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INVASIVE PLANTS AFFECTING PROTECTED AREAS OF WEST AFRICA

MANAGEMENT FOR REDUCTION OF RISK FOR BIODIVERSITY

IUCN-West and Central African Protected Areas Programme

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MANAGEMENT FOR REDUCTION OF RISK FOR BIODIVERSITY

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The "études du Papaco" (Papaco Studies) series offers documented analyses which aim to stimulate reflection and debate on the conservation of biodiversity in West and Central Africa.

It sheds light on a situation or a topic, but does not claim to provide an exhaustive coverage of the subject.

Readers wishing to deepen the analysis, add ideas or share their opinions on the topics raised, are strongly encouraged to do so by sending their comments to: **uicn@papaco.org**

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Report prepared by Yann Itard, and supervised by Geoffroy Mauvais (UICN-PAPACO). IUCN-PAPACO, 2011. « Mining sector development in West Africa and its impact on conservation ». Report, Jupiles, 65 p + annexes.

It is also available on the website www.papaco.org under the "études du Papaco" section.

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AGENCE FRANÇAISE DÉVELOPPEMENT

Invasive plants affecting Protected Areas of West Africa – management for reduction of risk for Biodiversity

SUMMARY

Biological invasion

Biological invasion (in the context of this study) occurs when a non-native species is introduced to a new environment (ecosystem or habitat) and spreads causing damage – to native biodiversity that is being conserved. This requires that a species not represented in the vegetation of an area enters from "outside", survives to reproduce, spreads from its point of introduction, becomes naturalised and then spreads further – eventually causing damage.

The initial introduction may, in rare cases, be natural; but most often introduction is associated with people and can be intentional or unintentional (accidental). Most species introductions do not survive to the next stage of establishment. Those that do establish are able to reproduce and may stay where they were introduced – as harmless new arrivals. Some, however, will spread and "naturalise" which means they will establish in the local vegetation and may, with time, be considered as local species – but do not spread or cause harm. A small proportion of species may spread further and cause damage to the local biodiversity: these are the invaders.

This process and its steps from introduction to invasion may take weeks or months, sometimes years or even decades or centuries (as in the case of some species of trees). This is why we need to take note of new species that arrive (alien species) and join the flora of a protected area – and check if they have a reputation of invasion elsewhere. This process is termed "biological invasion", the species becomes known as an "invasive species" or "invasive alien species" in this context (but not necessarily in other situations). In other words, a species should not be called an **invasive species** unless it is actually **causing problems** after going through the stages (above). Before going through those stages or in other places, it does not get the label of "invasive species". In the study, we are discussing alien species that have arrived in protected areas and which have become invasive (the "invasive plants") as well as those alien species that have arrived (or have been planted) in protected areas which have a history of invasion in other places – and so may become invasive in the future. This has happened in protected areas in some places, especially when alien trees have been planted for shade at entry gates and around staff houses and offices or as boundary markers along the edge of national parks, wildlife reserves and forest reserves. Such species may stay in a non-invasive state for decades (or even centuries) and then start to spread and cause damage both inside and outside the protected areas. This late delay is sometimes referred to as the "lag phase" of invasion and may be caused by a species' slow adaptation to new surrounds (sometimes involving the arrival of suitable pollinators) before viable and dispersable seed is produced in enough abundance to initiate spread and the next steps to biodiversity damage.

Invasive species can be animals, plants or microorganisms (including agents of disease) but in the case of most protected areas in Mainland Africa it is the invasive plants that cause most damage to native species and to wild or production ecosystems. There are very few (if any) invasive mammals amongst the native fauna and flora in African PAs, and a few alien bird species that have become problematic – but none were detected as significant in this survey in West Africa. Invasive alien reptiles and amphibians are similarly scarce on the continent while there are several species of alien fish, intentionally introduced for food production, which are invasive in some cases. Free living invasive invertebrates as well as parasites and pathogenic organisms may occur but these require specialist expertise for almost every phylum and class. Among alien species, invasive plants have the most notable impacts on the biodiversity of African protected areas and so are the subjects of discussion here.

Impacts of biological invasion

The damage to native species or ecosystems by invasive alien species is usually the result of some characteristics of the invaders that allow them to compete with and dominate local species and alter habitats. Such characteristics include:

- Rapid growth rate which exceeds that of native plants,
- Great dispersal characteristics that quickly and widely disperse propagules1,
- Large reproductive capacity, often producing large numbers of seeds or other propagules
- Broad environment tolerance, while native species often exist within narrow limits of temperature, rainfall, soil types, etc.,
- Effective competitor with local species – for water, nutrients, light and space to grow,
- Production of allelopathic substance (from leaves, stems or roots) which prevent other species from germinating, growing or reproducing to their full capacity.

The result of a plant invasion that employs one or more of these characteristics is the “damage done to biodiversity” and can result in decline or even local extinction of native species or habitats. Key food plants, nesting and shelter trees and shrubs for wild animals, plants that purify waters and provide symbionts for others, those supporting climbers and sheltering delicate vegetation can also be compromised or even brought to extinction by invasive species. Ecosystems’ stability, ecosystem goods and services and special habitats can be harmed in this way – affecting the very values for which a protected area was established. In some cases, such changes in vegetation and ecosystem function can enhance the chances and effects of wildfires and increase the damage done by storms and floods and droughts.

This, for protected area managers, is the **invasive species problem**.

Pathways of introduction and invasion

If one considers the ways in which alien species can enter native ecosystems in a protected area, it soon becomes apparent that they can be a significant threat which results in ecosystem degradation and loss of species. Alien species (that may become invasive) usually come into protected areas in two ways (although the total number of possible introduction pathways is

many more than two): the first is accidental introduction to degraded or unoccupied areas where they can easily establish and then spread once a pioneer population has been established. Such areas as roads, road-sides, railways, aircraft landing strips, quarries, building sites, drains, streams and even formal park entries and parking areas can all bring propagules to sites where they can begin to establish plant populations in the absence of any competition. Over time these can enter the native vegetation systems and if they have one or several of the characteristics listed above, they can end up causing damage to native biodiversity as they begin to invade. This is, of course, a problem for protected area managers whose objective for management is "protection" of all species native to that area. It is worth noting that almost all of the sites of introduction are those places which are objects of other forms of management for a protected area – for access, transport, tourism, accommodation, research, etc.

The second common route of introduction of invasive plants is the intentional planting of alien species for production forestry, boundary marking, shade, beautification and even food production in and around the PA. These can be herbs, shrubs, garden plants or trees which after some time become acclimatized and then able to spread – especially if they have (or regain through gradual adaptation to their new habitat) one or more of the invasive characteristics listed above. These may be species which are benign (not invasive) in other situations where they have natural enemies but in a new locality are able to express their invasive tendencies.
Or, for some flowering plants, it may take decades before a pollinator begins to visit the flowers and fertile seeds are produced.

Of course, there are many other pathways and vectors of alien species that enter a PA – such as people and their clothes, luggage, trade items, deliveries, steel containers, builders' materials, garbage and garden waste disposal, livestock movements, wild animal migrations, and natural events like storms and floods.

Biological invasions in protected areas

During the last century, it became clear to some PA managers that alien invasive species were having some negative impacts on their conservation efforts from within the protected areas. An early African example of this was in Kruger National Park in South Africa where the first list of invasive plants (6 species of herbs and small shrubs) was produced in 1937 by Stevenson-Hamilton. Awareness of plant invasions in Kruger NP increased as more science was incorporated into management of the National Park with an estimate of 372 alien species recorded in the park, with the three most serious invaders being *Lantana camara*, *Chromolaena odorata* and the cactus *Opuntia stricta*...

During the 1990s, awareness of the risk of not managing invasive alien plants in PAs and the need to reduce the use of herbicides led to attempts (some successful) at biological control and integrated control of alien species invading PAs. Realisation that Climate Change was a factor that increased the chances of alien species becoming established and turning into invasives combined with the recognition that Global Trade was at the same time increasing in volume

and reach and providing more and more pathways for introduction of alien species, led to the publication of the section on managing invasive alien species in the World Parks Congress (Durban, South Africa, 2004) publication of the IUCN World Commission on Protected Areas under the chapter on "Designing protected area systems for a changing world" entitled "2.4.5. Combating invasive alien species in protected areas" (Barber, 2004). This article exhorted protected area managers to abide by a list of ten approaches as derived from the IUCN Guidelines (ISSG, 2000) and the GISP Global Strategy on Invasive Alien Species (McNeely *et al*., 2001) which can be summarized as:

1. Establish the prevention, detection and eradication or control as a priority objective for PA management
2. Raise awareness of invasion threats in PAs with other government agencies, local communities and relevant businesses
3. Prevention should be the main strategy, but eradication should be used if it fails and control employed if eradication fails
4. Introduction of any alien species to PAs and surrounding areas should be legally prohibited
5. Early detection and rapid response capacity should be encouraged
6. Special emphasis should be given to invasions in vulnerable habitats and areas of high native biodiversity
7. All stakeholders inside and outside PAs should be consulted and involved in invasion management
8. Eradication and control methods should by socially and ethically acceptable and not affect native biodiversity or human endeavor
9. Re-introduction of species absent from PAs should consider the risks of invasion
10. Invasion information should be shared amongst PA managers and other relevant agencies\

Apposite as these recommendations may be, they appeared at a time when many PA managers and management systems in Africa did not have the resources – human, material or financial – to allocate to this issue. However, the presence of alien invasive species, especially plants, is gradually becoming recognized as a serious impediment to management effectiveness in African PAs. Some are now developing systems to identify alien species, recognize plant invasions and publicize this situation in the hope that they can prepare to prevent and manage such invasions…

The relative importance of invasive species in relation to other influences damaging protected areas

Protected areas conserving biodiversity in Africa are beset by many drivers of disruption of the basic intentions of the managers – to conserve native biodiversity *in situ* and, in most cases, make it available for research and tourism – at least in part…
These negative influences vary in significance from place to place, country to country (see the results of PA management effectiveness assessments conducted by IUCN-PAPACO since 2008 on www.papaco.org) and usually include:

- Wild fires
- Illegal hunting (poaching)
- Unlicensed harvesting of natural products – for use or sale
- Illegal prospecting and mining
- Water pollution, air pollution and waste disposal
- Grazing of domestic animals
- Diseases of wild animals and plants
- Severe storms, droughts and floods
- Roads and traffic
- **Biological invasions**
- Climate Change

In general it is not possible to rank these in any way because they vary from place to place. This author would like to suggest, however that biological invasions are likely to be significant threats in every PA that is physically managed by PA authorities (some no-go areas or reserves may be the exception). Whether or not the threats of biological invasions are being (or should be) managed is the purpose of this assessment – in relation to a range of PAs across a range of climates in West Africa. What is clear across the African continent is that invasions are increasing in number and (negative) impacts and that the responses are varied – from no action to detailed prevention and management…

The extent of this problem is still being elucidated as more and more PA managers come to realize the potential threats from alien invasive plants and the fact that there incidence is increasing and their damage becoming more noticeable.

One of the major threats to PAs in Africa which can be exacerbated by invasive species is that of wild fire and fire escaped from controlled burning. This happens for several reasons because invading plants usually grow faster and produce more vegetative material than the native species that they invade – adding to the fuel for wild fires and also making then hotter. Some invading species have aromatic oils that are flammable and result in hotter and faster spread of fires as in *Lantana camara*. Another is the growth form of some invasive plants - again *Lantana camara* is the example. This widespread invader (in Africa) has been shown (in Australia in dry forest equivalent to savannah) to not only increase the fuel available, but by climbing trees up to the crown and so taking ground fires upwards to become crown fires – which are much more destructive to dry woodlands.

Another association is the link between plant invasions and **Climate Change**. Acting together, the impacts of each of these drivers of change are compounded and interactions between these two threats present even greater challenges to field conservationists, especially protected area managers. The most evident is the survival of invasive species when climate change has brought about local changes (in temperature, humidity, precipitation) which native species of plants cannot adapt to in time to survive while alien invasive species, due to one of their basic characteristics being a broad tolerance of environmental characteristics, are able to survive and thrive.

Climate change is expected to bring about more and stronger storms, floods and waves in fresh and marine water – all of which may give advantage to invading species (as above) and also increase their dispersal through violent movements. A common characteristic of invading plant species is their ability (indeed sometimes preference) for establishment in degraded areas resulting in a healthy population which can then invade vegetate areas with ease. Climate change will increase the areas of degraded landscape as a result of changes in rainfall and temperature and the demise of local species die-off leaving bare or uninhabitable habitats where invaders can settle. This general aspect of climate change bringing about degraded areas will also require that agriculture and perhaps livestock rearing may have to move to more suitable areas – thus increasing or changing trade routes for agricultural goods – which are inevitably pathways for invasive species. It has also been suggested that climate change may remove or change the cues that native plants need to flower or germinate – thus reducing their populations even further, leaving degraded areas where invasives can settle.

A more subtle interaction is possible if native species either manage to adapt quickly to new conditions brought about by climate change or they are helped to do so by moving populations to new areas ("managed relocation") and then, being in a different habitat or even ecosystem, they are now alien and thus could become invasive.

Climate change can bring about advantages to biological invaders (and even create them). The researchers involved in invasion biology and now faced with an added and real threat to find ways to counter – in general and in PAs. But knowing that such impacts of climate change on inceasing prevalence and impacts of invasive species is helpful knowledge for PA managers to add to their (evergrowing) list of items to be considered in their management routines and in applied research in their PAS.

Addressing the invasive species problem in protected areas

Biological invasion of biodiversity in protected areas is a complex problem because, first of all, it is often difficult to distinguish a new (alien) species of plant when it is in amongst the native vegetation that is being conserved: this is often a specialist's skill and such specialists are rarely available when needed. It is also difficult because awareness about the extent and range of invasive species in PAs is often limited to a few people (often at senior levels) who are too busy to make the necessary monitoring possible that is needed to recognize alien and possibly invasive species. Also, there are often conflicts over whether an invading plant can be used rather than removed – for various uses that seem to outweigh the threats to biodiversity. Then, even if such species are recognized and a decision is made to reduce or remove their negative impacts, solutions are not always known or available… or are not a priority for PA management.

