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Status and trends of forests and tree pests and diseases in West and Central Africa

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Paul P. Bosu, PhD

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African Forest Forum
United Nations Avenue, Gigiri.
P.O. Box 30677-00100, Nairobi, Kenya
Tel: +254 20 722 4203
Fax: +254 20 722 4001
E-mail:exec.sec@afforum.org

www.afforum.org.
Twitter @ africanff.
Facebook / African Forest Forum.
LinkedIn / African Forest Forum (AFF).

Design & Layout: Conrad Mudibo, Ecomedia (mudibo@ecomedia.co.ke)

Cover photos (L-R), credit: *P.P. Bosu*: *Hypysipyla robusta* (Mahogany shoot borer) an endemic pest of native trees in the humid zone; *Cirina forda* outbreak on shea nut trees (*Vitellaria paradoxa*) observed in Bolgatanga, Ghana in August 2004; Evidence of mahogany shoot borer attack.

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Paul P. Bosu, PhD
(Principal Research Scientist, Entomology & Forest Health)
Deputy Director
CSIR-FORIG
Kumasi - Ghana

Acronyms

A/R	Afforestation and Reforestation
AFF	African Forest Forum
APSD	African Plantations for Sustainable Development
AU	African Union
BGC	Blue Gum Chalcid
CENAREST	Centre National de la Recherche Scientifique, Gabon
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CSIR	Council for Scientific and Industrial Research
ECCAS	Economic Community of Central African States
FAO	Food and Agriculture Organization
FHM	Forest Health Monitoring
FHS	Forest Health Surveillance
FISNA	Forest Invasive Species Network for Africa
FORIG	Forestry Research Institute of Ghana
FPS	Forest Pest Surveillance
IAPSC	Inter-African Phytosanitary Council
IPPC	International Plant Protection Convention
ISPM	International Standards for Phytosanitary Measures
LCB	Countries of the Lake Chad Basin
MOU	Memorandum of Understanding
NPPO	National Plant Protection Organization
REC	Regional Economic Community
RPPO	Regional Plant Protection Organization
SPS	WTO Agreement on the Application of Sanitary and Phytosanitary measures
WTO	World Trade Organization

Executive Summary

Forests and trees constitute a very important component of natural resources for countries in West and Central (W/C) Africa. The region also has one of the highest rates of deforestation and forest degradation in the world, largely due to illegal logging, slash and burn agriculture, wildfire and unsustainable mining practices. In W/C Africa, pest and disease problems are frequently underreported or unreported, and sometimes go unnoticed. In order to gain a better understanding of the occurrence and trends of forest and tree pests and diseases in the two regional blocks, the African Forest Forum (AFF) commissioned this study to evaluate the status and trends of forest and tree pests and diseases in the two sub regions and further, to develop mechanisms and actions for their management, including the drafting of a protocol for pests surveillance in the sub region.

Two main approaches were used to gather data for the study. First, a review of the literature on forest pests and diseases in the two sub regions was conducted. This was followed by visits to six countries, *viz.* Ghana, Nigeria, Niger, Senegal, Gabon and the Democratic Republic of Congo (DRC), to interview national experts (researchers, policymakers, forest managers and industrialists) for their views on pest and disease challenges in the sub region.

Forest and tree pest and disease problems in the W/C African sub-regions are generally sporadic, compared to the situation in other regions of the world. Insect or disease outbreaks spanning large forest areas, and killing several thousands or millions of trees as regularly reported from North America or Europe, are not common in the region. A few pest problems of ecological and economic significance are known. However, these are of little concern in naturally occurring forest stands, and their impact becomes significant only in plantations. As a result, the potential for these pests to cause problems is drastically reduced by simple avoidance of plantations of the host species. In the humid forest zones of W/C Africa, plantations of high-value timber species, such as iroko (*Milicia excelsa* and *Milicia regia*) attacked by the iroko gall bug *Phytolyma* spp., and mahogany (*Khaya* and *Entandrophragma* spp.) susceptible to the shoot borer *Hypsipyla robusta,* have been largely avoided for that reason. Although a few daring attempts have been made to establish plantations of some of these indigenous species, the outcome has not been encouraging, to say the least.

The story is not completely different in the Sahel zone. Insect pest occurrences are largely sporadic. Tree planting is limited, usually consisting of a few stands in the backyard or farm, or at best in the form of woodlots of often about one or few acres. The economic implications of losing some or all of these trees to pest often does not warrant control efforts. Throughout the Sahel zone, and also in some parts of the closed forest zone, termites are the leading cause of tree pest problems.

Termites usually attack individual or pockets of trees, often requiring urgent control actions to be undertaken. But at least there is one exception from the literature. In the mid-1980s, an outbreak of the oriental yellow scale insect, *Aonidiella orientalis* (Hemiptera:Diaspididae), affected millions of neem and other trees in at least four countries of the Lake Chad Basin, including Cameroon, Chad, Niger, and Nigeria.

The trends of forest pest and disease occurrence in the two sub regions are unclear. Except for a few cases, endemic pests and disease problems have persisted for a long time. However, a new trend seems to be emerging where exotic species planted widely in the sub region for their relative stability to pests and diseases now appear to be succumbing to attacks. Recent forest health surveys in Ghana, for example, revealed potentially serious stem canker infections on cedar (*Cedrela odorata*) and *Armillaria* root disease on teak (*Tectona grandis*). Also, cases of what appears to be symptoms of blue gum chalcid (*Leptocybe invasa*) attacks, which have caused serious problems on eucalypts in eastern and southern Africa, have been observed in the region. This trend can be quite worrying considering that some of the most devastating native pests of these widely planted exotic species have not yet arrived on the continent.

Implementation of forest pest surveillance measures will be crucial to the prevention of the introduction and spread of alien invasive pests and diseases in the sub region. Fortunately, all the countries in W/C Africa are parties to the International Plant Protection Convention (IPPC) and have National Plant Protection Organizations (NPPOs) mandated to implement the International Standards for Phytosanitary Measures (ISPM) and the World Trade Organization's Sanitary and Phytosanitary (SPS) Agreement. However, most countries focus on pests and diseases of agricultural importance. Modalities for the implementation of forest pest and disease surveillance in W/C Africa should include the harmonization of national policies and laws on phytosanitary measures, strengthening of institutional capacity and networking within member countries, development of human capacity, and awareness creation.

1.0 Introduction

Trees and forests constitute an inseparable component of the livelihood of the people in the W/C African sub regions. Forest-dwelling communities, as well as those living further away from forests, have depended directly or indirectly on forests for centuries. Globally, utilization of tropical forest resources has generally been described as unsustainable, resulting in serious declines in forest area. According to FAO, deforestation rates in tropical Africa are among the highest in the world (FAO, 2010). Major causes of deforestation on the continent include slash and burn agriculture, unsustainable logging practices, illegal mining and urbanization. Sustainable forest management (SFM) practices include the application of good silvicultural techniques to utilization of existing forests, as well as the planting and tending of trees to improve forest cover, often described as afforestation and reforestation.

There is currently a high level of interest in many African countries towards afforestation/reforestation (A/R) and restoration initiatives. However, there are several challenges to successful A/R operations on the continent, among which are the impact of pests and diseases. Consequently, measures to protect forests from pests and diseases should be an integral part of forest management programmes. Current global trends, especially climate change and increased trade among nations, have affected the dynamics and spread of pests and diseases across the world (FAO, 2011). Effective management of pests and diseases requires reliable information on the biology and ecology of the pests, as well as their impacts on forest ecosystems and possible methods of control.

1.1 IMPACT OF CLIMATE CHANGE ON FOREST PESTS AND DISEASES

Several climate change models estimate that Africa will perhaps be the worst affected by the consequences of climate change (IPPC, 2007). The continent is now warmer by between 0.1–0.3°C than the averages of the 1960s. Inter-annual variability in rainfall has decreased by between 20-40% across the region. However, certain areas, such as the Guinea coast, have seen increases of up to 30% of rainfall in the last 30 years. Deforestation remains a major challenge in many African countries and tree plantation development has been intensified throughout the continent. To minimize the effects of pests and diseases in plantations, most African countries have resorted to planting apparently “safe” exotic species to the neglect of perhaps more valuable and sustainable indigenous species.

Teak (*Tectona grandis*). Credit: Forest & Kim Starr, CC BY 3.0

Today, exotic species, such as eucalypts, pines and teak, dominate plantation forests in Africa, but there are strong signals that the 'immunity' of exotic species to pests and diseases is gradually breaking down. In Ghana, for example, popular plantation species like teak (*Tectona grandis*) and cedar (*Cedrela odorata*) which have been widely planted because of their resilience to pests and diseases appear to be succumbing to attacks.

Pest and disease surveillance systems provide a mechanism to protect forests (natural, plantations, and other managed forests) through early detection of incursions followed by the appropriate management interventions, if required. The underlying principle is that early detection of a pest or disease problem allows more scope for its management. However, the capacity and experience to undertake surveillance on the continent is limited and the step taken by the African Forest Forum is timely.

