Ngara T, New M, Lister D (2000). African Climate Change: 1900-2100. Revised Manuscript for Climate Change.

Inouye RS (1980). Density-dependent germination response by seeds of desert annuals. Oecologia. 46: 235 – 238.

Joubert AM, Hewitson BC (1997). Simulating present and future climates of southern Africa using general circulation models. Prog. in Phys. Geogr. 21: 51-78.

Kjaer ED, Graudal L, Nathan I (2001). Ex *situ* Conservation of Commercial Tropical Trees: strategies, options and constraints. Paper presented at ITTO International Conference on *ex situ* and *in situ* Conservation of Commercial Tropical Trees in June 2001, Yogyakarta, Indonesia.

Kokwaro JO (1988). Conservation status of the Kakamega Forest in Kenya - the Eastern relic of the equatorial rainforests of Africa. Monographs in Systematic Botany of the Missouri Botanical Garden.. 25: 471- 489.

Lodoen D (2010). Cameroon's conservation plan could put protected medicinal tree products back on international markets in 2010. Website.

Malcolm JR, Liu C, Neilson RP, Hansen L A , Hannah L (2006) .Global warming and extinctions of endemic species from biodiversity hotspots. Conserv. Biol., 20: 538–548. (doi:10.1111/j.1523-1739.2006.00364.x).

Melgoza G, Nowak RS (1991). Competition between cheat grass and two native species after fire: implications from observations and measurements of root distribution. J. Range. Manage., 44: 27–33.

Nsawir AT, Ingram V (2007). *Prunus africana*: Money growing on trees?

A plant that can boost rural economies in the Cameroon Highlands. FAO Nature Faune J., 22 “The value of biodiversity”.

Pake CE (1993). Sonoran Desert annual plants: empirical tests of models of coexistence and persistence in a temporally variable environment. Ph.D. Dissertation, University of Arizona, Tucson. p. 185.

Ringius L, Downing TE, Hulme M, Waughray D, Selrod R (1996) Climate change in Africa - issues and regional strategy CICERO Report No.1996:8, CICERO, Oslo, Norway. p. 154.

Stewart K (2009). Effects of bark harvest and other human activity on populations of the African cherry (Prunus africana) on Mount Oku, Cameroon. Forest Ecol. Manage. doi:10.1016/j.foreco.2009.05.039.

Stewart KM (2003a). The African cherry (*Prunus africana*): Can lessons be learned from an over-exploited medicinal tree? J. Ethnopharmacol., 89: 3 –13.

Stewart KM (2003b). The African cherry (*Prunus africana*): from hoe-handles to the international herb market. Econ. Bot., 57(4): 1-11.

Stewart KM (2001). The Commercial Bark Harvest of the African Cherry (*Prunus africana*) on Mount Oku, Cameroon: Effects on Traditional Uses and Population Dymanics. Ph.D. Dissertation. Florida International University.

Tchouto P (1996). *Prunus* Populations on Mount Cameroon. A Strategy for the Conservation of *Prunus africana* on Mount Cameroon. Technical Papers and Workshop Proceedings, 21–22 February, 1996.

Terry C, Sunderland H, Tako CH (1999). The exploitation of Prunus africana on the island of Bioko, Equatorial Guinea. A Report for the People and Plants Initiative, WWF-Germany and the IUCN/SSC Medicinal Plant Specialist Group. http://www.ggcg.st/bioko/bioko_prunus.htm.

Thomas DW, Cheek M (1992). Vegetation and plant species on the south side of Mount Cameroon in the proposed Etinde Reserve. Royal Botanic Gardens, Kew, UK.

White F (1983a). The Vegetation of Africa: a Descriptive Memoir to Accompany the UNESCO/AETFAT/UNSO Vegetation Map of Africa by F. White. Natural Resources Research Report XX, UNESCO, Paris, France.

Ziervogel G, Cartwright A, Tas A, Adejuwon J, Zermoglio F, Shale M , Smith M (2008). Climate change and adaptation in African agriculture. Stockholm Environment Institute.