The purpose of this study was to take a first step of recognizing some of the more common plants that could be invasive in a range of PAs in dry to wet areas. The report (please see www.papaco.org) on a quick assessment of easily detectable invasive (or potentially invasive) alien plants in some PAs in West Africa covers a range of ecosystem types from Dry hot Sahel to

Wet Tropical Forest from northern Burkina Faso to southern coastal Ghana (see Figure thereafter). It will allow us to draw some conclusions that could assist PA managers to prepare for, prevent and manage plant invasions in the future (see next NAPA letter)…

Ideally such an assessment would stretch over a full year to encompass all seasons – especially where rainfall is limited or restricted to certain months. This was not possible during this study as it was in the dry season – which was selected to enable ease of movement within and between the Protected Areas. Thus alien herbaceous herbs and shrubs may need the rains to germinate, to become evident or to produce flowers that facilitate their recognition. In this way we probably missed species that are abundant or obvious at other times of the year.

CONTENT TABLE

1.Introduction

1.1.Biological invasion

Biological invasion (in the context of this report) occurs when a non-native species is introduced to a new environment (ecosystem or habitat) and spreads causing damage – to native biodiversity that is being conserved. This requires that a species not represented in the vegetation of an area enters from "outside", survives to reproduce, spreads from its point of introduction, becomes naturalised and then spreads further – eventually causing damage.

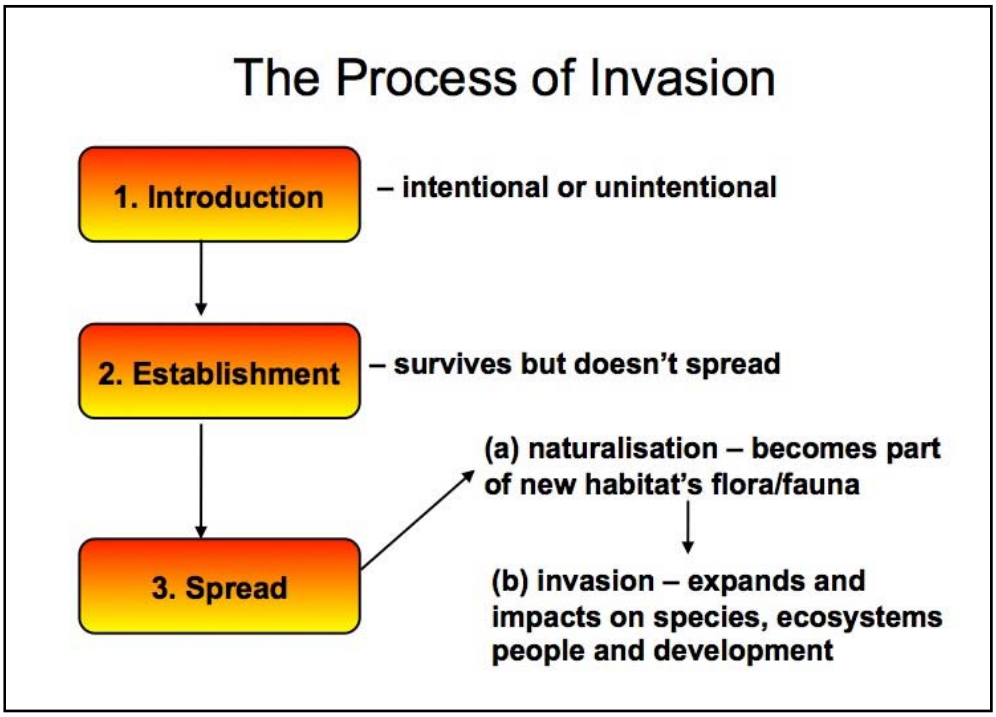

Diagram of the biological invasion process

The initial introduction may, in rare cases, be natural; but most often introduction is associated with people and can be intentional or unintentional (accidental). Most species introductions do not survive to the next stage of establishment. Those that do establish are able to reproduce and may stay where they were introduced – as harmless new arrivals. Some, however, will spread and "naturalise" which means they will establish in the local vegetation and may, with time, be considered as local species – but do not spread or cause harm. A small proportion of species mayspread further and cause damage to the local biodiversity: these are the invaders.

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1.2 Impacts of biological invasion

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- Rapid growth rate which exceeds that of native plants,

- Great dispersal characteristics that quickly and widely disperse propagules[1],
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- Broad environment tolerance, while native species often exist within narrow limits of temperature, rainfall, soil types, etc.,
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1.3 Pathways of introduction and invasion

If one considers the ways in which alien species can enter native ecosystems in a protected area, it soon becomes apparent that they can be a significant threat which results in ecosystem degradation and loss of species. Alien species (that may become invasive) usually come into protected areas in two ways (although the total number of possible introduction pathways is many more than two): the first is accidental introduction to degraded or unoccupied areas where they can easily establish and then spread once a pioneer population has been established. Such areas as roads, road-sides, railways, aircraft landing strips, quarries, building sites, drains, streams and even formal park entries and parking areas can all bring propagules to sites where they can begin to establish plant populations in the absence of any competition. Over time these can enter the native vegetation systems and if they have one or several of the characteristics listed above, they can end up causing damage to native biodiversity as they begin to invade. This is, of course, a problem for protected area managers whose objective for

[1] A plant **propagule** is a product of a plant that can initiate a new individual plant – such as a seed, a spore, tuber, corm, bulb, extension (ramet) or plant fragment that can grow under ideal circumstances. Propagules may be spread by wind, waterflows, tides, animals, people, vehicles and machinery

management is “protection” of all species native to that area. It is worth noting that almost all of the sites of introduction are those places which are objects of other forms of management for a protected area – for access, transport, tourism, accommodation, research, etc.

The second common route of introduction of invasive plants is the intentional planting of alien species for production forestry, boundary marking, shade, beautification and even food production in and around the PA. These can be herbs, shrubs, garden plants or trees which after some time become acclimatized and then able to spread – especially if they have (or regain through gradual adaptation to their new habitat) one or more of the invasive characteristics listed above. These may be species which are benign (not invasive) in other situations where they have natural enemies but in a new locality are able to express their invasive tendencies, Or, for some flowering plants, it may take decades before a pollinator begins to visit the flowers and fertile seeds are produced.

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1.4 Biological invasions in protected areas

During the last century, it became clear to some PA managers that alien invasive species were having some negative impacts on their conservation efforts from within the protected areas. An early African example of this was in Kruger National Park in South Africa where the first list of invasive plants (6 species of herbs and small shrubs) was produced in 1937 by Stevenson-Hamilton (Foxcroft & Freitag-Ronaldson, 2005). Awareness of plant invasions in Kruger NP increased as more science was incorporated into management of the National Park with an estimate of 372 alien species recorded in the park, with the three most serious invaders being *Lantana camara*, *Chromolaena odorata* and the cactus *Opuntia stricta* (Foxcroft & Freitag-Ronaldson, 2005).

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a. **Invasion by *Mimosa pigra* on an important floodplain for biodiversity conservation in Zambia**.

   The Kafue Flats, in the Southern Province of Zambia is a species-rich area of seasonal flooding of the Kafue River, part of which is located in Lochinvar National Park. The diversity of species includes mammals, birds, lower vertebrates, aquatic plants and terrestrial floodplain plants (as well as grazing for livestock in the non-flood season – near the park). *Mimosa pigra*, the Giant Sensitive Plant (see Annex 1, species no. 19), was a relatively uncommon riparian plant on the edges of the Kafue River until a high flood in 1982 carried some plants onto the outer edge of the floodplain within Lochinvar NP. Over the next few years this small area of plants expanded and began to spread on

the floodplain until it covered an area close to 3,000 ha in and near the NP by the early 2000s until it had formed an impenetrable one-species thicket which excluded all large mammals, many wetland birds, many plants and, of course, tourists and park managers. These impacts, particularly on the formerly abundant water-birds are described by Shanungu, 2009 as well as the approaches being used to manage the invasion.

NOTE: The origin of *Mimosa pigra* is uncertain but probably is tropical America; it has however, been present in damp situations in Africa beyond people's memories. It is now acting as an alien species and invading many floodplains and wetlands across Africa.

b. In**vasion of *Parthenium hysterophorus* in Awash National Park, Ethiopia.**

The Awash National Park in central southern Ethiopia (in Afar and Oromia Regions) is situated in the wide valley of the Awash River (the largest in the country) and conserves a range of small and large mammals, birds and dryland vegetation. It has been gradually and steadily infested by the pernicious weed, *Parthenium hysterophorus* (from tropical America). The infestation of parthenium came into the PA from the main, busy road that crosses the park and from the flooding of the Awash River. By the end of the first decade of the current century, *P. hysterophorus* was well-established in the park and gradually replacing native vegetation through its rapid growth, local spread by wind and water (and animals) and the effects of its allelopathic exudates to become a significant invasion – which has been described in detail by Etana, Kelbessa and Soromessa (2011). This has reduced the available pasture for large herbivores as well as reducing the occurrence of a range of native plants and generally altering the dryland habitats. Parthenium is a herb/small shrub which not only invades native vegetation (and crops and livestock pastures) but causes sickness in livestock and also in people and is regarded as one of the worst invasive plants in Africa – it is present in West Africa and spreading fast across eastern and southern Africa.

c. Invasion of *Senna spectabilis* in PAs in Tanzania and Uganda (both affecting primates)

Senna spectabilis is floribundant tree from tropical America which has been planted in many parts of Africa as a garden decorative, a street tree and a boundary marker for PAs – both conservation areas and forest reserves. In two such reserves, Mahale Mountains National Park in western Tanzania and Budongo Forest Reserve in central Uganda, *S. spectabilis* has spread from the boundaries, entered the PA and become invasive, dominating both trees and understory in the forested areas (NARO, 2009; Nishida, 1996; Turner, 1996). The damage done to the vegetation is quite significant requiring efforts to remove the invaders – and in both places, the invading trees have affected the food

supply of resident chimpanzees. Various management approaches and attenmpts at restoration of native vegetation are being considered.

d. Invasion by Chromolaena of a PA in South Africa

Chromolaena odorata began to infest the small Hluhluwe-Imfolozi National Park in Kwazulu-Natal, South Africa, in the mid1980s – initially in low density at one end of the park. By 2002 it had covered almost half of the area of the PA and peripheral areas outside the park; several years later it was clear that it would invade/engulf most of the park if it was not controlled – and, similarly it would spread far and wide outside of the PA in suitable low-lying r damp areas (Preston, 2011). A study was carried out to assess the effect of the invasion on the mammals of the park – knowing already that the vegetation had been compromised by the dense shrubs and climbing plants of chromolaena. The researcher compared diversity and population densities in areas occupied by *C. odorata* and in control areas which it had not yet invaded. The results showed that small mammals avoided areas of chromolaena – indicating that they were no longer suitable for habitation and food supply; some large mammals avoided the chromolaena while others used it for cover as a protection from carnivores. Both large and small mammals increasedin density and diversity when areas previously occupied by chromolaena were cleared of the invading plants (Dumaslisile, 2008). Integrated control is now being used to reduce the threats.

e. Invasion by Chromolaena in a PA in equatorial Africa

Chromolaena odorata (Annex 1, species no. 11) originates from tropical America and is widespread in moister areas of western and central Africa.In the Campo Ma'an National Park in the rainforest of southern Cameroun, western lowland gorillas are present and one of their main food sources (and a source of their nesting material) is several species of wild gingers (family Zingiberaceae, especially *Afromamum* spp.). These tall herbs grow on the edges of the dense forest and along openings, such as access and logging tracks, because they need sunlight to grow and flower. This habitat is also the main type of habitat preferred by *Chromolaena odorata* – which is steadily over-growing and suppressing the wild ginger plants as well as other vegetation which is heavily invaded. The incidental impact of this invasion is the gradual removal of access by the gorillas to one of the favourite resources – the wild ginger. The prediction of the main researcher who studied this is that eventually chromolaena will seriously impact the gorilla population by effectively invading and removing an essential food source (van der Hoeven, 2007).

1.5 The relative importance of invasive species in relation to other influences damaging protected areas

Protected areas conserving biodiversity in Africa are beset by many drivers of disruption of the basic intentions of the managers – to conserve native biodiversity *in situ* and, in most cases, make it available for research and tourism – at least in part. (The precise reasons for managing a protected area have been discussed in detail during preparations for PA management through "management effectiveness" where the initial definition of the reasons for management, and the intentions of the managing authorities who established the PA in the first place, are a first step to effective management – e.g. IUCN-PACO, 2009; UICN-PACO, 2010). These negative influences vary in significance from place to place, country to country and usually include:

- Wild fires
- Illegal hunting (poaching)
- Unlicensed harvesting of natural products – for use or sale
- Illegal prospecting and mining
- Water pollution, air pollution and waste disposal
- Grazing of domestic animals
- Diseases of wild animals and plants
- Severe storms, droughts and floods
- Roads and traffic
- **Biological invasions**
- Climate Change

In general it is not possible to rank these in any way because they vary from place to place. This author would like to suggest, however that biological invasions are likely to be significant threats in every PA that is physically managed by PA authorities (some no-go areas or reserves may be the exception). Whether or not the threats of biological invasions are being (or should be) managed is the purpose of this assessment – in relation to a range of PAs across a range of climates in West Africa. What is clear across the African continent is that invasions are increasing in number and (negative) impacts and that the responses are varied – from no action to detailed prevention and management.

In a very recent assessment of the relative threats to tropical forest protected areas (Laurance *et al*., 2012) compared threats and their effects across 60 forest PAs in 36 nations during 262 expert interviews to PA managers and experts with many years of experience and compared the impacts of 28 drivers of environmental damage against 24 animal and plant guilds inhabiting the protected areas. Results were presented in several ways, but it was clear that 70-

80% of all PAs were affected in some way by alien plants (there was no reference to alien invasive plants).

The extent of this problem is still being elucidated as more and more PA managers come to realise the potential threats from alien invasive plants and the fact that there incidence is increasing and their damage becoming more noticeable.

One of the major threats to PAs in Africa which can be exacerbated by invasive species is that of wild fire and fire escaped from controlled burning. This happens for several reasons because invading plants usually grow faster and produce more vegetative material than the native species that they invade – adding to the fuel for wild fires and also making then hotter. Some invading species have aromatic oils that are flammable and result in hotter and faster spread of fires as in *Lantana camara* (Barry *et al*., 2011). Another is the growth form of some invasive plants - again*Lantana camara*is the example. This widespread invader (in Africa) has been shown (in Australia in dry forest equivalent to savannah) to not only increase the fuel available, but by climbing trees up to the crown and so taking ground fires upwards to become crown fires – which are much more destructive to dry woodlands (Barry *et al*., 2011).