2.0 Objectives of the Study

The objective of the consultancy was to conduct an in-depth study to evaluate the status and trends of forest and tree pest and disease management in the W/C African regions with the view to proposing appropriate control measures, including development of protocols for pest and disease surveillance.

The specific tasks undertaken were to:

1. Make an inventory of forest and tree pests and diseases in the sub-region including current trends and drivers;
2. Review the impact of the identified pests and diseases on forest production and products at all levels (farm, natural and plantation forests, and trans-boundary forest areas) and their economic implications including gender considerations;
3. Assess and propose modalities (including policies, laws and institutional capacity) for facilitating the development of mechanisms and actions for surveillance of forest and tree pest and disease prevalence, including trans-boundary dimensions; and,
4. Develop appropriate protocols for the surveillance of pests and diseases and recommend ways for their implementation at national and regional levels.

Close up of the cedar (*Cedrela odorata*) trunk. Credit: Dick Culbert from Gibsons, B.C., Canada - 3.mel.cedrela.bark, CC BY 2.0

3.0 Study Methodology

Two main approaches were used to gather data for the study. First, a review of the literature on forest pests and diseases in the W/C African sub-regions was conducted. Published literature, which included refereed journal articles, technical reports, bulletins, books and various reports mainly from internet sources, were reviewed. Information obtained was summarized by country, region, forest zone and type, and pest and disease category.

The second phase of information/data gathering involved field visits to six selected countries in the sub-regions to interview relevant experts (researchers, policymakers, managers and industrialists) for firsthand information on past and/or current pest and disease challenges in those countries and regions. Four countries in West Africa (Ghana, Nigeria, Niger and Senegal) and two in Central Africa (Gabon and DRC) were selected and visited (Fig 1). In each country, one-to-one interviews were conducted with the identified experts using open-ended questionnaires.

In addition, field trips to natural forest stands or plantation estates were undertaken to observe past or current forest pest/disease outbreaks in those countries. Key information sought during the survey were: Existing and/or past forest pest and disease problems; impact of pests on forest management, including other environmental and socioeconomic effects; existing policies and laws on forest health and protection in the country; forest health surveillance programmes; and capacity to implement forest pest and disease management in the country. A total of 34 national experts of relevant expertise and backgrounds were interviewed in the six countries visited. Seven forest plantation estates and one natural forest stand were visited (Table 1, see also Appendix 1).

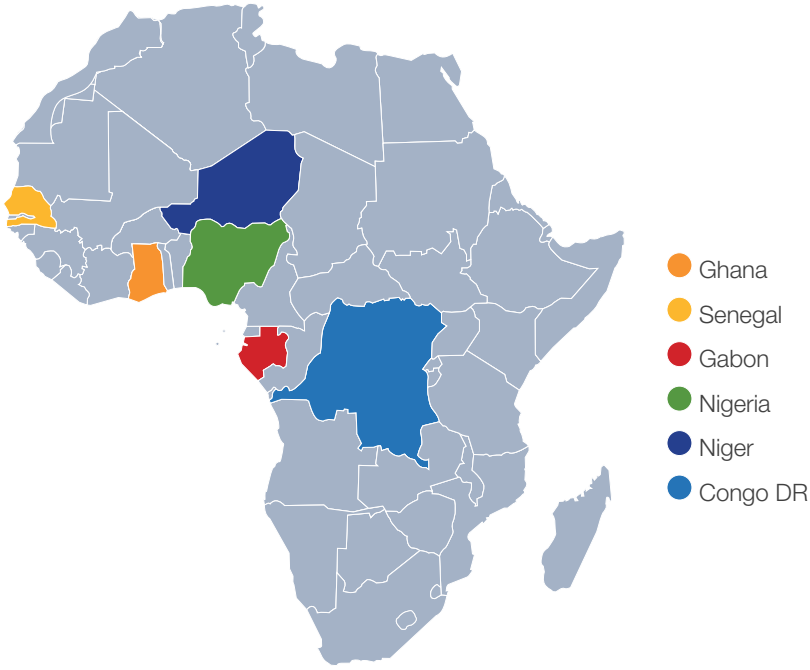

Fig 1. Map of Africa showing countries in West and Central Africa visited.

Table 1. Countries, No. of experts consulted and forest sites visited during the field survey.

Country	No. Experts Consulted	Forest Site/Plantation Estate Visited	Location of Forest/ Plantation
Ghana	8	• APSD Plantation Estate • FORM Ghana Plantation Estate	Kwame Danso Akumadan
Senegal	7	• City Forest • Casuarina plantation along the beach of Dakar	Dakar Dakar
Gabon	6	• CENAREST Research Forest	Libreville
Nigeria	5	• Bisrod Furniture Company (Forest Demonstration Center)	Ijebu-Ode, Ogun State
Niger	4	• Alhaji Eucalyptus Plantation	
Congo DR	4	• South Kwamouth REDD+ Agroforestry Pilot Project	South Kwamouth

4.0 Key results

4.1 FOREST AND TREE PESTS AND DISEASES IN THE SUB REGIONS INCLUDING CURRENT TRENDS AND DRIVERS

The results presented include information obtained from the review of literature as well as those obtained from interviewing the national experts. For clarity, the information has been discussed under three subheadings, *viz.* insect pests, diseases and other pests. A review of the literature indicated that a large number of insect pests and diseases of trees and forests have been observed in the two sub-regions, especially in West Africa (Appendix 2 and 3). Pest outbreaks are largely sporadic in nature with the most serious problems often encountered in planted forests.

4.1.1 Insect Pests

Endemic pests of trees and forests in the humid zone

In humid tropical forest areas, where there is high species diversity, outbreaks of pests and diseases rarely occur in natural stands. These insects and pathogens may be present and may damage or kill a few trees, but they never reach outbreak status. Most of these potentially serious insects and pathogens have been known for decades, but as long as the host species have not been planted in large scale plantations there has not been cause for concern in those countries. Indigenous tree species with endemic pest problems in the humid forest zone include Iroko (*Milicia excelsa* and *M. regia*), African mahogany (*Entandrophragma* and *Khaya* spp.), Afrormosia (*Pericopsis elata*), obeche (*Triplochiton scleroxylon*), opepe (*Nauclea diderrichii*) and *Terminalia ivorensis* (Table 2 below). Endemic pest problems of these high-value timber species generally account for the persistent failure of indigenous species plantations in the sub-region.

Iroko suffers severe attacks from the Iroko gall maker *Phytolyma* spp. (throughout the region and beyond, to as far as Tanzania and parts of East Africa (Wagner, *et. al*., 2008). *P. lata* attacks *Milicia* in Ghana and westward through Cote d'Ivoire to Senegal. Other species of *Phytolyma*, namely *P. fusca* and *P. tuberculata* attack *M. regia* in Ghana, and eastward through Togo, Nigeria, Cameroon, all the way to Tanzania. All life stages of the tree are attacked; however, seedlings and actively growing saplings in young plantations are mostly affected, often resulting in 100% failure. Another pest of serious regional and global significance is the mahogany shoot borer, *Hypsypyla robusta.* It attacks species of the *Meliaceae* family in Africa, especially African mahogany (*Khaya* and *Entandrophragma*). Planting of mahogany is a major challenge in Ghana, Nigeria, Cameroon, Togo and Cote d'Ivoire. Shoot

borer attack on mahogany often results in damage and deformation and sometimes death of plants at the nursery and young plantations. Other endemic pests of considerable importance include *Lamprosema lateritialis* on *Pericopsis elata (*Afrormosia), *Orygmophora mediofoveata* on *Nauclea diderrichii* (Opepe/Kusia), and *Anafe venata*, on *Triplochiton scleroxylon* (Obeche/Wawa).

The insects discussed above usually occur on host trees in natural forest stands. However, their presence is hardly noticeable and impact on tree survival and growth is almost insignificant. As a result, insect pest outbreaks are rare in natural forest stands in the humid/closed forest zone. However, from the literature, at least one major pest outbreak has been recorded in a natural forest stand in the humid forest zone (Sidibe, 2009). In late 2009 to 2010, an outbreak of *Achaea catacoloides* (Lepidoptera:Erebidae) occurred in the western African countries of Liberia, Sierra Leone and Guinea, with devastating environmental and socioeconomic effects on forests and agricultural lands.

Table 2. Some major insect pests of indigenous trees in the humid forest zone of West and Central Africa (Source: Wagner *et al*., 2008).

Insect pest species	Order: Family	Countries of occurrence	Host species	Feeding habit
Analeptes trifasciata	Coleoptera: Cerambycidae	Ghana, Nigeria, Sierra Leone, Benin, Côte d'Ivoire	*Ceiba pentandra, Tectona grandis, Bombax costatum, Eucalyptus alba, E. territicornis, Adansonia digitata, Anacardium occidentalis, etc*	Stem borer, mainly in the savannah zone and dry forest
Apate monachus	Coleoptera: Bostrichidae	Ghana	*Azadirachta indica, Terminalia ivorensis, Antiaris africana,* various other species	Stem borer
Apate terebrans	Coleoptera: Bostrichidae	Ghana	*Tectona grandis, Terminalia ivorensis, Cedrela odorata, T. scleroxylon, Eucalyptus* spp*., Khaya senegalensis,* various other species	Stem borer
Diclidophlebia eastopi	Homoptera: Psyllidae	Nigeria, Ghana, Côte d'Ivoire	*Triplochiton scleroxylon*	Sap feeder

Insect pest species	Order: Family	Countries of occurrence	Host species	Feeding habit
Hypsipyla robusta	Lepidoptera: Psyllidae	Ghana, Nigeria, Togo, Côte d'Ivoire, Cameroon	*Khaya ivorensis, K. anthotheca, K. grandifoliola, K. senegalensis, Entandrophragma utile, Eucalyptus cylindricum*	Shoot borer, also bores into fruits and seeds
Lamprosema lateritialis	Lepidoptera: Pyralidae	Ghana	*Pericopsis elata*	Defoliator, leaf roller
Orygmophora mediofoveata	Lepidoptera: Noctuidae	Ghana, Nigeria, Togo	*Nauclea diderrichii*	Shoot borer
Phytolyma lata	Homoptera: Psyllidae	Ghana, Sierra Leone, Liberia, Côte d'Ivoire,	*Milicia regia*	Gall maker
Phytolyma fusca	Homoptera: Psyllidae	Ghana, Nigeria, Togo, Cameroon	*Milicia excelsa*	Gall maker

Major Insect Pests of Exotic Species in the Humid Forest Zone

In addition to the problems encountered on indigenous species, introduced or exotic species, such as *Gmelina arborea*, *Cedrela odorata*, *Tectona grandis* and various species of *Eucalyptus,* which are widely planted in the sub-region, often succumb to insect pest attacks. In the humid forest zone, *G. arborea* suffer severely from attack by *Achaea* and *Apophylia* species which record show resulted in significant damage in Nigeria in the past (Loupe *et al*., 2008). Teak (*Tectona grandis*) and Cedrela (*Cedrela odorata*) are perhaps the most commonly planted species in the humid zone of West Africa, widely planted in Ghana, Togo, Nigeria and Côte d'Ivoire. These two species do not have many problems with insect pests, except for sporadic attacks by some generalist insects. In Ghana, outbreaks of the wood borer *Apate terebrans,* during the dry season are of some concern to tree growers. Several such outbreaks were reported during 2004 and 2005. However, no significant economic damage was recorded. The attack is characterized by multiple boring of the stem, reducing the quality of the pole or wood. In heavy infestations, a few trees may be killed. In young plantations, defoliation by the variegated grasshopper *Zonocerus variegatus* can be very visible in plantations in the forest zone; however, attacks appear to have very little impact on plant growth as the trees usually recover over time. *Cedrela* also suffers attacks from another species of *Apate* (*A. monachus*) and other bark borers, especially when the trees are under stress. But, unlike teak, *Cedrela* often responds to borer attack by exuding sap which pushes out the invading insects, often killing them. This has been observed in various plantations in Ghana, e.g. the Afram Headwaters, Anhwiaso South and Worobong South forest reserves.

Major Insect Pests of the Savanna and Sahel Zones

Pests and disease problems in the forest zone are generally different from those in the dry forest region (savannah and Sahel zones). However, like the forest zone incidence of pests in the woodlands are not common, except for the routine outbreak of the desert locust (*Shistocerca gregaria*) in the Sahel zone that, although it is a major problem on agricultural crops, also affects some trees. Common tree species in the savannah region often planted for shade include neem (*Azadirachta indica*), *Terminalia mantaly, T. catappa* and *Eucalyptus* spp. Nearly all of these are commonly planted in towns and cities in the humid zone. *T. mantaly* grows very vigorously, with nearly evergreen leaves and beautifully spreading canopy, and is often the tree of choice in most cities for shade and avenue planting. Together with its relative *T. catappa*, these two species rarely suffer attacks from pests and diseases except for occasional infestation by generalist stem and bark borers. In instances where trees are located in ceremonial streets or compounds, damage inflicted by borers become conspicuous and makes the trees unattractive. These may necessitate prompt pest control intervention or outright removal.

The most serious recent tree pest problem in the Sahel region is the outbreak of the oriental yellow scale insect *Aonidiella orientalis* on neem (*Azadirachta indica*). The outbreak was particularly serious in countries within the so-called Lake Chad Basin, which includes Cameroon, Chad, Niger and Nigeria (Lale, 1988). The emergence of this insect in Africa is a classic example of an introduced invasive pest with serious consequences. It is believed to have originated from India, South East Asia or China, and was first recorded in the northern part of Cameroon in 1985. A few years later, its distribution covered over one million km^2, causing significant damage to neem trees. In Niger and several other countries in the Sahel region where neem is very important, the impact of the scale insect was quite significant. Attack is followed by premature browning which frequently leads to death of leaves on some or all of the branches of the affected tree. Old trees - 10-15 years or older - are more susceptible to attack than younger trees. As a result of serious management efforts in the 1990s the neem scale insect problem is now under control.

Various species of *Eucalyptus* are widely planted in the sub-region, e.g. *E. camaldulensis, E. territicornis* and *E. alba*. The objectives for planting include pulp, poles, amenity or wood fuel. Worldwide, *Eucalyptus* spp. are highly susceptible to pests and diseases, and in Africa the blue gum chalcid (BGC) *Leptocybe invasa* is causing significant havoc in eastern and southern Africa. During the field survey in Niger and Senegal, leaf galls characteristic of BGC attacks were observed on saplings of eucalypts in plantations. In Senegal, the observation was made in a small plot of *Eucalyptus* located within the city of Dakar. In Niger, the observation was made on saplings in an 80 ha plantation established in a town north of Niamey. In Ghana, BGC attack has been reported in a plantation at Kwame Danso, in the Forest-Savannah Transition zone (Plate 1).

In Senegal, it was reported that a filao worm (*Thyridopterix* sp.) outbreak was recorded in 2011 on a plantation of *Casuarina* established along the beach between Dakar and St. Louis (El Hadji Omar Dieng, DPV Dakar, pers. comm.). The attack affected over 1 100 ha of trees and was halted by the application of a broad spectrum insecticide. Again in Senegal, authorities are battling with pest problems on *Acacia senegal* established as part of the Great Green Wall project. According to Colonel Papa Sarr, Technical Director of the Project in Senegal, tree mortality of 2-3% was recorded in the plantation areas in 2015. Though no formal assessment has been carried out, it is believed to have been caused by termites. An expert at the University of Dakar has indicated that termite-related tree mortality has assumed serious dimensions in Senegal in recent years, affecting species of *Eucalyptus*, *Casuarina*, *Balanites, Acacia*, and several other planted trees. He believes that the increased rate of infestation is not the result of climate change, but rather to increased tree planting and awareness, as the problem has always been there (Dr. Abdnilaye Ndiaye, pers. comm.).

Plate 1. *Left:* Suspected blue gum chalcid, *Leptocybe invasa*, galls on young *Eucalyptus* plants in Niger. *Right:* Vigorously growing *Cedrela odorata* pushes stem borer following attack (Photos by *P.P. Bosu*).

4.1.2 Diseases of Trees and Forests in the Sub-region

Diseases affecting trees and forests in W/C Africa include soil-borne diseases, dieback, canker, rots and rusts. Like insect pests attacks, tree diseases are also more prevalent in plantations than in natural forests or woodlands (Appendix 2).

Damping-off in the nursery is common throughout the sub-region whenever the conditions permit. From the literature, root diseases, decline and dieback are the major tree and forest diseases in the sub-region. Among these, dieback of *Ceiba pentandra*, *Terminalia ivorensis*, *Gmelina arborea* and *Casuarina equisetifolia,* and a few others, have caused considerable havoc to plantations in West Africa (Apetorgbor and Roux, 2015; Agyeman and Safo, 1997; FAO, 1994) (Table 3). Also, host plant dieback, associated with attack by the insects *Phytolyma* spp. and *O. mediofoveata,*

have been recorded on *Milicia* spp. and *Nauclea diderrichii*, respectively (Table 3). Root diseases and cankers are gradually becoming a serious concern in plantation forests in the sub-region, especially in Ghana (Plate 2).