Another association is the link between plant invasions and **Climate Change**.Acting together, the impacts of each of these drivers of change are compounded and interactions between these two threats present even greater challenges to field conservationists, especially protected area managers (Mainka & Howard, 2010). The most evident is the survival of invasive species when climate change has brought about local changes (in temperature, humidity, precipitation) which native species of plants cannot adapt to in time to survive while alien invasive species, due to one of their basic characteristics being a broad tolerance of environmental characteristics, are able to survive and thrive.

Climate change is expected to bring about more and stronger storms, floodsand waves in fresh and marine water – all of which may give advantage to invading species (as above) and also increase their dispersal through violent movements. A common characteristic of invading plant species is their ability (indeed sometimes preference) for establishment in degraded areas resulting in a healthy population which can then invade vegetate areas with ease. Climate change will increase the areas of degraded landscape as a result of changes in rainfall and temperature and the demise of local species die-off leaving bare or uninhabitable habitats where invaders can settle. This general aspect of climate change bringing about degraded areas will also require that agriculture and perhaps livestock rearing may have to move to more suitable areas – thus increasing or changing trade routes for agricultural goods – which are inevitably pathways for invasive species. It has also been suggested that climate change may remove or change the cues that native plants need to flower or germinate – thus reducing their populations even further, leaving degraded areas where invasives can settle (Burgiel & Muir, 2010).

A more subtle interaction is possible if native species either manage to adapt quickly to new conditions brought about by climate change or they are helped to do so by moving populations to new areas (“managed relocation”)and then, being in a different habitat or even ecosystem, they are now alien and thus could become invasive (Mueller & Hellman, 2008).

Climate change can bring about advantages to biological invaders (and even create them). The researchers involved in invasion biology and now faced with an added and real threat to find ways to counter – in general and in PAs. But knowing that such impacts of climate change on inceasing prevalence and impacts of invasive species is helpful knowledge for PA managers to add to their (ever-growing) list of items to be considered in their management routines and in applied research in their PAS.

1.6 Addressing the invasive species problem in protected areas

Biological invasion of biodiversity in protected areas is a complex problem because, first of all, it is often difficult to distinguish a new (alien) species of plant when it is in amongst the native vegetation that is being conserved: this is often a specialist's skill and such specialists are rarely available when needed. It is also difficult because awareness about the extent and range of invasive species in PAs is often limited to a few people (often at senior levels) who are too busy to make the necessary monitoring possible that is needed to recognize alien and possibly invasive species. Also, there are often conflicts over whether an invading plant can be used rather than removed – for various uses that seem to outweigh the threats to biodiversity. Then, even if such species are recognized and a decision is made to reduce or remove their negative impacts, solutions are not always known or available… or are not a priority for PA management.

The purpose of this brief survey was to take a first step of recognizing some of the more common plants that could be invasive in a range of PAs in dry to wet areas. This report on a quick assessment of easily detectable invasive (or potentially invasive) alien plants in some PAs in West Africa covers a range of ecosystem types from Dry hot Sahel to Wet Tropical Forest from northern Burkina Faso to southern coastal Ghana (see Figure 1). It will allow us to draw some conclusions that could assist PA managers to prepare for, prevent and manage plant invasions in the future.

The survey was carried out between 7th and 20th May, 2012, by the author with assistance of a colleague from IUCN PACO (Ouagadougu), Ms Beatrice Chataigner, and another from the Kumasi National University of Technology in Ghana, Mr Michael Kewku. We visited seven PAs in that time and made observations on the alien invasive plant species present as well as discussing invasive issues with PA managers and the PA authorities in Accra, Ghana.

In each PA we met the most senior manager available and discussed any problems concerning invasive species and the range and extent of such species in their area before making a brief survey of areas of importance for biodiversity and those thought to contain invasive plants. This was done by vehicle and by walking, all the time searching for alien and invasive species. When

possible we reported our findings to the PA managers and discussed any other threats to biodiversity that invasive species might enhance. A summary of the results of these assessments follows in Section2, below, where there is a brief account of the alien plant species we detected and their possible potential for invasion in the ecosystems.

Ideally such an assessment would stretch over a full year to encompass all seasons – especially where rainfall is limited or restricted to certain months. This was not possible during this quick survey as it was in the dry season – which was selected to enable ease of movement within and between the Protected Areas. Thus alien herbaceous herbs and shrubs may need the rains to germinate, to become evident or to produce flowers that facilitate their recognition.In this way we probably missed species that are abundant or obvious at other times of the year.

An eighth PA that is mentioned was forest reserve that GH visited to Ghana in November, 2009 during a tour of pilot sites for the UNDP-GEF project "Removing Barriers to the Management of Invasive Plants in Africa" in that country and witnessed several invasive species (two of which were the subject of the pilot site work in the area concerned) and it was felt that the inclusion of some limited data from that site was worth adding to the assessment. This was the Afram River Headwaters Forest Reserve, also placed on the map, Figure 1, below.

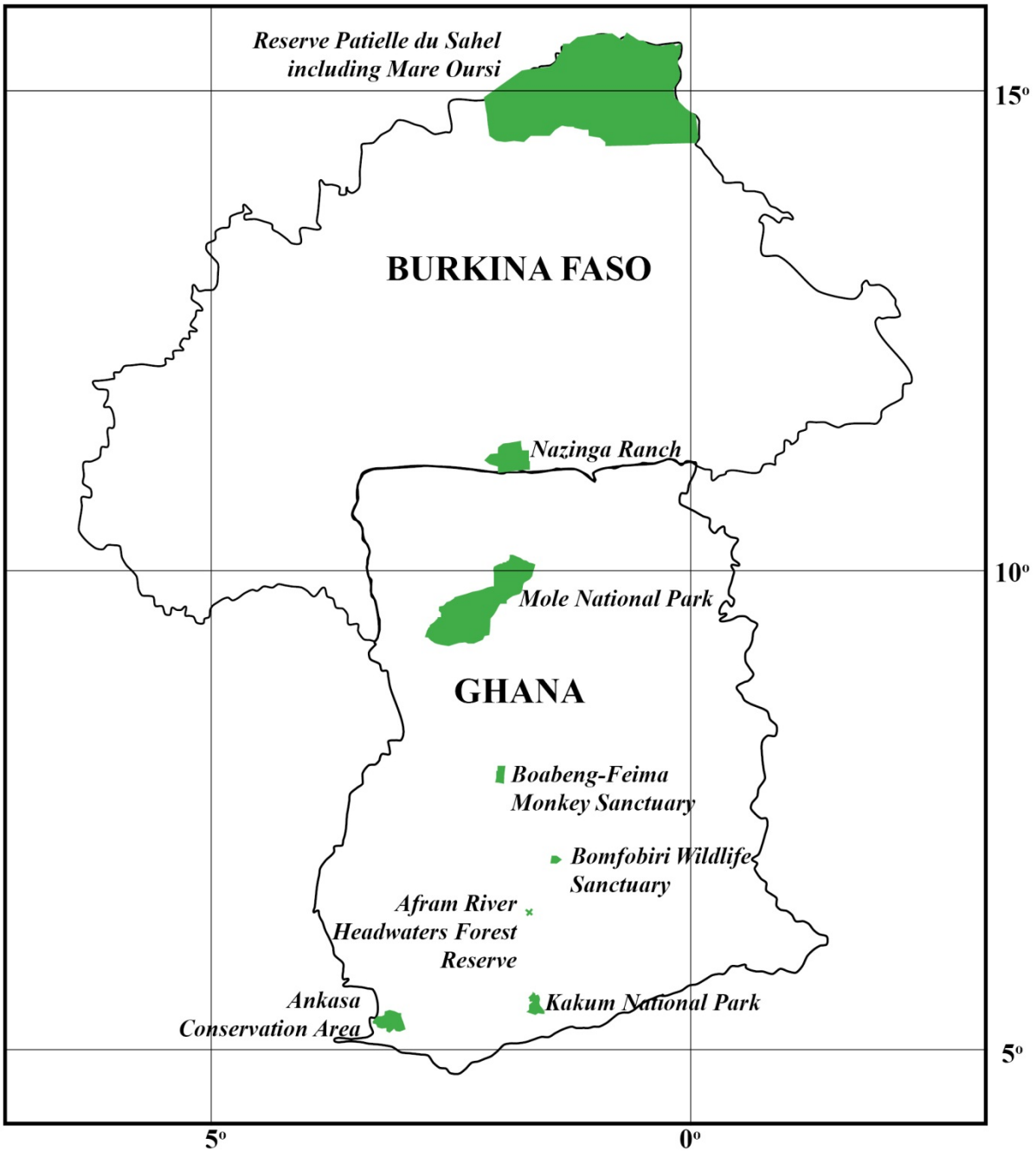

Figure 1. Map of the protected areas visited – from North to South. 15°N is in the Sahel ecosystem; 5°N is in the high rainfallwarm Tropical Rain Forest zone near the Atlantic Ocean coast

2. Results of the surveys from North to South (Figure 1)

2.1 Mare Oursi within the Reserve Partielle du Sahel, Burkina Faso

The Mare Oursi is an impoundment of several seasonal streams and sheet flows that make up a wetland of 1,595 ha within the Reserve Sylvo-pastorale et partielle du Sahel (450 km^2) in very northern Burkina Faso next to the border with Mali. Mare Oursi is a Ramsar Wetland of International Importance and a recognized conservation area as well as a source of water year-round for people and livestock as well as a source of freshwater resources such as fisheries and harvesting of water lilies.

This partially protected area is in the Sahelian Zone with limited rainfall (less than 350 mm per year) and high ambient temperatures. Areas around the wetland are greatly degraded by many passing and grazing livestock and overuse of scant vegetation cover near the impoundment. This situation would favour the growth of invasive plants but as we visited the area in the dry season, no terrestrial invasive alien herbs were visible. Persistent alien shrubs that can become invasive included *Calotropis procera* and *Jatropha gossypifolia.* Most notable, however, were the alien, evergreen trees of *Prosopis* sp. (mainly *P. juliflora*) which have been intentionally planted for shade, erosion control and fodder (also as part of the "Great Green Wall") which were clearly spreading and, as such can be classified as invasive. While the evergreen foliage of prosopis is always seen as attractive in dryland situations, this tree has extremely deep roots which access deep groundwater resources and deny these to native trees – thereby becoming first dominant and then a monoculture unless managed to prevent this situation.

The same older, larger prosopis trees have enabled an invasive bird species to settled and thrive in this area on a more-or-less permanent basis. This is the Red Billed Quelea (*Quelea quelea*) which is native to Africa but which takes advantage of native or artificial grasslands and seed crops to establish in its millions of individuals which have taken to perching and shelteringin the prosopis trees in the hundreds of thousands

Cattle and water lilies in Oursi wetland

***Prosopis* sp. grown for shade and shelter near the Oursi wetland**

Red Billed Quelea birds, (*Quelea quelea*) roosting in a prosopis tree near the edge of Mare Oursi

***Jatropha gossypiifolia* shrubs, northern Burkina Faso**

2.2. Ranch de Gibier de Nazinga, Burkina Faso

The Nazinga Ranch covers 913 km^2 in the extreme south of BurkinaFaso adjacent to the international border with Ghana. It has an inner core devoted to strict protection of biodiversity with an outer area for sport hunting.

Nazinga is located within the Sudanese (or Guinea) Savannah landscape which is an "open" type of savannah with tall grasses, herbs, shrubs and scattered trees. It is traversed by the Sissili River (a significant tributary of the Nazinon River which flows into the Volta system in Ghana). There are also numerous impoundments (barrages) on the main river as well as dams on the tributaries of the Sissili. Thus biodiversity includes both terrestrial and aquatic components – and so do the alien species.

The well-vegetated savannah seems to have resisted invasion so far – apart from an unidentified and probably alien species of *Triumfetta* which has occupied the sides of the access roads in the PA and is moving laterally into the grasslands replacing grasses and shrubs. The freshwater systems are harbouring submerged *Ceratophyllum demersum* and floating*Pistia stratiotes* and *Mimosa pigra* and we were informed that water hyacinth (*Eichhornia crassipes*) was prevalent during the wet season and built up in the river and lagoons.Two species of trees planted at the entrance to the reserve are known invasives in other similar places: *Senna* (formerly *Cassia*) *siamea* and*Azadirachta indica* (neem). Other potentially invasive plants recorded at the tourist facility were *Catharanthus roseus* and *Calotropis procera.*

Invasive *Pistia stratiotes* in an impoundment of the Sissili River together with native Lemnaceae and *Ludwigia stolonifera*

2.3. Mole National Park, Ghana

Mole NP is a large protected area of Guinea Savannah with some patches of denser woodland, covering 4,577 km^2 in northern Ghana (Fig. 1). Mole NP is by far the largest biodiversity conservation area in the country and comprises several major vegetation types within the Savannah system: open woodlands, riverine forest and floodplain grasslands and swamps. The annual rainfall is around 1,000 mm per annum, typical for this part of northern Ghana, and is mostly restricted to the "wet season" from April to October. Further current details are available in the most recent Mole NP Management Plan, 2012-2016 (Forestry Commission, Ghana, 2011).

Invasive alien species in Mole NP have been addressed by the current Park Management (Forestry Commission, 2011) as a nuisance that exists around the park HQ and Motel and park entrance. Here the species are Neem (*Azadirachta indica*), Gmelina (*G. arborea*), Cassia (*Senna siamea*) and Asian Teak (*Tectona grandis*) some of which were recorded in other parts and edges of the park. In the same areas several other alien plants were recorded in abundance (*Hyptis suaveolens, Senna hirsuta, S. obtusifolia* and *S. occidentalis*) as well as an unidentified species of the weedy genus *Triumfetta* (which was also present in Nazinga Ranch); details in Annex 1.

Most notable, however, and most important was a relatively new infestation of the dangerous shrub/climber, *Chromolaena odorata* (Acheampong or triffid weed) which was identified in a damp area in and around a stream in a relatively remote part of the estate. Here some plants were extending 5 m up and over native vegetation and also forming dense, impenetrable thickets in the riparian vegetation. This is a very serious invader common in medium to high rainfall areas of Ghana (and other African countries) which is likely to spread due to its wind-blown seeds and the ability of its seeds to attach to animal fur, footwear and vehicles and be borne by water after rain and in streams. Other herbaceous alien species that could become invasive were not seen – possibly because at the end of the rainy season (our visit was in early May) they may have died down, awaiting the season of rainfall for a new generation to germinate.