Of the major tree diseases, dieback of *Terminalia ivorensis*, *Gmelina arborea* and decline of *Azadirachta indica* were recorded between 1970 and 1990. The occurrence of dieback on *Terminalia ivorensis* in Ghana and Côte d'Ivoire during the early 1970s was a major setback to the progress of forest plantation development in the sub-region. Dieback was observed at the time when *T. ivorensis* was gaining popularity as a candidate for establishing indigenous species plantations. Plantations aged 10-20 years were mostly affected, with very high mortalities. Symptoms of attack include branch dieback beginning at the crown apex, chlorotic and wilting foliage, crown thinning and sapwood staining. In Ghana, the imperfect stage of *Endothia* sp. has been associated with the high mortality recorded (Ofosu-Asiedu and Canon, 1976). However, no biotic agents were clearly linked to the disease and the infection has been more associated with environmental and nutritional stresses. Fortunately, the other *Terminalia* species, *T. superba,* is not affected and is now widely planted in West Africa.

Dieback of *Ceiba pentandra* is another disease with major impact on the regeneration of the species. It was first observed in Ghana in experimental trials at the Bobiri Forest Reserve in 1996 and is not yet reported in other countries of the sub-region. Unlike the *T. ivorensis* dieback, *Ceiba* dieback affects hosts at the nursery stage and can cause significant damage to seedlings, and can persist throughout the growing stage. Without proper care and maintenance the likelihood of recording a 100% mortality of the seedlings at the nursery stage is quite high. However, infected plants two years old and above often recover from the attack, which occurs during the wet season. *Fusarium* sp. and *Lasiodiplodia theobromae* have been associated with the disease (Apetorgbor *et al*., 2003).

Another species which is susceptible to dieback is *Gmelina arborea*. It is a fast growing species introduced to some West African countries with the aim of producing wood for pulp and paper. Over time, many of the plantations established in Ghana, Nigeria and Sierra Leone suffered from dieback. In Ghana, dieback was prevalent in the 15 000 ha Subri Industrial Plantation at Daboase in the Western Region. The cause was not determined but it was believed that regional droughts and changes in water tables were possible causes, with the disease condition complicated in some cases by the activity of weak pathogens. In Sierra Leone, dieback incidence was very high with infection rates of up to 40% in plantations, while in Côte d'Ivoire and Nigeria, *Armillaria mellea, Chaetophoma* sp., *Polyporus* sp. and *Thanatephorus cucumeris* have been reported as fungal pathogens (Gbadegesin *et*. *al*., 1999).

Table 3. Major diseases of trees and forests in W/C Africa (see also Appendix 3).

Host tree	Disease type	Causal pathogen (s) or Predisposing factors	Countries of occurrence	Host species Indigenous or Introduced
Azadirachta indica	Decline	No pathogen associated with decline. Caused by environmental/ nutritional stresses	Cameroon, Chad, Mali, Niger, Nigeria	Introduced
Casuarina equisetifolia	Dieback	Associated with soil nutrition limitations	Benin	Introduced
Cedrela odorata	Stem canker	*Armillaria* sp.	Ghana	Introduced
Ceiba pentandra	Dieback	*Fusarium solani*, *Lasiodiplodia theobromae, Colletotrichum capsici*	Ghana	Indigenous
Gmelina arborea	Dieback and root diseases	*Gibberella fujikuroi, Sclerotium rolfsii, Armillaria mellea, Chaetophoma* spp., *Polyporus* sp., *Thanatephorus cucumeris.*	Ghana, Côte d'Ivoire, Nigeria	Introduced
Terminalia ivorensis	Dieback	No pathogen associated with dieback. Caused by environmental/ nutritional stresses	Ghana, Côte d'Ivoire	Indigenous
Tectona grandis	Root disease	*Armillaria* spp., *Phellinus noxius, Phaeolus manihotis, Ganoderma* spp. and *Rigidoporus lignosus*.	Ghana, Nigeria, Côte d'Ivoire, Benin	Introduced

In addition to outbreaks of the neem scale insect in the Lake Chad Basin (LCB) during the mid-1980s, symptoms of decline were also reported, first in Niger and subsequently in the other countries of the LCB. Although the symptoms of the decline were initially confused with the scale insect outbreak, critical analyses later found it to be different. According to Boa (1992), the most conspicuous symptom of *Azadirahta indica* decline is the loss of older foliage. The foliage loss gives the normally dense crowns an open appearance with clumps of foliage occurring at the branch apices. In advanced cases, only a small tuft of foliage remains at the branch tip, a condition described as 'giraffe neck'. Similar to the *Terminalia* and *Gmelina* dieback described above, also neem decline has not been clearly associated with any biotic agents. Although several fungi, e.g. *Nigrospora sphaerica* and *Curvularia eragrostidis,* have been recovered from neem with symptoms of decline, they have been shown to be secondary pathogens.

Teak and *Cedrela* are two introduced species which have been grown extensively in the sub-region without major concern for pest and disease problems. However, a survey of plantations has shown signs of disease infections with potentially serious consequences observed in Ghana (Bosu *et al*., 2015; Bosu and Apetorgbor, 2009). In 2006, *Armillaria* root rot was observed on teak and cedrela plantations located within the Kwamisa, Tano Nimiri, and Mamiri reserves in the Moist Forest zone (Apetorgbor *et al*., 2013). In several other places, including Anwhiaso, Worobong South, and Afram Headwaters forest reserves, stem canker of *Cedrela odorata* have been observed. At the Anwhiaso Forest Reserve, where the disease was first reported from a 16 hectare plantation, spread of the disease was halted with sanitation thinning and selective application of fungicides on infected trees. Consistent monitoring of pests and diseases in plantations of teak and cedrela will be needed to ensure the success of plantation development in the subregion.

4.1.3 Other Pests

The impacts of invasive plants, which are often introduced, have become quite significant in forested and woodland ecosystems in recent years and are likely to continue into the future. Also, the effect of snail (mollusc) pests in nurseries and newly established plantations appear to be gaining ground in the subregion lately. A discussion of forest pests and diseases in W/C Africa would be incomplete without at least a brief mention of this category of pests.

4.1.4 Invasive Plants

Invasive plants do not directly attack trees but their presence can result in considerable setback to forest or woodland ecosystems as they compete with native or resident trees for essential habitat resources such as light, water and nutrients. Commonly known invasive species in the sub-region include *Chromolaena odorata*, *Lantana camara*, *Prosopis* spp. and *Broussonetia papyrifera* (Bosu *et al.*, 2009).

A.

B.

C.

D.

Plate 2. A. Stem canker on *Cedrela odorata*. B. *Cedrela odorata* stem canker in advanced stage. C. Suspected *Armillaria* root disease of *Tectona grandis* in Ghana. D. Root disease of *T. grandis* in Ghana caused by poor site conditions. (Photos by *P.P. Bosu*).

4.1.5 Molluscs or Snail Pests

At the Bisrop Plantation Estate in Nigeria, it was reported that a serious outbreak of a snail pest was experienced in a *Cedrela odorata* plantation, resulting in a 100% mortality of the saplings. According to the plantation manager, the snails first consumed the leaves on the seedlings and saplings and afterwards attacked the young stems rasping off the bark, ultimately killing the plants. A second round of

planting resulted in repeated attacks causing the plantation manager to abandon the planting of *Cedrela*. Somehow, a fire which was set to remove slash from the field and cleanse it for another planting project succeeded in killing nearly all the snails. Following that, the few *C. odorata* that survived the fire re-sprouted and grew without any further damage. In Ghana, FORM Ghana Plantation Estate reported serious problems of snail defoliation of *Khaya ivorensis* seedlings at the nursery, leading to considerable cost to control (Plate 3). Snail pest attack on *K. ivorensis* seedlings has also been reported from the nursery of the Samartex Timber Company at Samreboi, in the Western Region of Ghana.

Plate 3. *Left*: Species of snail that damage *Khaya ivorensis* seedlings at the nursery of the FORM Ghana Plantation Estate, Akumadan (Photo by *M.M. Apetorgbor*). *Right:* Seedlings of *K. ivorensis* defoliated by snails. (Photo by *L. Amissah*).

4.2 IMPACT OF FOREST AND TREE PESTS AND DISEASES IN THE SUB-REGION

The impact of pests and diseases on forests and trees in the sub-region include partial to total damage or death of seedlings at the nursery, and/or of saplings or young trees during the early stages of plantation establishment. Unlike in Europe and North America, where thousands or sometimes millions of hectares of forests come under severe insect pest and disease attacks, such phenomena are quite rare in tropical Africa. This is largely due to the high diversity of forest stands which reduces susceptibility to attack, and the fact that plantation forestry is not well developed in the region. The impact of pests and diseases is often hardly noticeable if present in naturally occurring forest stands. However, on a few occasions, outbreaks in natural stands have had a significant impact on forests with corresponding socioeconomic impacts on local communities. The outbreak of *A. catacoloides* in West Africa 2009 is a good example. Otherwise, major effects of forest and tree pests and disease in the subregion have been on planted forests.