Abundant and characteristic old flower heads on *Chromolaena odorata* in Mole NP. These are packed with many seeds that can be dispersed by wind, water and animals (as well as vehicles)

Invasive *Chromolaena odorata* growing up and over tall vegetation in Mole NP in a small infestation in a relatively dense area of the reserve

2.4. Boabeng-Feima, Monkey Sanctuary, Ghana

The Boabeng-Feima Monkey Sanctuary is a very small wildlife reserve in Brong-Ahafo, central Ghana which was originally 4.4 km^2 (Attaquayefio and Fobil, 2005). It was established to provide safe land for two species of monkeys (Mona [*Cercopithecus mona mona*] and Geoffroy's pied colobus [*Colobus vellerosus*]) which are sacred to the people of the two villages – Boabeng and Fiema.

This is in savannah country with several alien species evident: Asian Teak and Neem in (and out of) plantations and *Leucaena leucocephala* predominating. The red-flowered alien herb *Canna indica* was also invasive in shrub and tree woodland where it was growing up to 3m high and dominating some local vegetation. The castor oil plant (*Ricinus communis*) was also quite common in the sanctuary amongst the wild vegetation.

Mona monkeys (*Cercopithecus mona mona*) and Asian teak, Boabeng-Fiema Monkey Sanctuary

2.5. Bomfobiri Wildlife Sanctuary, Ghana

Bomfobiri Sanctuary covers an area of 53 km^2 in the Ashanti Region of Ghana and is in the "transitional zone" between the true savannah and forest ecosystems. It is mostly composed of semi-deciduous forest with open savannah areas and some riparian forest. Teak plantations are noticeable within the reserve; wildlings can be seen distant from the planted forests.

In the more open forests and on the edges of denser vegetation there was very evident invasion by *Chromolaena odorata* – in some cases "climbing" high upon (and suppressing) native shrubs and undergrowth. Chromolaena has also spread across some to the more open grassed areas thereby changing the nature of the habitat. It is likely that this highly invasive species will continue to spread unless some action is taken to limit its growth – it is, however, understood that this could be expensive and long-lasting and that there is continuing debate about its possible usefulness – at least in farming areas.

Lantana camara was also evident in this sanctuary – in relatively high density but not obviously invasive yet. It was not possible to detect its interaction with chomolaena when the two were growing together – but this might benefit from further observation as a means to decide which to control first – if this was the desired management need.

Chromolaena odorata **invading grassland (either side of the path) in Bomfobiri Sanctuary and growing up and over other vegetation (background, left hand side)**

2.6. Kakum National Park, Ghana

Kakum NP is situated in the Central Area of southern Ghana, not far from the Atlantic Ocean coast, in a high rainfall area and ecosystem typed as "Moist Evergreen Forest"(UICN/PACO, 2010). The National Park covers 207 km^2 while the entire Conservation Area has 350 km^2 through the addition of the Assin Attandanso Resource Reserve.

Much of Kakum is dense rainforest a large proportion of which is closed forest with hardwood trees up to 65 m in height and very little undergrowth. The northern half of the NP is somewhat drier but nevertheless is mostly forested and similarly consisting of tall trees with little understory.

Most notable in Kakum was the absence of alien and invasive plants in most parts of the protected areas where closed forest was dominant. Chromolaena was recorded in open areas within the forest such as access tracks and where trees had fallen, opening up the forest to sunlight. The same was true of the park HQ where chromolaena was evident as well as along the main road which traversed part of southern section of the PA. The Kakum park manager related that chromlaena had been common in some areas of cleared forest (previously used for farming after logging) but when the forest was allowed to return to these areas and form a closed stand of tall trees – within the space of 20 years, chromolaena was no longer present.

Various alien and invasive herbs and shrubs were quite prevalent along the outside edges of the forest – especially in the northern sector of Kakum; some of which appeared to have spread close to the closed forest but been unable to enter. Such well-known aliens as *Canna indica*, *Lantana camara, Ricinus communis, Senna hirsuta* and *S. occidentalis*(and *Chromlaena odorata*) were among those seen near the outer edges of the dense forest.

Chromolaena odorata **(mixed with other vegetation) at Kakum NP headquarters**

Inside the closed forest, southern part of Kakum NP complex – note low light intensity (apart from camera flash) and absence of vegetative groundcover or understory

2.7. Ankasa National Park, Ghana

Ankasa Resource Reserve covers 330 km^2 in the Western Region inthe south-western "corner" of Ghana, even closer to the Atlantic Ocean coast than Kakum. It is in the Wet Evergreen Forest ecosystem with a rainfall exceeding that of Kakum and is regarded as Ghana's most special forest with the highest Genetic Heat Index (UICNPAC, 2010) – a value that estimates the biodiversity rating with reference to the most rare and endangered species and so the areas of greatest conservation value (Vermeulen & Koziel, 2002).

Ankasa is part of a larger conservation area which includes Nini-Suhien NP which makes it the second largest conservation protected area in Ghana (after Mole NP) and shelters the greatest diversity of forest species (animals and plants) in the country. Like Kakum, it is mostly dense tall forest which keeps the native biodiversity free of biological invasions within the reserve.

The open areas within the forest (park entry, visitor displays, roads and walking tracks) were mostly free of alien species apart from the ever-present *Chromolaena odorata* and the alien "UmbrellaTree" (*Cecropia peltata*, sometimes called "Abidjan").

In both Kakum and Ankasa, park personnel spoke of an invasive creeper/climber which grows up onto even tall trees, becomes heavy and then the tree and associated vegetation fall down. This turned out to be the native *Acacia kamerunensis* (see Annex 1), a climbing acacia widespread in West Africa and parts of East Africa (Dharani, 2006) which serves to open up spaces which can then become sites for regeneration of some forests plants – especially trees.

***Cecropia peltata*, Ankasa NP, beside the access road into the forest**

2.8. Afram River Headwaters Forest Reserve

This is a Forest Reserve maintained for conservation, forest farming and small forest products in the Ashanti area of southern central Ghana (Figure1). It was not visited during the assessment described above but was accessed by the author in 2009 as part of a (UNEP-GEF) project "Removing Barriers to Invasive Plant Management in Africa". In this and related forest reserves, several alien species of trees had been planted either to provide shelter for forest farming or to mark forest boundaries. Some of the trees had since become invasive, including *Cedrela odorata* and *Broussonetia papyrifera* and which were known to also inhabit conservation areas.

3. Plant invasions in the protected areas visited

3.1 Types of invasion detected

During the assessment of the seven PAs for invasive plants, 26 species were recorded or mentioned, all of which are known to have been invasive in some part of mainland Africa. These have been grouped into six categories and are discussed below; all of the species mentioned are further described, and most illustrated, in Annex 1 to this report.

a. **Alien trees: *Azadirachta indica, Broussonetia papyrifera, Cecropia peltata, Cedrelaodorata, Gmelina arborea, Leucaena leucocephala, Senna siamea* and *Tectona grandis***. Trees were not widely considered to be important invasive alien species until quite recently (Richardson & Rejmanek, 2011) when it became clear that many planted alien trees only became invasive after a long lag phase – sometimes exceeding a century. All but one of the trees with invasive potential in this assessment were planted as shade trees or garden trees or PA boundary markers (or, in the case of Asian teak and Spanish cedar, production forest trees) before they began to spread away from their planted origins and become invasive in woodlands and savannahs and deciduous forests. The exception is *Leucaena leucocephala* which was introduced to Africa as an agroforestry species and planted widely on farms and around homesteads – from where it spread to form first thickets and then to invade many types of tree-dominated landscapes. None of the species listed is capable of penetrating tall, dense rain forest system – and the only one that threatens the surrounds of such forests in *Cecropia peltata* which will spread in man-made and natural openings even in the densest forest. *C. peltata* has fruits/seeds that are attractive to small mammals up to the size of dikdik or suni and to many birds – all of which can spread the seeds widely and also occupy the same types of open spaces in forests.

Invasion by these eight trees is by entering native vegetation, replacing plants (including other trees) and shading herbs and shrubs and small trees below them – thus reducing or stopping their growth and survival. Leucaena can form one-species dense thickets and then expand the edges of the thickets to cover native shrubs and grasses.

Once these trees have become invasive, it is difficult to remove or thin them because trees cut down will coppice from the stump and even herbicide application is not always successful. Prevention of the wildlings from developing into adult trees (those that can produce viable seed) is the best way to forestall or prevent invasions.

b. **Woody shrubs: *Calotropis procera, Jatropha curcas, J. gossypiifolia* and *Ricinus communis*.**

These three species are characteristic of the drier lands of Africa with some reports suggesting that *C. procera* is native to dryland East Africa and the Arabian peninsula. Nevertheless the three are all capable of invasion, particularly of degraded areas, overgrazed and overused grasslands. *C. procera* often spreads along roadsides over long distances and then, from there, enters fields and pastures and native vegetation when it is in abundance. *J. curcas* usually begins as a planted hedge (live fence) which doubles as a small source of vegetable oil that can be made from the large fruits. From this position it can spread across considerable distances assisted by water and sometimes by animals that take the fruits. It has also been used commercially to produce biofuel and has been reported to escape from such plantations. It is capable of invasion of native shrublands and pastures and is poisonous to livestock while the fruits are poisonous to people and have resulted in deaths of children who have eaten the ripe fruits.

J. gossypiifolia is spread from village to village as a planted windbreak or hedge from where its fallen fruits are easily borne away by even small amounts of water after rain: in this way it can spread far in drainage ditches and natural dryland surface flows. This gives the species a start in germinating and establishing very quickly after rain by using the water of even quite small showers. Once established, it can form dense thickets that will dominate and exclude native vegetation. It can also thrive in the wetter savannah lands (in well-drained soils) and dominate grasslands as well as shrubs – which may be food for wild animals.

Ricinus communis has the name “Castor Oil Plant” because it was one of the main sources of lubricating oil in former times. Even today some homesteads have small fields of *R. communis* to produce oil for lighting and lubrication of farm machinery. While this plant is partly domesticated, it can readily live in the wild, spread and cause

damage to native vegetation; its stems, leaves and seeds are poisonous to most herbivores and it has few if any insect pests. Like the previous three species, *R. communis* can grow in tight, tall and quite dense thickets which can spread across native vegetation causing its demise.

c. Shrubs that can climb. *Chromolaena odorata* and *Lantana camara.*

These two species are amongst the worst invasive plants that have come to Africa – both are from tropical America and were introduced with the best of intentions: *C. odorata* for suppression of other weeds during fallowing for agricultural crops and *L. camara* for garden flowering shrubs and hedge plants. Both have since become widespread in mainland Africa – especially in the West for chromolaena. Lantana is also not only spreading within its favoured climate range but, in some places, becoming adapted to other (e.g. drier) conditions, allowing to spread even further.

The invasive success of both chromolaena and lantana is due to a number of traits common to both: fast growth and ability to grow over other (often native but also crops) vegetation, ability to ascend beyond the shrub stage (which is sometime 3 m high) up to as much as 10 to 20 m by growing over other taller vegetation and, in the case of lantana, ascending to the tops of trees. They both also produce allelopthic substances which suppress growth and germination of other plants – resulting in a monoculture of the invading species. Their dispersal mechanisms are reliable agents: lantana fruits (and so seeds) are dispersed by frugivorous birds which feed avidly on the sweet-tasting fruits while the seeds of chromolaena have a plume of hairs attached which ensures it can be borne on even the weakest air movements (winds) as well as floating on water as runoff and stream flows that can take the seeds far from the parent plant.

Mechanical control of invasions by these plants is not a sustainable method as both will coppice from cut stumps or exposed stems and roots. Other forms of integrated control are available, but the use of herbicides in PAs is sometimes difficult and, especially with chromolaena, there are often views opposing control because of the perceived usefulness of this plant outweighing its deleterious impacts.

d. Climber: *Cardiospermum halicacabum*

The Lesser Balloon Vine is a delicate climbing plant (with pale green finely-divided leaves and tendrils characteristic of true “climbers”) which appears to be too fragile to be invasive – but it can grow fast and thickly under some circumstances and overwhelm native plants. It was introduced to some African countries as a decorative garden plant,

but there is some debate about whether or not it is alien to Africa because it is currently termed "pan-tropical", a term for species found all around the tropics. However one opinion of its alien-ness is based upon the absence of evidence of having native pests and diseases – meaning that its leaves rarely have signs of being eaten or of infestations by plant pathogens such as moulds and rusts… which is a common indicator of non-nativeness. It should be regarded as a potential invasive species wherever it is detected and watched to see if it becomes destructive to native vegetation.

The more robust balloon vine (*Cardiospermum grandiflorum*) with larger leaves and larger, more-rounded fruits is reportedly alien – coming from tropical America - and can definitely become invasive in similar damp localities as *C. halicacabum* (Henderson, 2001); it is also recorded from West Africa.

e. Herbs and small shrubs. *Canna indica, Catharanthus roseus, Hyptis suavolens, Senna hirsuta, S. obtusifolia, S. occidentalis* and *Triumfetta* sp.

All of these herbs and small shrubs are alien to West Africa and all have some capacity for invasion – meaning that they can be destructive to biodiversity. Their impacts, however, are varied and not always obvious or extreme. *Canna indica* is often peri-domestic because it is seen as an easy flowering plant that needs no attention: however it can escape and cause problems with other herbs and has been known to grow tall and threaten small trees and large shrubs – especially in damp areas and on riverbanks.

Catharanthus roseus is rarely a threat in protected areas although often planted around dwellings – because it has some medicinal properties. It can escape and, being poisonous to livestock, can move into farms and pastures and from there to native vegetation (even inside PAs).

The three shrubby alien species of *Senna*are all capable of invasions and, especially *S. obtusifolia*(sicklepod), can become dominant in grasslands and short herb landscapes which they can steadily replace over years – if not controlled. All three have been planted as garden edge-plants and all three were seen in various parts of the savannah PAs with clear infestations heading towards invasions in some. Wherever they settled in PAs they should be monitored for spread or, more effectively, removed before they spread – bearing in mind that they are prolific seed producers and will leave behind a seed bank that may germinate in later years.