One of the most significant effects of forest/tree pests and diseases in the sub-region is the failure of plantations of most indigenous species, and the resultant high

interest in exotic species plantations. Throughout most of the humid zone, attempts to establish plantations of valuable hardwood timbers have failed, largely due to endemic pest and disease problems. For example, in spite of huge investments and research efforts over the past two decades to restore the declining fortunes of Iroko (*Milicia excelsa* and *Milicia regia*) as a major export timber in the region this has not been realized. Stakeholders are still apprehensive of investing in plantations of Iroko because of uncertainties and huge costs that may be associated with managing endemic pests and diseases. Similar cases can be made for species of African mahogany and *Terminalia*.

Normally, diseases and pests of trees and forests have had most impact on indigenous species in the humid forest zone. However, exotic species which were hitherto considered somewhat "immune" are increasingly becoming vulnerable to pest outbreaks for several reasons. Firstly, increased international trade has been proven to be responsible for the spread of major invasive species around the world, and some have found their way to Africa. Accidental introduction of native pests and pathogens of introduced species often result in outbreaks, as was the case for the oriental yellow scale insect on neem.

Second, widespread planting of certain exotic species often increases the likelihood of native pests adapting to them. Generalist or polyphagous pests often overcome the physiological barriers of trees, especially during extreme environmental conditions that stress the trees. Under such conditions, trees become vulnerable and serious damage or mortalities can occur. Such occurrences are becoming frequent in Ghana, especially with respect to disease incidence on teak, which is currently the most widely planted timber species and constitutes at least 70% of planted forests in Ghana (FC, 2013).

Third, impacts of climate change on biological/ecological systems such as host vulnerability/ resistance, pathogen biology, as well as pathogen-host interactions, have promoted pest problems in the region, as is the case in many other parts of the world. Pest and disease outbreaks of varying intensities continue to be recorded on previously "secure" exotic species such as eucalypts, teak, cedar, *Gmelina* and neem.

4.2.1 Pest and Disease Impact on Exotic Trees and Forests

In dry areas, termites have a major impact on growth and success of planted trees and forests. In addition to the well-known problem of desert locust outbreaks and its impact on agriculture and food security, other foliage feeding insects cause considerable damage to trees. For example, it was estimated that the oriental scale insect outbreak on neem resulted in the death of over one million trees, and covered an area of over one million km^2 in the Lake Chad Basin countries (Lale, 1988).

Nurseries of *Eucalyptus* for large scale plantation establishment in the region easily succumb to disease outbreaks if adequate care is not taken. Complete loss of

seedlings in nurseries is not uncommon, often resulting in loss of huge financial investments. In some instances, investors incur huge costs in pesticide purchases, application, and related pest control costs. For example, a visit to the FORM Ghana Plantation Estates as part of the study revealed that the Company spends approximately GH¢ 3 000 (USD 780) per week on pesticides to control snails on African mahogany seedlings in the nursery. At the APSD Plantation Estate, also in Ghana, it was reported that the Company has a breeding programme in place to ensure that superior clones are continually being selected for cultivation in order to minimize the risk of major pest damage. Such expensive pest management efforts only occur with large scale private investors. Hardly any efforts are made by individuals or small-scale tree growers to manage or control pest problems of planted trees or forests. Often, the response to a seemingly major pest outbreak by smallholder tree growers is abandonment of the project.

Unfortunately, plantation projects by national agencies sometimes face similar fates. Projects are often designed and implemented with no provision for pest monitoring and management or control. Consequently, such national plantation projects fail within a few years of initiation, unless no major pest or disease outbreak occurs.

4.2.2 Impact of Pest and Disease Outbreaks on Farmlands and Gender Implications

Not many reports were found on diseases and pests of trees on farmlands. From the literature, however, our knowledge of pest problems on multiple-purpose trees enables us to project what the problems on farmlands could be. For example, the sheanut tree (*Vitellaria paradoxa*) is common in parkland systems of the Guinea Savanna zone of West Africa. Any serious outbreak of pests on this tree, such as the outbreak of *Cirina forda* (Lepidoptera: Saturnidae) observed near Bolgatanga in northern Ghana in August 2004 can have serious impact on the tree, in addition to damaging crops (Plate 4). The implication of *C. forda* outbreaks can vary. Heavy defoliation of sheanut in farmlands can modify the microhabitat of the affected farm landscape, resulting in reduced crop yield. It can also drastically reduce or, in extreme cases, prevent fruiting of sheanut trees. This will have a direct effect on household incomes, since most women collect nuts for sale or process them into shea butter for sale. Unfortunately, no systematic efforts are in place to monitor and report on the dynamics of *C. forda* outbreak or other pests on this very important tree.

Another tree species of significant value in the parkland farming system of the savanna zone is mango (*Mangifera indica*). Farmers usually protect and manage existing mango trees on their farmlands. In many instances where mango plantations are to be established, it is done in the form of an agroforestry system, whereby crops are integrated into the plantation system for a number of years. An outbreak of the mango mealy bug (*Rastrococcus invadens*) can have a serious impact on the income of farmers, particularly women farmers, who manage mango trees on their farms with the view to generating additional income.

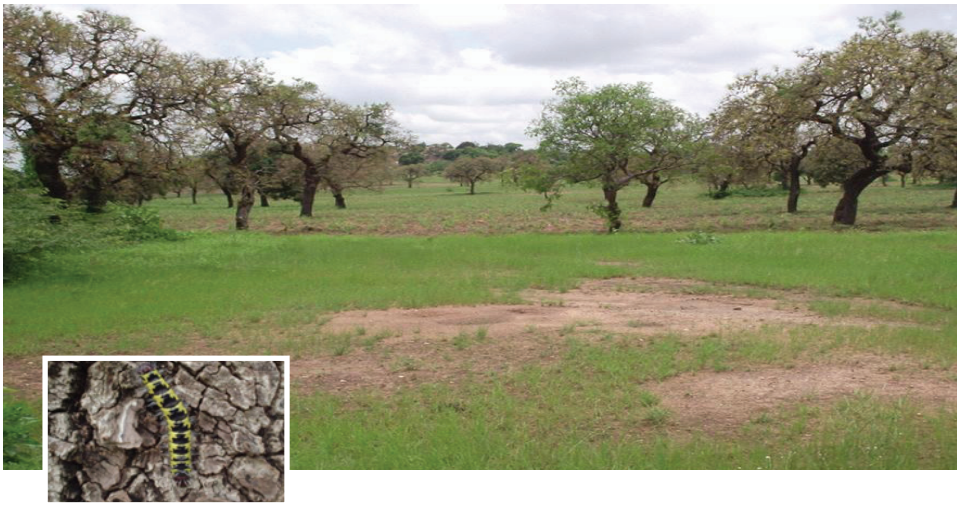

Plate 4. *Cirina forda* outbreak on shea nut trees (*Vitellaria paradoxa*) observed in Bolgatanga, Ghana in August 2004. (Photo by *P.P. Bosu*).

Parkia vitellaria, *Gliricidia sepium*, *Leucaena leucocephala* and *Faidherbia albida* are important trees for agroforestry or parkland farming systems throughout the subregion. Teak and various species of *Eucalyptus* are also commonly used in agroforestry or parkland farming systems. Nearly all of them suffer severely from termite infestations. Development and promotion of integrated pest management strategies in agroforestry setups will therefore be very necessary.

4.3 MODALITIES FOR DEVELOPMENT OF FOREST PEST SURVEILLANCE SYSTEMS

Surveillance is a process used to collect and record data on the occurrence or absence of a pest by means of survey, monitoring or some other procedure. The main purpose of pest surveillance is to generate information about the presence or absence of regulated pests in a way that is internationally acceptable as reliable and sound (FAO, 2011). Information gathered through pest surveillance may be used to:

- conduct pest risk analyses to justify regulating a particular pest and to require precautionary phytosanitary measures from trade partners;
- establish and maintain pest-free areas to convince trade partners that the commodities from those areas are free of certain pests and should be exempt from quarantine measures;
- aid the early detection of new pests;
- compile host and commodity pest lists and distribution records; and,
- report to other organizations such as RPPO and FAO.

The modalities for implementing an effective forest pest and disease (forest health surveillance, FHS) programme include the availability and use of sound policies and laws on phytosanitary measures, strong national and regional capacities, technical and financial resources, adequate human capacity, awareness creation, and regional cooperation.

4.3.1 International Phytosanitary Policies and Laws

Protection of the world's plants, including forest tree species, is achieved through coordinated international, regional and local efforts. In the international context, the International Plant Protection Convention (IPPC), which is an agreement between countries, aims to protect cultivated and wild plants by preventing the introduction and spread of pests. All countries in W/C Africa are parties to the IPPC and have National Plant Protection Organizations (NPPOs) mandated to implement the International Standards for the Phytosanitary Measures (ISPM) and the World Trade Organization's Sanitary and Phytosanitary (SPS) Agreement. Contracting parties to the IPPC are mandated to, among others, designate an official IPPC contact point, prescribe and adopt phytosanitary measures, share information on pests and regulations, and cooperate in the development of international Standards for Phytosanitary Measures (FAO, 2011).

In addition to the IPPC, W/C African countries are signatories to other binding instruments that primarily relate to international trade in plants, such as the Convention on International Trade in Endangered species of fauna and flora (CITES) and the Convention on Biodiversity Conservation. However, in almost all of W/C Africa, NPPO's activities focus on agricultural pests, with very little interest in issues about tree pest and disease impacts, if any.

4.3.2 The African Context

To ensure compliance of member states to the provisions of IPPC, the African Union has set up the Inter-African Phytosanitary Council (AU-IAPSC) with 53 member states. AU-IAPSC ensures that agriculture and natural resources are protected from the risks associated with the entry and establishment or spread of pests of plants and plant products for ensuring food safety and quality supply to intra-African and international markets. The IAPSC typically implements its activities through the African Regional Economic Communities (RECs) and sub-RECs. IAPSC also collaborates with Plant Protection Organizations in member countries. IAPSC's work places more emphases on agricultural plant protection than forest protection. It assesses, among other aspects, non-compliance with the International Standards for Phyto-sanitary Measures (ISPM), trade, regulation, and dearth of phytosanitary data (Pest Risk Analysis, Diagnostics and Surveillance) in Africa.

4.3.3 Role of National Plant Protection Organizations

National Plant Protection Organizations (NPPOs) are the governing agencies within the IPPC member countries that are charged with the implementation of phytosanitary standards. They achieve this through development and enforcement of national regulations. Some specific activities include: pest risk analyses for the establishment of phytosanitary measures; management of pest surveillance; reporting to other countries on pest status; coordination of the control of pests; and, establishment and monitoring of pest free areas. During the process of importation of goods into a country, the NPPOs also issue phytosanitary certificates to confirm that consignments meet an importing country's requirements. They ensure that phytosanitary security of consignments from certification until export is maintained through verification inspections and, if needed, treatment of consignments is done. In case treatment cannot be carried out, NPPOs destroy or refuse entry of the goods into the country. From time to time, an NPPO may also advise or request the IPPC to develop a new ISPM, or revise an existing one, to deal with a particular phytosanitary issue arising from the country.

4.3.4 Regional economic communities (RECs) and sub-RECs SPS policy framework

To ensure regional coordination and the harmonization of the SPS policy framework there are regional bodies that facilitate the efficient harmonization of rules that pertain to health and safety of plants. The thrust of these regional policies is basically to facilitate increased intra-regional trade as well as enhance regional integration**.** For instance, a draft ECOWAS Regulation (on the Harmonization of the Structural Framework and Operational Rules Pertaining to the Health Safety of Plant, Animals and Foods in the ECOWAS Region) has been developed (Magalhães, 2010). Through specific projects, ECOWAS in collaboration with AU, organizes training workshops for "SPS focal persons" in its Member States (Magalhães, 2010). However, the inability of ECOWAS to monitor regularly, and also assist member countries to implement new regional regulations, is a major challenge. On the other hand, the Economic Community of Central African States (ECCAS) currently does not have a common phytosanitary policy for the region. Inadequate human and financial resources and a lack of political awareness about SPS issues are serious constraints hampering ECCAS to develop common phytosanitary regulations (Magalhães, 2010). In the past, SPS regulation on food safety, animal and plant health was developed with FAO through the Food Security Regional Programme. A common phytosanitary certificate which follows the IPPC model has been recommended for the region.

In nearly every country in the subregion, NPPO activities focus on agricultural pests and their presence are very visible at major ports of entry. Field activities conducted for this report revealed that in at least three countries in West Africa, forest pest surveys have been conducted at some point. In Ghana, mandatory pest and disease surveys were conducted as part of an ADB funded Community Forestry

Management Project in the humid forest zone from 2005 to 2007 (Bosu *et.al*., 2015). The city of Niamey, Niger, hosts the subregional center for monitoring desert locust populations in the Sahel zone. The center is well-resourced to undertake monitoring and coordination activities in the subregion. Also, in Senegal, information obtained from the Crop Protection Directorate indicates that a national pest monitoring team is in place for the monitoring of pests and diseases throughout the country and in all landscapes, whether agriculture or forest.

4.3.5 Existing Legislation Backing Phytosanitary Measures in Selected Countries

Nearly all the countries in the W/C African region have sanitary and phytosanitary measures. They are almost all also signatories to IPPC and AU-IAPSC. However, policies, legislations, organizational structure as well as the level of implementation of phytosanitary measures vary from country to country, as illustrated for ten countries in the region in Table 4.

Table 4. Existing legislation backing phytosanitary measures in some W/C African countries.

Country/ Legislation	Description/Provisions
Ghana Plant and Fertilizer Act 2010 (Act 803) Plant Protection Regulatory 2012 (LI 2193)	These are two major plant protection instruments in Ghana. The part of the act that specifically deals with plant protection makes provision to prevent the introduction and spread of pests and diseases as well as regulate imports and exports of plants and planting material and related matters. To operationalize the Act, LI 2193 was also promulgated, which defines specific regulations and sets roles and responsibilities for different institutions to ensure the prevention and spread of plant pests. Provisions made in the Act and most regulations are consistent with international agreements on plant protection and are being implemented. *Remarks According to the Plant Protection and Regulatory Services Division of Ghana all regulations involving the issuance of import/ export permits, phytosanitary certificate, quarantining of regulated pest and periodic surveillance and pest risk assessment are carried out. Most of these provisions are implemented and follow the ISPMs related to forestry.

Country/ Legislation	Description/Provisions
Nigeria Agriculture (Control of Importation) Act. Chapter A13 Subsidiary Legislation	Plant protection in Nigeria is regulated by the Agricultural Act from 1964. The subsidiary regulation on plants makes provisions for regulating the importation of articles for the purpose of controlling plant diseases and pests. The Nigeria Plant Quarantine Service (NPQS) facilitates agricultural trade for importers and exporters and safeguard agricultural and natural resources from the risks associated with the entry, establishment or spread of exotic plant pests and noxious weeds. NPQS strives to ensure that imported plant and plant products are free of harmful pests through the use of an import permit system, import requirements, inspection, and treatment where necessary and the issuance of phytosanitary certificates. *Remarks The law has no specific provision on pest risk assessment and surveillance. It focuses on agricultural plants and products. However, many of the provisions in the Act can be applied to the protection of plants and wood products from the forest.
Niger **?**	The national organization responsible for plant protection was created in 1967. The Directorate of Plant Protection (DPV) was established in 1985, later changed to the Directorate General of Plant Protection (DGPV) in 2009. The legislation for SPS is readily available. The DGPV has a number departments/units, including the Secretariat of the Director General, Administrative and Financial Management Unit, Phytosanitary Interventions and Training Directorate, Directorate of Biological Studies, Directorate of Logistics and Phytosanitary Facilities and Directorate of Phyto-sanitary Regulation and Environmental Monitoring (DRP/SE). Phytosanitary inspections are carried out at 16 phytosanitary control posts along the borders with Nigeria, Benin, Burkina Faso, Mali and Algeria. Each of the the 16 phytosanitary officers is required to submit a monthly reports to the DGPV for processing and action.
Senegal Decree No. 003309 (15-03-2000)	The Decree established the Plant Protection Department (DPV) of Senegal, which is responsible for preventing the introduction of harmful organisms into the country and for combating those already present to contribute to increasing domestic production while preserving the environment, consumer health and quality control of products of plant origin. This responsibility is carried out in harmony with the inter-African and international phytosanitary regulations. Senegal has 11 entry points where inspections are conducted. The air and seaports in Dakar are primarily responsible for products from Europe, America, Asia and Africa as a whole. The other entry points are responsible for products from neighboring countries. The management structures for phytosanitary action are organized under a number of Divisions, e.g. the Crop Defense Division, Agricultural Warnings Division, Phytosanitary Legislation Division, Plant Quarantine and Quality Division and the Administrative and Finance Office.