Hyptis suavolens and *Triumfetta* sp. are essentially alien agricultural weeds that spread along roadsides and may enter native vegetation under circumstances of disturbance in the wild. The Triumfetta sp. encountered in Nazinga Ranch and Mole NP was clearly moving into the native vegetation from the roadsides and was said to be replacing native grasses. It will be essential to verify its correct species name before any further consideration is given to this weedy plant.

f. Water plants. *Ceratophyllum demersum*, *Eichornia crassipes, Minosa pigra* and *Pistia stratiotes*

These four species are a sample of the water plants likely to be in open water bodies and wetlands as well as rivers in the protected areas concerned. *Ceratophyllum demersum* is recorded from many such systems across Africa but, being mostly submerged, it is not always seen. It is certainly native to the waters of Africa and is now found in most areas around the tropical world. It can become invasive if conditions in a water body change (such as salinity or, especially, nutrients from agricultural or industrial runoff) rendering it alien in the new water conditions – but still in an area where it was previously native/indigenous. Invasion in this species is seen when it becomes especially dense and cuts out light and oxygen to organism below it, as well as occupies spaces near the water surface previously inhabited by other native water plants.

Eichhornia crassipes and *Pistia stratiotes*, together with *Azolla filiculoidesand Salvinia molesta* (the latter two not seen or reported in this assessment but known to be in the areas sampled) are the four alien floating water plants that are still spreading across Africa's aquatic systems and causing havoc with other freshwater life. This is especially true of lakes, ponds and isolated wetlands which are "islands" of biodiversity with their own precious native species – floating emergent and submerged. These are areas of special concern for plant invasions – especially when invaded by these four aggressive species - because they often contain endemic species of aquatic life such as native fishes, native crustaceans, molluscs and other invertebrate animals and some aquatic plants. The water bodies and, to a certain extent, the permanent rivers and streams in PAs should all be considered as centres of attention for invasive floating plants and their management for the safety of isolated aquatic native species.

Mimosa pigra as a riparian or floodplain species also needs to attention where ever it is located because of the possibility of sudden growth and invasion as has been observed and recorded in many wetlands in mainland Africa – irrespective of whether *M. pigra* is truly alien or not.

3.2 General state of invasion in PAs of the five terrestrial landscape types sampled in West Africa

The reason why these six groups of invasive plants have been discussed as above is to present findings in a way that enables the assessment of the threat of alien invasive species to the range of PAs sampled in this survey. These follow in the five landscape or major terrestrial ecosystem types where the PAs surveyed were located.

Dry areas (near 15^0N, Figure 1), From the survey in the drylands, as far as it was possible to assess in the dry season, biological invasion by plants is not a serious problem – at least at present. If development proceeds in this region, disturbed areas such as construction sites, new roads, cleared vegetation and over-grazed areas, invasions will become more prevalent due to passing propagules as a result of more activity with machinery and vehicles **and** the well-known attribute of alien invasive plants to settle in disturbed areas. Thus even in this area which is almost without significant invasions (apart from prosopis trees) there needs to be monitoring for arrival of new species (alien plants) and observation on any that may spread – to prevent new invasions. At the same time, the artificial water bodies (dams, impoundments) that are now so important for livelihoods and livestock production, need to be monitored for the inevitable arrival of the most invasive alien floating water plants (see above in e.) – bearing in mind that propagules and plant fragments of such species can easily be carried by wandering and migrating waterfowl which visit these water bodies. Arrival of such alien species and lack of action to manage them could seriously reduce the effectiveness of the water sources as well as the native biodiversity in the waters (including even the waterfowl that brought them). As far as dryland biodiversity is concerned, water-bodies like Mare Oursi are "islands" of native diversity which should be conserved and so protected from alien water plants with a tendency to become invasive.

NOTE: There may be one submerged invasive species already in the waters of Mare Oursie, but GH did not have the necessary equipment to retrieve, prepare and photograph it. This was a species of Najas, possibly *Najas horrida*, which can sometimes be an Opportunistic Species (as described by Henderson & Cillers, 2002), which is a native or pan-African species that can become problematic in "biologically disturbed aquatic habitats" – such as those with increased nutrients from livestock using the same water (Glen *et al*., 1999). This would need further, specialist attention to determine more precisely.

Savannah-dominated landscapes (12^0 to 7.5^0N. Figure 1)

This was the sector with the greatest number of invasive species (including small invasions of the worst two – *Chromolaena odorata* and *Lantana camara.* This is not surprising because the savannah landscape has a wide variety of ecosystems and habitats, including dry forests,

woodlands, open woodlands, shrublands, grasslands, wetlands, lakes and rivers (including the reaches of the vast Volta River-Lake system). In addition, these habitats are not "closed" like the taller forest system closer to the equator and so are not as resistant to invasion. The range of species in this area included all types of invasive species listed above (apart from the very dry). The impacts of these invasions were not so severe but it was clear that they could become so if not controlled before much longer – such as the new outbreak of *Chromolaena odorata*, the three Senna shrub species, the teak (*Tectona grandis*) and leucaena trees (*Leucaena leucocephala*), the tall *Canna indica* at Boabeng-Feima and the various water plants in Nzinga Ranch. Nevertheless, the range of invasions in this landscape was far less than equivalent ones in Eastern Africa (long-term personal observation, GH).

Dense forest and open grasslands (7.5^0 to 6^0N, Figure 1)

Here in the tall, dense but not closed forests and the forest farming areas, the invasive trees were prevalent – *Azadirachta indica, Broussonetia papyrifera, Cedrela odorata*, and *Tectona grandis* as well as *Lantana camara* in forest gaps and open areas – where *Chromolaena odorata.* was abundant. The impact of the invading trees was still at a low level but would clearly increase with time if not addressed; the effect of the chromolaena was quite damaging and it was obvious that native shrubs and smaller plants were being dominated and gradually removed where this species was prominent. Lantana was present but not yet dominating in most cases, but knowing its potential to spread upwards and outwards over time, it could become a serious pest in the coming years. This landscape was less open to alien species than the previous one but more so than the next one with closed forests.

Dense, closed, tall, wet tropical forests (6^0N to 5^0N, Figure 1)

There were no biological invasions visible **within** the tall, hardwood, closed forests. This is no surprise as there is "no room" for alien species that become invasive within the forest – species which need light and space to use their attributes that make then invasive – fast growth, abundant seed production, effective dispersal, etc.

Potentially invasive species that were present in openings in the forest (access tracks, roads, natural open spaces caused by falling forest trees) were the inevitable chromolaena and the occasional *Cecropia peltata,* but these were unable to penetrate the actual closed forest. Around the edges of the PAs and approaching the forest (but not entering it) was a range of possible invasive herbs and shrubs including *Canna indica, Ricinus communis, Senna occidentalis, S. hirsuta* and *Lantana camara.*

So threats of invasion in the body of the closed forest appear to be none at all, while the edges support some species that will not be able to enter the closed forest, but may invade plant communities and settlements outside the truly wet tropical forest.

3.3 Implications of these findings for PA managers

It is possible to say, from the summarized findings in Section 3.1 (above) that PAs in all of the ecosystem types assessed from driest to wettest (but not including large freshwater lakes and rivers or the marine environment) have actual or very likely incipient or potential biological invasion problems for Protected Area managers. This is based upon the alien species recorded and extensive experience of the actions of those species in other similar parts of the tropical and sub-tropical world. The same would be true for freshwater large lakes and large rivers where some riparian habitats are especially likely to be invaded and there would be a high probability of submerged and floating alien and invasive species on (and under) their open water bodies. The marine environment is so much more complex, "open ended" and biologically diverse that it would need a separate and special assessment.

It is appreciated that the assessment of invasion by alien (and sometimes indigenous) species and the level of risk to protected biodiversity is always predictive, not certain. Such prediction will always involve varying levels of accuracy because of the very nature of the invasion process and status of suspect species: most alien species (and other species in changed habitats) that have one or some of the characteristics of an invasive species, MAY or MAY NOT become invasion under any particular circumstances. We have tools to evaluate that level of risk – Pest Risk Assessment and Weed Risk Assessment protocols (see section 4.3, below), but these can never make 100% correct predictions because they all involve some "expert opinions" as well as definite facts. We also have models for predicting to where an established invasion can spread or further establish – but these (especially the **Climex Model**, Kriticos, *et al*., 2003; Legaspi & Legaspi, 2010[2]; Taylor & Kumar, 2012) are always based upon a probability of accuracy (usually 0 to 95%), not a certainty (probability 100%).

An example of the sequence of information that can lead to a significant prediction that an alien species present in a PA may become invasive is given below:

[2] The Climex map of *Cactoblastis cactorum* shows 8-24% probability of its suitability in the southern part of Ghana – indicating that the genus *Opuntia* (alien cactus), the host plant, is present. This is mentioned because we did not detect *Opuntia* spp, as present in the PAs samples but it is recorded as present by CABI in the ***Invasive Species Compendium*** (www.cabi.org/isc)

Alien*Jatropha gossypiifolia* was identified in northern (dry) Burkina as a roadside shrub, probably planted by the local government in several places as a decorative species (Figure 2) with younger plants scattered along a drainage channel away from the roadside (i.e., it was beginning to spread). This species was later seen in Mole NP HQ as a well-developed hedge (Figure 3) and, on our return journey to Burkina, as a dense roadside plant suppressing local vegetation in northern Ghana, (Figure 4) while experience of this species in another, similar, hot dry place in Southern Zimbabwe, reveals its capacity to form a dense monoculture completely dominating all other vegetation (Figure 5) as an established invasive species. A quick check of reliable invsasive species databases easily available on the internet (e.g., the Global Invasive Species Database of ISSG – www.issg.org/databse/welcome - or the CABI Invasive Species Compendium – www.cabi.org/isc/) to see if it has been recorded as invasive elsewhere, confirms this species as **alikely candidate for invasion** in the areas and PAs in West Africa.

Fig. 2: *J. gossypiifolia*on roadside in Burkina Faso

Fig. 4: *J. gossypiifolia* in northern Ghana

Fig. 3: *J. gossypiifolia*as hedge in HQ, Mole N.P.

Fig. 5: *J. gossypiifolia* invasive in dryland Zimbabwe

With this information (the first three images showing that this species can move away from a planted area, grow tall and dense and overgrow other vegetation, and, from the last image (Fig. 5) can establish an invasive monoculture) it would be appropriate for PA managers to learn to identify this alien and potentially invasive plant and, if it is planted or comes to their PA, to ensure that it does not spread. Following are some of the steps that can be taken to prepare for invasions, test for invasiveness, prevent introductions and then, if prevention fails, attempt eradication (if this is indicated) or management to reduce the threat from invasion.

4. Ways to address the risks once an invasion has begun or a species identified as a likely threat to native biodiversity

4.1 Awareness of biological invasions and threats they can cause to protected biodiversity

Awareness (or appreciation) of the general principles and impacts of biological invasion is a basic necessity for any attempts to counter present or future invasions. In PAs it is wise to have two levels or types of awareness available to those who manage or use the area: 1., a technical level for PA managers and other staff who might be deployed to have some role in the amelioration of the impacts of invasions, AND, 2., another available to the visitors to PAs – tourists, researchers, students and others who deliver goods and services but do not engage with biodiversity as part of their routines.

The first would usually arise from a **policy decision** by the national or regional body whose responsibility is to ensure PA management that gives native biodiversity the maximum chance of continued survival, good health, and stable populations and communities of animals, plants, and habitats. This decision would then need to be implemented through a set of in-service training routines for senior managers in, for example, the same style as the training on Management Effectiveness[3] or even as part of Management Effectiveness training. This would cover the topics elaborated in the first section of this report (pages 1-5).

The second form of awareness would be much less technical and tailored to tourists and other visitors to the PA who may want to know about invasive species – in general and in particular about notable invasive species to be seen in the PA and how to prevent further invasions. It may be possible for this to be organized and produced by a relevant NGO or a communications agency with links to the particular protected area and a wish to promote good conservation practice – through preventing and avoiding biological invasions. This could then be in the form of a dedicated static display (like the one at the entry to Ankasa Conservation Area – figure 6) which would be easily accessible by all visitors to the PA – perhaps located at or near the

[3] As in IUCN-PACO, 2009 and UICN-PACO, 2010.

entrance or near park accommodation or any other visitor or information centre. The alternative is to prepare awareness leaflets devoted to certain types or stages of invasion or to particular invasive species that are in or threaten the PA. These leaflets would be readily available and point out the characteristics of the invading species, the way that it was (or is expected to be) introduced to the PA and some hints on what the reader can do to reduce the risk of further damage or more invading species – as in the example in Annex 2. The reason for this emphasis on awareness is to ensure that the threat of invasion is real **to the PA managers.**

Figure 6. An awareness display on a water-proof standing structure in Ankasa Conservation Area, Ghana

Even more effective (but beyond the resources of most protected areas) is the publication by Murray & Powell (no date) which is an illustrated booklet describing 45 the most important invasive plant species in Kruger National Park (South Africa) with notes on identification, general species information and the most effective treatment methods for their control.

4.2 Recognition and monitoring of alien species and invasions by alien species

The process that leads to a species invasion usually begins with the introduction and establishment of an alien species. Thus one of the ways to reduce or prevent the threat of

negative impacts on native plant diversity is to recognize a foreign species that has appeared in the PA and is beginning to establish and reproduce - and then test it for likely invasiveness and remove it if this species is a perceived threat. This requires two things – the first of which is present in most PAs in West Africa: a vegetation study of the reserve with, in some cases, a list of the native plants known from the conservation area. While it may be difficult for a PA manager or biologist to search the conservation area for new arrivals and then to be sure they are new-comers, it is often the case that those who carry out routine patrols will be very familiar with "the look of the area" where they patrol and so notice a new species of plant. Increasingly, those who patrol may carry a digital camera and possibly a GPS. With this easily portable equipment, it is possible to record the salient features of the unexpected plant species and record its exact position for future reference – and to make this information available in the patrol's report upon return to base. The next steps to recognition of the species as either new to the PA (or already part of the native biodiversity) and then its status as a potential invasive species would be the responsibility of a PA Biologist or Ecologist (or PA manager) with access to identification materials or an institution (such as a government or university herbarium) that could confirm its identity and so its likely status as an alien and/or potentially invasive species.

The outcome for the PA will vary with the policy of the managers – some prefer to remove all species that are not native to the area, others may let it remain and observe its spread or otherwise in the future. If the latter is the course taken, the patrol system should then be required to monitor the locality of the suspect species and record any changes in area or density of the plant over time – also to be reported from observations but also, where possible, through photographic images of the size and shape of the new species' distribution or spread.

The same process can be used to monitor areas for invasions that may have begun before any alien species were recognized. This requires those on patrol to report and record any significant changes in vegetation compared to what they would expect. Then the PA manager can decide to bring in an expert or continue monitoring to assess if the situation is worsening and then take action to reduce its impact.