Country/ Legislation	Description/Provisions
Gabon Act 7/77 (15-12-1977) established a phytosanitary police for Gabon	The Act established a phytosanitary policy for Gabon with the mandate to "carry or cause to quarantine, disinfection, refoulement, products and/or parts of plants, seeds, land and packaging for transport". The National Plant Protection of Gabon is governed by the Directorate-General for Agriculture, which has a phytosanitary legislation department and provincial phytosanitary officers, including the head office brigade and mobile brigades. The former is responsible for the certification of plant material exported to member countries of IPPC while the mobile brigades ensure strict compliance with the rules within the national territory. There are nine main phytosanitary access points in Gabon. The legislative activity and national conservation policies cover the areas of environment, forestry, agriculture, pest, fisheries and aquaculture and the impact of trade on human health.
Democratic Republic of Congo **?**	Specific legislation regulating sanitary and phytosanitary (SPS) controls in DRC has been difficult to locate. There is indication that SPS measures are in place in DRC. Records from the IPPC website indicate that the Congolese NPPO (Plant Protection Division) is under the Directorate for Production and Protection of Plants of the Ministry of Agriculture. The Division operates under three main offices, responsible for Phytosanitary Surveillance, Legislation and Phytosanitary Regulations and one for Promotion, Quality Assurance and Plant Products. There are also provincial branches under the Directorate each of which also has a Phytosanitary Protection Unit and entry points where regulations of SMS measures are carried out.
Cape Verde Law No. 29/VIII/2013 phytosanitary protecting norms within its territory.	The Law consists of 6 Chapters and 41 articles and establishes phytosanitary protecting norms to be applied to plant and plant products. It also creates the National Organization for Plant Protection (ONPV), which ensures the implementation of the National policy on plant protection. It prescribes instruments of prevention and fighting against plant harmful organisms, issuing to competent authorities for phytosanitary inspection the necessary resources and means to control imports, exports and carry out controls on the National territory of related products, and establishes offence and penalty regimes.
Guinea-Bissau Decree-Law No. 7/2000 ruling on plant protection products	This Decree-Law, composed of 38 articles, rules on the homologation system for plant protection products. It regulates the import of such products and related inspections. It stipulates that the homologation shall be undertaken by the Sahelian Committee for Pesticides (C.S.P.).It institutes the National Commission of Pesticides Management as a consultative body. Finally, it provides guidelines on the characteristics and requirements of plant protection products, its packaging, labelling, storage and commercialization.

Country/ Legislation	Description/Provisions
Mali Law n°02-013 June 2002 institutes the Phytosanitary Control	In its articles 2, 3, 4, 5, 15, it defines the concepts, prohibits the import of some plant products, regulates the official review of plants and plant products, and identifies harmful organisms. The Regulatory and Control Services (DGRC) is mandated with enforcement of the law.
Cameroon Law Relating Phytosanitary Protection Law No 2003/003 of April 2003	The law ensures that phytosanitary protection in Cameroon shall be undertaken through the setting, adoption and adaptation of standards on the following: 1. the prevention and control of plant and plant product pests ; 2. the use of phytosanitary products which are safe for humans, animals and the environment ; 3. the dissemination and popularisation of appropriate phytosanitary protection techniques ; 4. the control of the importation and exportation of phytosanitary products, plants, plant products and other regulated items that may lead to the release of plant pests; 5. the control, throughout the national territory, of phytosanitary products, plants and plant products that may serve as vectors of the harmful organisms.

4.3.6 Challenges to the Implementation of an Effective Forest and Tree Pest and Disease Surveillance Programme for West and Central Africa

Having good phytosanitary policies and laws is only the first step towards an efficient pest surveillance and management system. Many African countries have a deficit in phytosanitary capacity, especially in the area of protection of trees and forest resources. For instance, most countries in W/C Africa do not have rigorous programmes that facilitate pest reporting by individuals or plantation developers on a regular basis. To achieve effective implementation of forest pest surveillance, a number of barriers will have to be overcome at the national and regional levels. Key barriers include:

- Lack of experts specialized in plant protection.
- Lack of research to update pest lists.
- Too few experts to maintain accurate pest lists for forest/tree resources/ commodities.
- Inadequate pest surveillance in plantations and forest areas.
- Lack of funds for relevant government institutions (e.g. NPPOs) to implement regulations.
- Inability of private forest plantation companies to fund surveillance programmes.

4.3.7 Modalities for Implementation of Mechanisms and Actions for Surveillance of Forest Pests and Disease in West and Central Africa

Modalities for successful implementation of Forest Pest Surveillance (FPS) programmes are needed at national and country levels in the two sub regions. Issues to be considered when developing modalities at country level will include: increased capacity to undertake FPS at country level as well as support regional mechanisms and actions; networking and collaboration among relevant national institutions and experts in the area of FPS; human capacity development; and creation of awareness on phytosanitary measures and actions. These points are commented upon below:

Increase institutional capacity

Throughout the subregion there is little capacity to implement forest pest and disease surveillance programmes. NPPO offices in countries focus primarily on agricultural pests with only a few concerned about forest pests. However, the three examples from Ghana, Niger and Senegal can provide a basis for developing and implementing country and regional level FPS systems for W/C Africa. The following strategies could be adopted:

- NPPOs should be sensitized about threats of forest pest challenges in the sub region and the need to include these into their programmes and operations;
- NPPOs should compile a list of potential experts who may be involved in the development and implementation of national FPS programmes;
- Countries should develop national protocols and guidelines for the implementation of FPS programmes. The drafting, testing and implementation of these protocols should involve all or as many relevant national experts and institutions as possible;
- The capacity for taxonomic service provision in the subregion is among the poorest in the world. Worse still, laboratories and museums for providing taxonomic support for an effective FPS are either non-existent or poorly managed. These should be restored or upgraded. The capacity of the scientific and support staff should also be upgraded, whiles equipment and software for analyses, storage and retrieval of taxonomic samples and data should be provided and/or regularly updated;
- NPPOs should monitor and ensure that individuals or companies establishing forest plantations design and undertake regular pest surveillance as part of their operations.

Promote networking and collaboration between national institutions

NPPOs should ensure that relevant national institutions and experts are involved in the process of developing and implementing national FPS programmes. Institutions in academia (research institutions and universities), forest and agricultural sector agencies, environmental protection agencies, civil society organizations, and development partners can collaborate to achieve good results.

Develop human capacity

Development of human capacity is necessary to achieve efficient delivery of phytosanitary measures. In the short to medium term, available human resources with specialized training or skills may be upgraded through short courses, seminars and workshops. Such individuals or experts could constitute a pool of expertise from which NPPOs can consult or engage to undertake specific tasks when required. In the long term, universities, training institutions in forestry, agriculture, customs, and other relevant national professional training institutions should be encouraged or obliged to incorporate phytosanitary training in their curricula.

Increase involvement of professional associations in phytosanitary and forest pest surveillance programmes

Professional bodies with expertise in the area of plant health and protection can play a major role in the protection of trees and forests against diseases and pests. Associations of entomologists, plant pathologists, foresters, agriculturists, and those with related expertise and interests should be encouraged and supported by national authorities. NPPOs can work directly with these associations in various ways, including submitting issues of phytosanitary concern for discussions during annual or periodic meetings, obtain data and information on phytosanitary issues, as well as receive inputs to help manage specific pests and diseases.

Increase awareness on phytosanitary measures

Creating awareness on phytosanitary and FPS measures will greatly increase the under-standing of policymakers, civil society organizations and the general public. Especially for policymakers, increased awareness will improve their understanding of the consequences of their actions and inactions, which will likely increase their interest and support for phytosanitary measures and actions. This can also increase their interest and support for phytosanitary programmes in the country. Awareness may be created through traditional media outlets such as radio, TV and print, as well as through social media (facebook, twitter, whatsApp, etc.). NPPOs could use emergency pest outbreaks, which have become relatively frequent in recent years, as leverage for initiating or increasing awareness programmes on phytosanitary actions.

4.3.8 Sub-Regional Level

Nearly all the issues of concern at country level are applicable at the sub-regional level. In effect, subregional activities will focus more on networking and harmonization of national protocols, mechanisms and actions.

Harmonize national surveillance protocols, mechanisms and actions

The RPPOs should facilitate the development of national protocols/guidelines for pest and disease surveillance in member countries, and further harmonize these individual country documents into regional documents. Additionally, RPPOs can link up with the NPPOs to organize region-wide forest pest surveillance programmes, within the context of enhancing compliance with phytosanitary measures.

Create network of regional phytosanitary-support centers

The RECs could identify national and international organizations within the regions with facilities and expertise in phytosanitary and FPS activities for the benefit of member countries. Through the development of MOUs among the various institutions, facilities as well as expertise could be shared to achieve effective implementation of phytosanitary actions in the sub-regions. The RPPOs should organize regular meetings among member countries to promote networking and facilitation of regional-wide FPS activities.

Develop a system for information sharing

The RPPOs should serve as hubs for collation and sharing of information on phytosanitary actions including, pest outbreaks, incursions of alien invasive species, and emerging issues of phytosanitary concern on the continental and global scenes.

Increase collaboration with relevant professional associations

As discussed in the previous section, professional associations can be a valuable pool of readily available expertise and information source for implementation of phytosanitary measures and FPS activities. RPPOs can gain easy access to quality data and information from member countries through these associations. The Forest Invasive Species Network for Africa (FISNA), for example, is one such body with membership countries throughout sub-Saharan Africa. FISNA members seek to create awareness of invasive species on the continent, promote research and coordination, as well as management of invasive species.