There are two more avenues to the detection of alien and invasive species in a PA. One is simply to recruit an expert in plant invasion to make an assessment for that purpose; the other is to prepare to search for invasive species that are already present in the larger area around the PA. This would require a guide to the recognition of such a species and, if possible the usual pathways for its introduction to a new area –and/or the preferred habitats that it might occupy. With this information it is then possible to search the likely places where it might settle and record any likely species incursions and, as before, take some camera images and/or plant specimens for definite identification by an expert.

4.3 Estimating likely risk of invasion and possible impacts of an alien species

When a suspect species or possible new invasion has been identified there is no guarantee that it does, in fact, represent a significant threat to biodiversity – even though it may be a likely candidate for the ecosystem type where it has been found. It make be possible to follow the steps listed in the section 3.2, above may indicate that a risk exists, but that will still rely on the opinions of experts unless a risk assessment is implemented. There are several types of Weed Risk Assessment (WRA) or Pest Risk Assessment (PRA), but all use the same process of assessing the known or observed characteristics of the suspect species with usual invaders and matching the conditions of the area it is likely to threaten.

One of the standard WRAs that has been widely used for this purpose is the Australian Weed Risk Assessment (Pheloung *et al*., 1999). This is based on a screening system of 49 questions that relate to biogeography, invasion history (in other places), invasive traits (as listed in section 1.2, pages 2 and 3), and ecology of the target species in relation to the site in question. Each of the 49 answers is given a numerical value (to coincide with a range of extremes including "Yes. very important" to "No, not at all important"). Some responses may be allocated negative values and then, when all the questions are answered, a numerical total is calculated. This is then compared with a set of numbers – usually the highest being "Not at all likely to become invasive" through to "Very likely to become invasive". Then the final answer of how to proceed, which is usually taken by another group, different from those who answered the 49 questions (to avoid conflict of interest), leads to: 1. prevention of introduction (or eradication), 2. introduction - but under conditional circumstances that would include monitoring and possibly test plantations, 3, allowing introduction without conditions.

In the last decade there have been many analyses of this process (e.g. Dawson, *et al*., 2009), and resulting refinements and procedures appropriate to different needs and different countries. Special adaptations have been made for quarantine agencies, border inspection units, "post-border analyses" and impacts on agriculture, forestry, fisheries, livestock production and biodiversity – including ecosystem function as well as species diversity. An early assessment of the risk assessment procedures for introductions that may affect biodiversity was made by the CBD Secretariat (UNEP-CBD, 2001) which refers to recommendations from various International Organisations and Conventions and covers both animals, plants and micro-organisms (including pathogens of animals and plants).

An up-to-date website that publishes details of weeds risk assessments of many common invasive plant species and shows the questions and then answers for each question in the WRA is the Weeds Network of Monash University in Australia (http://weedsnetwork.com/rs/::wra_newspage).

Using the appropriate WRA tool it is possible to make informed decisions about potentially invasive alien species that are near a PA or already within its boundaries – and even those in the country or region that may, in due course, become a threat to biodiversity conservation.

4.4 Decision on action

Once a WRA or other means has been used to define the seriousness of a threat from an alien species of actual or possible invasion, there is need to take some action. Actions can range for "doing nothing" through no action apart from "monitoring the situation", to the extreme of deciding to initiate a programme of eradication or management of an invasive species within or near the PA concerned. The decision will usually be in line with senior management principles and procedures as well as PA Management Plan priorities and may, in serious cases, require an Environmental Impact Assessment through the Regulating Environmental Agency of the country. It is also recommended that such a decision and its later actions follows the **Ecosystem Approach**[4], especially to define in detail the objectives of any actions and to involve all stakeholders in both planning, decision-making and implementation of the action. Stakeholders in this situation would of course be the PA managers at all levels, but also local communities (which may be affected or have their own values for the species to be managed), local authorities, tourism managers (and their clients) as well as research organizations associated with the PA concerned.

Defining objectives is important in working with IAS in PAs because the end-point desired may have many more required actions than removal of the threatening species. In some cases, removal of an unwanted invasive species has been followed by another alien species "taking over" and replacing the one removed. The desired end-point (such as restoration of the original habitat or population) needs to be considered in the action because this may require other considerations and activities than removal of the IAS – even before that removal is completed. It is also possible that some stakeholders may want to use the same (alien) species for its desirable properties – which may be possible within an integrated management plan which includes the acceptable needs of all stakeholders.

4.5 Available prevention and management techniques for invasive alien plants affecting PAs

A helpful document that summarises prevention and management of alien invasive species (Wittenberg & Cock, 2001) which is a product of the Global Invasive Species Programme (GISP)

[4] An Advanced User Guide to the Ecosystem Approach (CBD, 2009) is available as a pdf file at www.cbd.int/ecosystem/sourcebook/advanced-guide/?task9

and can be found in English and French on the former GISP website at www.gisp.org/publications/toolkit/index.asp .

Prevention of the introduction of known IAS to PAS that may be susceptible to their threats requires that the species concerned is stopped before it becomes established. This is best implemented if the most common pathways for introduction of the threatening species (see section 1.3, above) are known. This knowledge makes it possible to predict how, where (and possibly when) the species will come to the PA so that it can be prevented. If its main pathway is through natural means (winds, water flows, storms, floods, animal migrations) then it will be necessary to search in the preferred habitat of the expected invasive to establish if it has come – and then eradicate it on site (and on sight). If it likely to come with traffic and deliveries and tourism, then it may be necessary to make this known and all people and vehicles entering the PA need to be searched and any propagules destroyed. Or if, for example this species is known to be spread on motor vehicle and earthmoving equipment tyres and vehicle parts, these may have to be cleaned at the PA entry point. If it is known to be spread on walking shoes, these can be disinfected at the entry. With this general approach, it is possible to prevent any species entering a PA provided that its pathway details are known.

Eradication is the process of completely removing the offending species and all of its propagules. This may be deemed necessary if a highly invasive species is first encountered inside the PA or outside the PA boundaries but near susceptible, fragile or very important species or animal or plant communities. In some cases this can be achieved by physically removing all plants and destroying them and then closely monitoring the site for germination of the species from its seed bank in the soil. This is possible for some species with a short survival life of seed – but many invasive species have seed that can last for decades in the soil with some individuals germinating every year (or every growing season) for many years. This can be overcome if the infestation is recognized before the first flowering of the IAS plants – provided that all plants and their flowering and fruiting parts are destroyed before ***any*** seed is set. Removal of plants may also be possible through burning – provided that all propagules are destroyed (such as corms, bulbs and roots that may sprout after fire) and also provided that other conserved plants are not affected.

Chemical means to destroy newly invading plant populations can be effective – if a suitable (tested) herbicide is both available and has been registered in the country – but this will also need to be allowed under policies and regulations for use of chemicals in PAs. Herbicides that can kill the whole plant above ground (and perhaps the roots) often have no effect on the seed bank if it has already been laid down after the first flowering. In this case the same need for subsequent monitoring exists (as above).

A combination of both mechanical and chemical means for eradication may be necessary in situations where invasive plants have grown in fragile soils where they cannot be up-rooted without loss of soil (such as on steep slopes and rocky outcrops). In this case plants should be removed down to the stump or base of the main stem and then systemic herbicide applied to the cut surface so that it kills any remaining plant parts – above or below ground.

Management (or control) of established invasions is needed if attempts at eradication have failed or if the invasion had begun and spread before it was detected (or before a decision was made to reduce its threats to biodiversity). This will often take a long time and much expense to overcome entrenched invasive plants and, just as with eradication, does not in most cases overcome the problem of a long-lasting seed bank which is characteristic of many of the worst invasive alien species. This is why prevention and eradication should be the first forms of protection against biological invasion – and why early detection of alien species or actual invasions is emphasized, above.

The three main types of invasion management are mechanical, chemical and biological control, or in some preferred situations combinations of two or more of these techniques – referred to as "integrated control.

Mechanical control is carried out by hand, often with hand-tools, or with cutting machines or mechanized mowers – or, in dense invasions, with soil-moving machinery such as bulldozers. Fire can be used separately or as an adjunct to the mechanical removal by tools and machinery.

Chemical control is as described above for eradication – but on a larger scale and often using different herbicides for different growth forms or even plant growth in different seasons. Plant hormones that can disrupt growth, flowering or seed production are also in use – especially where herbicide use is forbidden. Chemical control agents, especially systemic poisons, can be applied by "painting" cut surfaces of stems and woody parts or by drilling suitably slanting holes into tree trunks to ensure that the herbicide reaches the inner parts of the plant. Topical applications by hand sprayer or mechanized spraying machines can cover substantial areas with herbicide – while very large areas can be the subject of aerial spraying from agricultural crop-spraying small aircraft – provided that non-target plant species and water courses can be avoided.

Biological control (biocontrol) is by far the most sustainable and cost-effective form of invasion management because once established, it usually maintains its own population of biocontrol agents. The principle of biocontrol is that invasive alien plants that have been introduced to new areas or ecosystems ***arrive without their "natural enemies***" (insect herbivores, plant parasites, plant diseases, plant competitors) which keep their populations in check in their native environment. Native enemies are selected from the original (native) habitat of the

invasive plants and released in/on the invasions to control the invasive characteristics of the alien species. In principle, it is possible to introduce native enemies that can: reduce growth rates, affect structural parts of the plant, affect leaves and other green parts which photosynthesize and provide the plant with energy, reduce the uptake of nutrients by the plant roots, reduce or disable flowering, seed production or fruit production and generally remove the characteristics that enable the alien plant to compete with and dominate native species.

Some countries have used and are using effective biocontrol to manage most of the serious invasive species in their territories (e.g. Palmer *et al*., 2010) – and without negative impacts on native species of plants. Other countries are using biocontrol sparingly while some are reluctant to do so because of fears that the biocontrol agents will cause extinctions with native species. So far in the 100 or so years that biological control has been used, this form of native plant damage has not been recorded. Biological control is frequently used to manage crop weeds and other invasive plants of agriculture – but not all have sanctioned biological control of invasions affecting biodiversity.

Integrated control is employed where one technique or another does not reach some parts of an invasion or when the main methods are not effective everywhere or cannot physically reach all areas of the invasion.

All methods and programmes of invasion management or control need to be monitored for effectiveness and for decisions made when they are effective to continue or lessen the effort. Sometimes monitoring leads to changes in the methods used or introductions of updates with new forms of management.

4.6 Priorities for eradication and management of invasions in protected areas

Many PAs have priority areas for conservation action where particularly fragile habitats or endangered species are found. Clearly, these should be priorities for monitoring for alien species and any signs of invasions as well as eradication or management action if any are detected.

Another priority should be prevention or eradication or management of IAS considered as the most serious in a PA (such as *Chromolanea odorata* or *Lantana camara*) as these are likely to do the most damage and so their control will serve a wider purpose in the long-run. Another reason for this approach is that protected areas can provide a “protected nucleus” of invasive species which may then spread to surrounding areas well outside the PA boundaries and damage productive ecosystems (such as agriculture, livestock production, forestry, fisheries, aquaculture and development such as hydropower generation in rivers and urban “green

spaces"). This gives a new responsibility to the PA managers to consider the impacts of their own protection processes on neigbouring enterprises outside of conservation areas.

The areas surrounding PAs, even as far as 30 or 40 km distant or far upstream of a water system, also need to be checked for IAS and support given to their management. While "buffer zones" around PAs may help to filter the introduction of invasive species to a protected area, some species are capable of infesting a PA from quite some distance outside the boundary or buffer zone (Foxcroft, *et al*., 2011). Thus surveillance and monitoring should, if possible extend to likely areas of invasion outside a PA. Ultimately, however, priorities for action against potential biological invasion will rest with the park managers, park policies and priorities and the availability of funds.

Closed tropical rainforests will remain largely immune to invasion except at access roads and other openings which can provide pathways for invasion in that area and the natural edges of the forest. Such forest-associated open areas may have species of plants that valuable in themselves and may also be important to the PA fauna (e.g. the native Zingiberaceae species that are required food for Gorillas in Guinea Forests – section 1.4, example e,). Open forests, woodlands, grasslands and shrublands are the most susceptible so that pathways of invasions should be priorities for their attention and degraded areas within them are most suspect sites for initial entry and establishment by invading species.

4.7 Building IAS prevention into existing structures of PAs

The processes described above need to be part of the existing procedures of PA management for each separate protected area. If not already present, the general subject and the threats to conserved biodiversity should be introduced during the usual stakeholder discussions for the preparation of a Management Plan for the PA. This may need outside expertise and intervention – unless there is awareness and willingness that biological invasion is indeed an issue for management to prevent biodiversity loss. It was noted that most PA managers were indeed aware of the presence of IAS in or near their PAs; however, few, if any, had incorporated monitoring or management into the routines of PA management. IAS monitoring and management was rarely mentioned in those management plans that were available.

IAS monitoring might fit best as a regular task for PA routine patrols (as suggested above), especially if the staff on patrol have access to GPS and a digital camera. In addition, most PAs have a research group or encourage research within the PA and it is suggested that biological invasions become a requested research topic to better assist the management process and investigate impacts of invasions on specific elements of protected biodiversity.

Funding for monitoring could be part of the budget for management effectiveness until such time as a potentially serious invasion requires a risk assessment and then eradication or management procedures. At that time it is likely that most PAs will need outside assistance (technical and financial) – unless the national PA management authority has an invasive species unit. In Ghana there is a small unit for invasive species awareness and management in CSIR as well as knowledge and expertise in the environment agencies and the University in Accra. It is not clear if these organisations are available to PA managers when/if invasions need to be investigated and then controlled.

Some guidance on how invasive alien species in protected areas can be addressed is given by De Poorter *et al.*, 2007a and ways to include such issues in the process of Management Effectiveness are suggested by De Poorter *et al.*, 2007b. This may be a suitable entry point for invasion biology in PA management – although other areas could be primarily through research or in league with other national government agencies involved in IAS management – in Agriculture, Environment and Water Management. Interactions with regional bodies (especially ECOWAS) may be an advantage to acquire information about potentially invasive species spreading across West Africa.

Internationally available information about most species which have been alien and invasive in PAs is available from a number of websites – some with databases of species with their means of recognition, native and invasive range (by country), impacts on biodiversity (and often on productive ecosystems), pathways of introduction and invasion and methods of effective management. These are available on the internet with the most comprehensive being: the Global Invasive Species Database (www.issg.org/database), the CABI Invasive Species Compendium (www.cabi.org/isc), and the Global Invasive Species Information Network (www.gisin.org). There are more than 400 databases of invasive species and specialized IAS websites on the Internet – all of which are readily retrievable through the usual web search engines such as Google. These can provide general and specific information about all aspects of Invasion Biology and so can be valuable sources of information for invasive species issues in Protected Areas.

5. Conclusions

Following are some generalised conclusions from the information presented and discussed in the foregoing document and its annexes:-

- All of the Protected Areas sampled in this assessment had some interaction with actual or potential invasive alien (plant) species which are known (in some places) to have serious impacts on native biodiversity,
- PAs in some ecosystem types are more susceptible than others to invasion and its impacts – the most susceptible being the savannah areas,
- Native plant communities and species have differing susceptibilities to biological invasions but all may result in damage,
- Awareness of biological invasion and its impacts was generally present in PA management systems and some invasive species were known – however no systems for monitoring or managing invasive species were seen – indicating that invasion was not considered a serious threat (or that funds and procedures were not in place to support remedial action for invasions)[5],
- Utilization of invading species (by mainly local community and agricultural interests) was seen as a conflict and negative incentive for managing at least one serious invasive species (*Chromolaena odorata*) which was prevalent in the wetter PAs,
- If and when PA managements embrace invasive species monitoring and management, there will be need for a process of priority decision-making for action because it is likely that more and more invasive species will come to the PAs in region (due to increased visitation and development) and more invasive species that are already present will be detected,
- Steps to initiate and install invasive species monitoring and management are presented in detail for protected areas in this region of Africa.

[5] OR that these were not detected during our visits and discussions with PA managers

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GWH, November, 2012

Annexes to the Report: Invasive plants affecting Protected Areas of West Africa - management for reduction of risk for Biodiversity

ANNEX 1.Species of plants mentioned in the text

Many of these species were actually invading vegetation in the PAs sampled, while some of them were only present and known to be invasive in similar situations.One (no. 1, below) was mistaken for an invasive species because it was seen to damage vegetation. Details of each species are provided to give an idea of its presence in the PAs sampled and its likely impacts.

The species are listed in alphabetical order to enable quick reference – but not in order of importance, prevalence or level of impact.

1. *Acacia kamerunensis*
2. *Azadirachta indica*
3. *Broussonetia papyrifera*
4. *Calotropis procera*
5. *Canna indica*
6. *Cardiospermum halicacabum*
7. *Catharanthus roseus*
8. *Cecropia peltata*
9. *Cedrela odorata*
10. *Ceratophyllum demersum*
11. *Chromolaena odorata*
12. *Eichhornia crassipes*
13. *Gmelina arborea*
14. *Hyptis suavolens*
15. *Jatropha curcas*
16. *Jatropha gossypiifolia*
17. *Lantana camara*
18. *Leucaena leucocephala*
19. *Mimosa pigra*
20. *Pistia stratiotes*
21. *Ricinus communis*
22. *Senna hirsuta*
23. *Senna obtusifolia*
24. *Senna occidentalis*
25. *Senna siamea*
26. *Tectona grandis*
27. *Triumfetta sp.*

1.*Acacia kamurunensis* Climbing forest acacia Family Fabaceae,

Sub-Family Mimosoidea

A woody liane capable of climbing high into forest trees and developing a strong, wide and heavy stem; quite common in forested areas. This is not an invasive plant but has been labeled as such – it is indigenous in many areas of West Africa. When mature its weight can pull down adult trees thus making a space in even a closed forest which has given it a bad reputation as a destructive plant.However, this is a natural process which opens the closed forest and results in regeneration of forest species that can only germinate in open, sunny areas. The spiny stem (or trunk) can yield a soapy substance which is used for washing hands and clothes.

***Acacia kamerunensis*, mature stem leaves**

***Acacia kamerunensis*, spiny young stem &**

2. ***Azadirachta indica***Neem tree Family Meliaceae

This well-known and widely dispersed “wonder tree” from India was widely planted across Ghana and has, in some places, become very invasive in savannah and woodland situations.It was recorded as a shade/decorative tree at the gate of Nazinga Ranch, in Mole NP and at the Boabeng-Fiema Sanctuary

3. ***Broussonetia papyrifera***Paper mulberry Family Moraceae

Paper mulberry is a deciduous tree growing to 15 m high with characteristic deeply-lobed leaves and small red fruits. It has been planted as a forest boundary marker and a shade tree but has become invasive in some PAs, especially forest reserves in Ghana. It was mentionedinvasive in Mole NP by the Park Manager and recorded as dominating native vegetation in a prior visit to the Afram River Headwaters Forest Reserve (ARHFR) and known from other areas as invasive.

Characteristic leaf shape of *Broussonetia papyrifera* **_B. papyrifera_ invadingARHFR**

4. ***Calotropis procera*** Calotrope Family Apocynaceae

The calotrope is a dryland plant originally from Eastern Africa and the Arabian Peninsula which is now widespread in most dry areas of Africa and can be seriously invasive under some circumstances. It specializes in degraded areas – such as overgrazed pastures and abandoned farmlands. Its sap is unpalatable and said to be poisonous to some animals – but hungry goats will eat the smaller leaves. It was present throughout Burkina Faso, mostly in low density in the two PAs, but should be watched as it can dominate native vegetation and spread quickly.

Calotropis procera **occupyingabandoned farmland(in a dry area of Zimbabwe)**

5. ***Canna indica*** Indian Shot (because of its hard, round back seeds) Family Cannaceae

This herbaceous plant from tropical America is often planted as a decorative or garden species from where it can escape into wild lands and become invasive dominating and replacing native herbs, grasses and small shrubs.It has lush, pale green leaves and small red flowers (there are also orange and yellow-flowered forms) that can produce many viable seeds.In open ground it is usually no more than 1.5 m high but when it enters forest edges or woodlands it has the capacity to grow to as high as 4 m.

C. indica was present in the Boabeng-Fieme Monkey Sanctuary and outside the forest at the northern end of Kakum NP where it had begun to move towards the edges of the forest in clearings.The Kakum forest is too dense for any such herb to survive but it could compromise any clearings within the forest and compete with native edge vegetation.

6. ***Cardiospermum halicacabum*** Lesser balloon vine Family Sapindaceae

The lesser balloon vine (named for it's the shape of its fruits) is a delicate climber with white flowers and paper-like, almost hollow, hanging fruits.It is thought to have originated from tropical America but is now almost pan-tropical as a result of garden plantings and then escapes.It can be invasive in damp areas where it will cover native vegetation in savannahs, forest edges and river banks.

This species was recorded in Mole NP and, while not aggressively spreading, it has the potential to cover most vegetation up to several metres high.

C. halicacabum, **leaves, flowers, fruits**

C. halicacabum **covering native vegetation,Mole NP**

7. ***Catharanthus roseus*** Madagascar periwinkle Family Apocynaceae

C. roseus is a well-known, widely-planted herb from Madagascar with dark green shiny entire leaves and either pink or white flowers.It is planted around villages, homesteads, government buildings, etc., in mainland Africabecause it is brightly coloured and easy to propagate.It is also a medicinal herb with many applications.However it can escape from gardens and spread quite widely becoming invasive and replacing native plants.

C. roseus was present in gardens of tourist facilities in Nazinga Ranch in Burkina Faso and outside several other PAs.

White and pink flowers of *C. roseus*, Nazinga

8. ***Cecropia peltata***Trumpet tree Family Cecropiaceae

C. peltata comes from tropical America and is recognized by its large palmate leaves with seven or solobes and long petioles – its characteristic shape is illustrated here – from a gap in Ankasa N.P. dense forest.

This species will quickly establish in a break in the forest cover or along the edge of accessroads, tourist trails, etc.It is invasive in some West African countries and can dominate local shrubs and young trees and replace usual pioneer species that fill a sun-lit space; such gaps in the closed forest may appear after a tree falls or a storm disturbs the forest.

9. ***Cedrela odorata*** Cedro, Spanish cedar Family Meliaceae

C. odorata is native to tropical America where it is regarded as endangered, however it is found in plantations in various parts of Asia and Africa from some of which it has escaped and become invasive. It is a tall tree (up to 30m m high) with large pinnate leaves which can be 30 cm long.It has been planted in Ghana as a shade tree in "forest farming" and was recorded as invasive in the Afram River Headwaters Forest Reserve (in a previous visit); mature trees and many seedlings as illustrated below.

10.*Ceratophyllum demersum* Hornwort Family Ceratophyllaceae

Hornwort is a water plant that stays submerged just below the water surface and is not attached to any substrate.It can have long branching stems (up to 3 m) with many small filamentous leaves and originates from North America but is now considered pan-tropical having spread widely.

Hotnwort is a common freshwater plant in tropical wetlands in Africa and has been described as invasive when it becomes dense (especially in nutrient-rich waters) and excludes native water plants as well as blocking waterways.*C. demersum* was recorded in impoundments of the Sissi River system of Nazinga Ranch and may become invasive in some seasons.

11. ***Chromolaena odorata***Triffid weed, Acheampong Family Asteraceae

C. odorata is well-known in Ghana as a serious invader of wetter regions – particularly in agricultural areas but also in Protected Areas.It is a shrub or climber that can reach high (5 m)by growing on other vegetation and can completely dominate and eradicate the plants beneath. It can form a monoculture in other situations and become a dense shrubby plant replacing most other plants.It originates from tropical America and has heart-shaped dark green leaves and characteristic white or pale blue flowers which leave behind “fluffy” winged seeds which aid its dispersal.

It was recorded in almost all PAs in Ghana from Mole NP (small, new infestation), Bomfobiri, Kakum and Ankasa – although only present in areas where sunlight penetrates in the densely forested areas.

Characteristic mature seed bunches of *Chromolaena odorata*, Mole NP

12. ***Eichhornia crassipes***Water hyacinth Family Pontederiaceae

Water hyacinth is a floating aquatic plant from South America which has now infested most large water bodies in tropical Africa.It was mentioned as present during the wet season in Nazinga Ranch in the impoundments of the Sissili River.While it can be extremely invasive in confined waters, when in a river system the dense growths tend to be swept downstream and not form mats that are problematic.There is a small chance of serious impacts of water hyacinth in the wetlands of Nzinga,

13. ***Gmelina arborea***White teak Family Lamiaceae

G. arborea is a relatively tall tree (up to 30 m) with a spreading crown, pale green rounded leaves and many small red, brown or yellow flowers. Its origin is in tropical Asia and in Africa it has been quite widely planted as a woodlot species, windbreak and boundary marker for forestry and conservation reserves – as well as a shady street tree.It can, however, produce many fertile fruits with dispersed seeds that spread seedlings quite far from the parent tree.In this way it has escaped from plantations entered wild biodiversity and become invasive by replacing native trees.

Gmelina arborea was seen to be starting this process of escape and spread in Mole N.P.

Seedlings from *Gmelina arborea* speading from parent trees, Mole NP

14. ***Hyptis suaveolens*** Bush tea Family Lamiaceae

H. suaveolens is a weedy herb fromNorth America which is common as a weed of agriculture in tropical West Africa.It grows as tall as 1.5 m but is usually shorter and has dark green hairy leaves with a very strong aromatic aroma – reminiscent of mint.The small flowers are blue, purple or almost white and occur throughout the year but with a marked flowering in the wet seasons.

This herb is a familiar plant of roadsides and waste places and is recognized as a weed because it dominates and replaces other herbs and grasses of the same size.It may do some damage to native vegetation but is hardly considered as an important invader as it seems unable to penetrate native-dominated habitats.This plant is very common around the buildings, roads and waste places of Mole NP but is probably not a threat to biodiversity – unless it becomes more" aggressive" over time.

15. ***Jatropha curcas*** Family Euporbiaceae

This alien species from tropical America, usually referred to as “jatropha” is well-known and frequently found in villages and small settlements – often as a hedge.Most recently it has been used widely as a source of biofuels.However this species can become invasive under some circumstances and plants within or near PA boundaries should be monitored to check for any movement of seedlings into conservation areas (as near Mole NP).

The image shows seedlings of *J. curcas* spreading away from a hedge of that species

16. ***Jatropha gossypiifolia*** Family Euporbiaceae

This dryland species of *Jatropha* from tropical America is sometimes planted in villages as a hedge or a windbreak but can become invasive and replace native vegetation if it escapes to the wild.*J. gossypiifolia*is a shrub up to 2m high which has leaves which, initially, are green but which turn brown with age.It has small red flowers and green, poisonous fruits.This species was recorded often in the Sahelian zone and occasionally in the dryer savannah zones adjacent to PAs.

17. ***Lantana camara***“lantana” Family Verbenaceae

Lantana is a shrub/climber from tropical South America which was introduced to many parts of Africa in the late 1800s as an attractive multi-coloured flowering plant and as a suitable hedge plant for tropical Africa.It is still used as a decorative plant in some areas but has spread on its own to many places across the tropical parts of the continent and is quite prevalent in PAs as a seriously invasive plant.Not only does it produce allelopathic substances that prevent other plants from growing near it, but it can be a destructive climber that smothers tall shrubs and trees and can take forest wild-fires from the ground to the crown of trees causing great and lasting damage.

***Lantana camara* invasive in a PA (in Burundi)*Lantana camara* occupying a termite mound**

18. ***Leucaena leucocephala***"Leucaena" Family Fabaceae,

Subfamily Mimosoidea

Leucaena, from tropical America,is a large shrub or small tree with pale green finely pinnate leaves, cream-coloured flowers, reminiscent of Acacia flowers, and large brightly brown pods – which grow in dense groups and produce many seeds.

Leucaenawas introduced to Africa as an agoforestry species and a source of poles and firewood.It has since escaped from deliberate plantings and is gradually spreading wider and wider and invading fields, riverbanks, woodlands and even quite dense forests as an invasive species dominating and replacing native vegetation.

Leucaena was evident across the savannah areas of southern Burkina and northern Ghana and recorded in Boaben Faima Monkey Sanctuary and Mole National Park.

19. ***Mimosa pigra*** Giant sensitive plant Family Fabaceae,

SubFamily Mimosoidea

This spiny shrub has finely pinnate green leaves which fold up when touched or subjected to changes in temperature - hence its common name.*M. pigra* can grow as high as 4 m in ideal situations which are on the edges of wetlands and across floodplains.It has pink spherical flowers and pale green pods covered with hairs which dry to become dark brown and break into many segments (which are able to float) each containing a seed.

The origin of *M. pigra* is still uncertain although it is certainly native to tropical America.It has been in Africa for at least two centuries as an uncommon riparian shrub.However in the last thirty years it has become aggressively invasive in many damp areas and is known to complete dominate some wetlands and floodplains to the detriment of all other vegetation.It was not seen to be invasive in any of the visited PAs but was present in damp areas of both Nazinga Ranch and Mole NP – and should be watched for any signs of spread that could lead to invasion.

20. ***Pistia stratiotes*** Water lettuce, Nile cabbage Family Araceae

P. stratiotes is an alien floating plant from tropical America which is commonly invasive in African wetlands and quiet waters.It has a rosette of pale green leaves (which can be as large as 25 cm diameter).The tiny flowers are cream in colour and the plant has quite long rhizoids beneath the water which stabilize it as it floats and absorb nutrients from the water.

Water lettuce is quite widespread in lakes, dams, impoundments, slow stream and wetlands across tropical Africa and can be quite destructive – especially of submerged aquatic life – when plants are densely covering the water surface, denying light and oxygen to the water column.This can seriously affect aquatic biodiversity in general and fisheries in particular.

P. stratiotes was widespread in dams and wetlands in the savannah ecosystems and recorded in the impoundments of the Sisilli River in Nazinga Ranch

21. ***Ricinus communis***Castor Oil Plant Family Euphorbiaceae

R. communis is an annual herb or softly woody shrub/small tree originating from Eastern Africa (it is believed from ancient records) which behaves as if it is an alien species in becoming invasive in some situations.It has large 5-9-lobed leaves which are dark green or red in colour and a long petiole.Small reddish and cream coloured flowers are often present on a spike and give rise to fruits which have structures that look like beans which can produce usable lubricating oil.

This species is planted in some homesteads and small fields from where it spreads to roadsides, gutters and waste places.Here it may develop heavy infestations that can further disperse into and dominate native vegetation.The seeds are highly toxic and lethal with substances that keep the plant free from insect pests.

R. communis is quite common in Savannah areas and was clearly evident on the edges of Mole NP, in the Boabeng-Fiema Monkey Sanctuary and associated settlements.

24. ***Senna hirsuta***Hairy senna Family Fabaceae, SubFamily Fabales

Senna hirsuta is one of several annual or perennial herbs or small leguminous shrubs, originating in tropical America, which have spread widely in Africa and are often invasive.All have small yellow papilionate flowers, pinnate leaves and distinctive pods that are green when developing and then turn to brown and black upon maturity.*S. hirsuta* can grow to almost 2m in height and has leaves with 3-6 pairs of leaflets, the ones furthest from the stem are often larger than the others – all are pointed with "sharp" tips.Both the leaves and pods are covered with fine greyish-white hairs which give the plant a "hairy" appearance compared to other species of *Senna.*The pods grow upwards from the stem and bend outwards in a characteristic shape; old pods can remain on the plant for many months.

S. hirsuta was recorded around and near the HQ of Mole N.P. in apparently new infestations that are very likely to spread; this species was seen growing on roadsides in many parts of Ghana.

22. ***Senna obtusifolia***Sickle pod Family Fabaceae, SubFamily Fabales

This species of *Senna* is a relatively short-lived (up to two years) shrub distinguished by the rounded shape of its leaflets.Leaves are soft in texture and pale green usually with only three pairs of leaflets.The pods are at first green and grow upwards at a slight angle from the stem and then bend over towards the outside of the plant in an arc – which some say looks like a sickly – hence the common name.

S. obtusifolia was present around parts of the HQ at Mole N.P. and, like the previous and following species, was seen in many roadside and degraded land situations in Ghana.In any protected area it should be monitored in case it begins to spread and progress towards an invasive status.Such potential is possible in Mole NP as can be seen by the many new seedlings below the main plant illustrated.

23. ***Senna occidentalis***Coffee senna, Stinking weed Family Fabaceae, SubFamily Fabales

S. occidentalis (a shrub from tropical America) is widespread in the wetter parts of tropical Africa and is sometimes used as a source of herbal medicine and occasionally as a substitute for coffee – and sois protected in some homesteads and villagesThis species can grow to more than 2.5m in height and has reddish-coloured stems which can be quite woody at lower levels.Leaves are composed of 3 to 5 pairs of opposite leaflets which have pointed outer ends; the pods grow upwards and then turn inwards towards the stems – in contrast to those of the two previous species – they have notable division between the cells containing the seeds – giving a striated appearance.

S. occidentalis was recorded near the boundaries of Mole NP, near the Mole HQ and the northern part of Kakum NP as well as on roadsides, in farms and degraded areas: its potential of invasion means that it should be monitored wherever it is found in association with conservation of native flora.

***Senna occidentalis* invading an abandoned field near the northern part of Kakum N.P.**

25. ***Senna siamea***Cassia tree, Iron wood Family Fabaceae, SubFamily Fabales

Senna (formerly *Cassia*) *siamea*originates from South-East Asia and has been planted widely in tropical Africa as a garden and shade tree as well as a source of wood products such as building poles.It is renowned for its brilliant yellow flowers which, in some places, are present all-year round.It is often planted in PAs at entrance gates, vehicle parks and staff and tourist accommodation as a useful and attractive tree – but the risk of spread from these areas is significant as is the ability of this species to become invasive and compete with native vegetation – especially in savannah ecosystems.It was recorded in Nazinga Ranch and reported as possibly problematic in Mole NP.

26.***Tectona grandis*** Asian Teak Family Lamiaceae

T. gandis is a large deciduous tree from South Asia with very large leaves and sizable inflorescences with many white flowers.This species grows well and quickly in parts of tropical Africa and has been a component of production forests for many decades.The timber of Asian teak is of high quality and is a valuable export commodity for some African countries.However, unless a plantation is managed and the resulting seedlings cleared, this species can spread and establish “wildlings” (or wildings) which can establish new colonize and move further in an open of savannah situation to become invasive and dominate native vegetation. It was established, away from plantations, in Mole NP, Boabeng-Fiema Monkey Sanctuary and in Bomfobiri NP

Wildlings of *Tectona grandis* inside the entrance to Mole National Park

27**.Triumfetta**sp. Family Tiliaceae

Triumfetta is a genus of annual herbs that are well-known as weeds of agriculture. One species was recorded in Nazinga and Mole NP occupying the roadsides but beginning to enter the park vegetation. This herb grows to slightly over 1 m in height in and has pale green leaves with a toothed edge and a pointed tip. The flowers are found on long inflorescences and are yellow in colour; the fruits are woody, prickly spheres about 2 cm in diameter which seem to be produced in abundance. In both PAs the species concerned (believed to be *T. lepidota* in Burkina) were beginning to replace native vegetation.

ANNEX 2. An example of an awareness leaflet for an invasive species

Overleaf is an awareness leaflet for an invasive species (Water Hyacinth, *Eichhornia crassipes*) which is a problem in the Lake Tanganyika ecosystem.

It is designed to illustrate and describe the species concerned, its recognition, impact as an invasive species and the responsibility of the general public to prevent it spread and support, and its control and management. The same is also useful for scientists, non-scientists, interested people, PA staff and visitors to PAs such as tourists, to learn about invasion in general and this species in particular.

This awareness leaflet was prepared by an IUCN-UNDP-GEF project on invasive alien species in Lake Tanganyika (Burundi, DRC, Tanzania and Zambia).

Water Hyacinth, an Invasive Plant in the Lake Tanganyika Basin

What is an invasive species?

An invasive species is an animal or plant which is introduced into a new area where it does not occur naturally. If the introduction occurs without the accompaniment of its pests and diseases that keep the species in check (under control) in its natural range and if it is able to survive, establish and spread thus causing damage to biodiversity, peoples' livelihoods or development, it is called "invasive". Water hyacinth, sometimes called the World's Worst Water Weed, is becoming invasive in the Lake Tanganyika basin and on the shores and wetlands of some parts of the lake.

Water hyacinth (*Eichhornia crassipes*) is an exotic free-floating aquatic plant from the Amazon River basin in tropical South America. The dark green, shiny leaves have expanded hollow stems (petioles) that enhance its ability to float and can extend to 2 m above the water level. Below the water surface, there are root-like structures (rhizoids) which balance the plant and keep its aerial parts upright while taking up water and some nutrients. It reproduces through flowers and seeds (which can remain viable for up to 15 or more years) and has vegetative propagation by its stolons which are lateral extensions from the main plant which produce new plants which eventually leave the "mother plant".

Impacts of water hyacinth

- *Eichhornia crassipes* can form dense floating mats that cover large areas of water surface - thus excluding light, and air. This then affects animals (including fish) and plants that live and grow below the water surface; the area of a water hyacinth mat can double over several days when conditions of water and temperature are optimal;
- The floating water hyacinth mats can have serious mechanical impacts on water supply systems, drainage canals, inflows to hydropower turbines, movement of ships and river flows;
- Water hyacinth increases evapotranspiration well above that of open water (often over 3 times "open pan" evaporation) thus causing significant water loss to dams, reservoirs and wild waters;
- The crowding of plants at edges of water bodies can prevent people's access to the water for domestic use, fishing and transport, and can, at the same time, make the water unsuitable for human use;
- The mats provide habitats for intermediate hosts of human diseases such as bilharzia-carrying water snails and larvae and pupae of malaria-spreading mosquitoes;
- The floating plants and the mats they produce can also provide habitats for dangerous animals (snakes, crocodiles) and can support other aquatic plants that then form "floating islands" that can block water flows and damage machinery - such as hydropower turbines.

It's presence in the Lake Tanganyika ecosystem

Water hyacinth is present and invasive in wetlands and swampy shorelines around Bujumbura and other parts of the Burundi shoreline. This is a recent invasion which entered the lake in the late 1990s and has spread widely – to the detriment of other aquatic plants, fish, other aquatic animals and people. We do not have records of lake-side invasions in the other riparian countries of the lake (DRC, Tanzania and Zambia) but are aware that this water weed is present in other parts and catchments of all three countries – and in upland wetlands and lakes in Burundi as well as in Rwanda. *Eichhornia crassipes* is quite able to spread across the lake and establish in suitable sites – but does not seem to have done so – YET.

How does it spread?

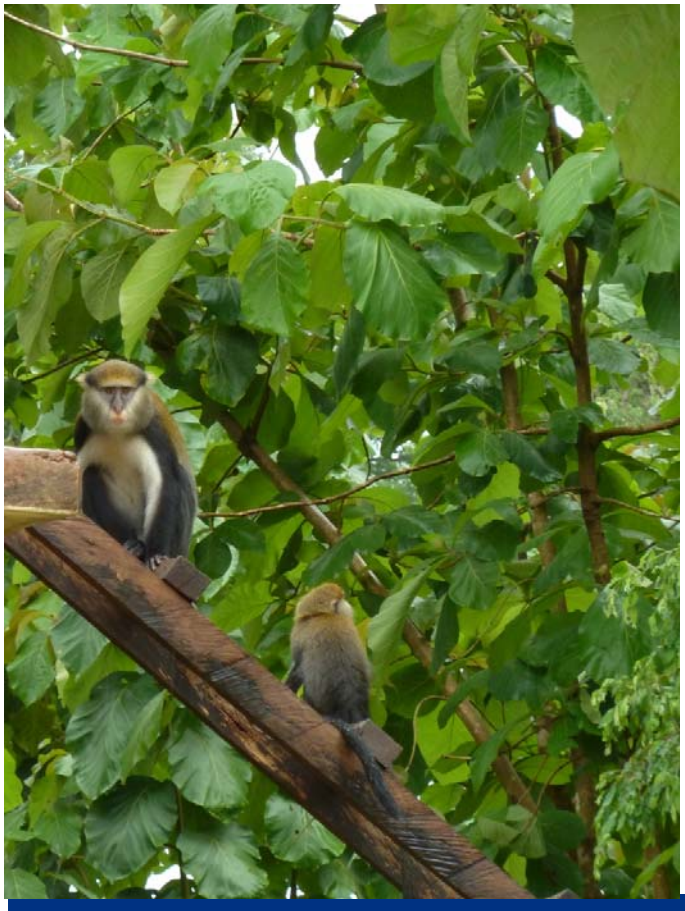
Water hyacinth came to the lake from infestations upstream in the Rusizi River and from "water gardens" where the plant was growing in cities and towns near the lake – where it was kept for its attractive foliage and beautiful flowers. Once it is established in a wetland or water body it can spread through wind propulsion of floating plants (or plant fragments), through water currents and on the feathers and feet of the numerous species of local and migratory waterbirds. In other countries in Africa it has been spread by people – as a green cover for dams and other water supplies; and as packaging for fresh fish on their way to far-off markets.

How can it be controlled?

- Mechanical control can be effective (in the short-term), using manpower and machines. However, this has to be repeated frequently because once the plants flower, seeds accumulate in the substrate and can then germinate from the seed bank – sometimes several times a year for many, many years;
- Herbicides have been used and can be effective, but there is always concern for effects on non-target aquatic biodiversity and peoples' use of the waters; and poisoning does not affect the seed bank which will replace the poisoned plants within months;
- Biological control is the most effective, affordable and self-sustaining means of management and some very effective agents (insects) have been used effectively in many large and small water bodies across Africa;
- Integrated control where two or more of the above methods are combined to manage the plant to reduce its impacts and stop its spread;
- Water hyacinth requires some dissolved nutrients in its waters to grow and spread. Thus effective control of water pollution from agricultural run-off, rural and urban drainage and insufficiently treated sewage should be maintained to ensure that if there is a first infestation, it is unable to grow into a significant water hyacinth invasion.

What is my role in controlling this invasive species and so retaining the benefits of Lake Tanganyika?

- Ensure that any effluents that are released into the lake or its tributaries are treated first to avoid providing nutrients to the water hyacinth plants;
- Discourage or ban the sale of water hyacinth plants for decoration and the sale of its flowers which can easily spread seeds and encourage private growing of the plants;
- After clearing the invading plants from urban areas, do not dispose of the debris on the river banks or lake shore because decomposition that follows will release nutrients that will then flow back into the water; also plant fragments from such clearing can regrow if they reach the water. If possible transport all waste from the clearance site and burn the debris elsewhere;
- If any new infestations are noticed, please inform the relevant authorities or LTA;
- It is inadvisable to make any economic use of cleared plants of water hyacinth as this is likely to give this plant economic value and so stop its control and management. If utilisation is desirable or congruent with current national policy then carry this out in drainage basins far from Lake Tanganyika.



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