4.3.9 International Best Practices and the Regional Context

The IPPC has developed a set of guidelines which are collectively known as the International Sanitary and Phytosanitary Measures (ISPMs) that help countries and regional bodies (NPPOs and RPPOs) to effectively implement sanitary and

phytosanitary activities. Some of these are particularly relevant to forest product pests and are highlighted in this report as follows:

ISPMs associated with pest risk analysis

- Framework for pest risk analysis (ISPM No. 02, 2007);
- Guidelines for the export, shipment, import and release of biological control agents and other beneficial organisms (ISPM No. 03, 2005);
- Pest risk analysis for quarantine pests including analysis of environmental risks and living modified organisms (ISPM No. 11, 2004);
- Pest risk analysis for regulated non-quarantine pests (ISPM No. 21, 2004).

Comment: In most of the W/C countries pest risk analysis associated with trade in forest commodities is not done regularly, unlike regular pest assessment for agricultural crops.

Regulation of wood packaging material in international trade (ISPM No. 15, 2009)

The standard requires that wood used for making packaging material should be debarked. This will include pallets, boxes or dunnage used in a container, aircraft or ship's hold to secure a variety of trade goods (FAO, 2011). Where fumigation is used, the debarking process must occur before fumigation. Long thin pieces of bark are allowed to remain after the debarking process if these pieces are no wider than 3 cm (regardless of the length). If bark pieces are wider than 3 cm, they must be short enough so that the wood will dry out before bark beetles can develop. Therefore wide pieces of bark cannot have surface area greater than 50 cm2.

Comment: These guidelines for wood packaging are generally followed by most countries in the sub-regions.

Guidelines for pest eradication programmes (ISPM No. 09, 1998); the use of integrated measures in a systems approach for pest risk management (ISPM No. 14, 2002)

Systems approaches provide the opportunity to consider many procedures that can help reduce risk from pre-planting to final use. A systems approach in forestry manages the risk of pests in wood and wood products by using a combination of independent measures, from selection of genetic material and site preparation activities to post-harvest treatment and handling to transportation and distribution.

Comment: A good example of such an approach being used can be found in Ghana, where the African Plantations for Sustainable Development (APSD) Ltd. regularly uses resistant planting material chosen through an aggressive tree breeding programme to minimize pest damage.

Guidelines for surveillance (ISPM No. 06, 1997)

According to ISPM No. 06, surveillance is an official process which collects and records data on pest occurrence or absence by survey, monitoring and other procedures such as literature reviews.

Comment: The NPPO is responsible for gathering and maintaining information for general surveillance. For most parts of W/C Africa, general surveillance is hindered by a lack of funding and logistics.

Pest reporting (ISPM No. 17, 2002); Determination of pest status in an area (ISPM No. 8, 1998)

Signatories to the IPPC have an obligation to report pests when they are identified as a potential threat to trading partners or neighboring countries, e.g. a new occurrence or a change in pest status. Pest reporting allows countries to adjust phytosanitary requirements, based on PRAs, and to take measures as necessary to respond to any changes in risk. Pest information that might affect planting and marketing choices can also benefit foresters and assist them in working with NPPOs in planning management measures.

Comment: From the studies, it does appear that there is not a single country within the sub-regions that has a rigorous programme or policy in place to ensure pest reporting by individuals or plantation developers on regular basis.

Requirements for establishment of Pest Free Areas (ISPM No. 04, 1995); Requirements for establishment of pest free places of production and pest free production sites (ISPM No. 10, 1999); Recognition of pest free areas and areas of low pest prevalence (ISPM No. 29, 2007)

Exporting countries may be able to establish official pest free areas or areas of low pest prevalence. They may then be able to negotiate agreements with importing countries to allow export of regulated commodities from those areas, which may help them gain, maintain or improve market access. A pest free area (PFA) is defined simply as an area in which a specific pest does not occur.

A pest free place of production (PFPP) is a place of production where a specific pest does not occur, as determined by the NPPO, even though the pest may be present in the area. The absence of the pest must be demonstrated by scientific evidence such as periodic specific surveys. Trading partners will expect, as a minimum, to see documentation supporting the PFPP declaration.

Guidelines for inspection (ISPM No. 23, 2005); Methodologies for sampling of consignments (ISPM No. 31, 2008)

NPPOs or personnel authorized by the NPPO perform inspections prior to export and at import. An export inspection is performed by the exporting country to ensure that a consignment meets the specified phytosanitary requirements of the importing

country at the time of inspection. If requirements are met, the inspection may result in the issuance of a phytosanitary certificate by the exporting country's NPPO for the consignment in question.

Comment: All timber/wood products exporting countries in the subregion meet these standards, simply because the consequences for not doing so are quite expensive. It usually means that the consignment will be rejected at the destination country. This is especially so if the destination country is in Europe, North America or Asia. However, it cannot be confirmed whether wood products exported overland across neighboring countries in the subregion strictly follow these guidelines.

Export certification system (ISPM No. 7, 1997); Guidelines for phytosanitary certificates (ISPM No. 12, 2001); Consignments in transit (ISPM No. 25, 2006); Categorization of commodities according to their Pest risk (ISPM No. 32, 2009)

NPPOs of exporting countries issue phytosanitary certificates to certify that consignments of plants, plant products or other regulated articles meet the specified phytosanitary import requirements of trading partners, such as demonstrating that a treatment has been performed.

Comment: Most countries, especially in West Africa, issue phytosanitary certificates that are modeled after the provision made in the IPPC. For example, a sample phytosanitary certificate of Niger is available on the IPPC website.

Guidelines for the notification of non-compliance and emergency action (ISPM No. 13, 2001)

When consignments do not meet phytosanitary import requirements they are considered to be non-compliant. The NPPO of the importing country notifies the NPPO of the exporting country about the non-compliance.

Comment: These guidelines are also used by most countries in W/C Africa.

Guidelines for a phytosanitary import regulatory system (ISPM No. 20, 2004)

An important regulatory system should consist of two components: a framework of phytosanitary legislation, regulations and procedures; an official service, the NPPO, responsible for operation or oversight of the system. NPPOs have the sovereign right to regulate imports to achieve an acceptable level of protection, taking into account their international obligations, in particular the IPPC (1997) and the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement).

Comment: For most of the West African countries phytosanitary and regulatory system exist, which mostly is consistent with the provisions of IPPC and the SPS agreement, though in some cases incorrect interpretation of SPS measures arises in an attempt to set out national regulations.

5.0 Conclusion and recommendations

Major insect pests and diseases of forests and trees in W/C Africa occur on valuable tropical hardwood species in the humid forest zone. These endemic pests become serious and cause significant damage to trees when established in large scale plantations. Widely planted exotic species such as *Eucalyptus* spp., *Tectona grandis* and *Cedrela odorata* have been grown for many decades in the sub-regions without much pest problems. However, a new trend is now emerging and many of these exotic species are succumbing to pressure by indigenous pathogens. This means accidental introduction of the native pests of these exotic species in the future could worsen the pest problems in the region. In their native range, teak, for example, suffers severely from defoliation by *Hyblaea puera*, and *Cedrela* suffers severely from the other strains of the mahogany shoot borer *Hypsipyla grandella*). So far, *C. odorata* has enjoyed protection from *H. robusta*, but this could all change if *H. grandella* arrives on the continent. With the increased global trade and the climate change phenomenon, which most experts believe could exacerbate pest and disease problems around the world, W/C African countries should take steps to prevent the introduction and spread of forest pests and diseases in the region.

Countries in the two sub-regions have been involved in the global and continental phytosanitary processes and have ratified nearly all international and continental conventions and agreements on phytosanitary measures. However, implementation of the requirements of these measures is weak. A combination of factors, including lack of institutional and human capacity, logistical/financial constraints, lack of effective coordination and networking among member countries, absence of national and sub-regional protocols, guidelines, mechanisms for undertaking forest pests surveillance and phytosanitary actions, and focus on phytosanitary measures of agricultural concern, have all contributed to the current situation.

The following recommendations have been proposed:

- Inclusion of pest monitoring in all forest plantation projects. Multinational donors, such as World Bank and the African Development Bank, should make it mandatory for fund recipients to include forest pest surveillance measures in plantation development projects.
- Most private investors have the consciousness and follow strict phytosanitary procedures to avoid unnecessary introductions. Nonetheless, regular national monitoring inspections should be conducted.
- The African Union should promote cross-national or regional protocols for monitoring. Organizations such as FISNA and Entomological and Pathological Societies should be promoted through provision of financial and logistical support.

6.0 References

Agyeman, V.K. and E.Y. Safo, 1997. Mineral nutrition and dieback in *Terminalia ivorensis* A. Chev. in Ghana. *J. Trop. Ecol*. 13:317-335.

Apetorgbor, M.M. and J. Roux, 2015. Diseases of plantation forestry trees in Southern Ghana. *International Journal of Phytopathology* 4(1):5-13.

Apetorgbor, M.M., J. Roux and E. Nkrumah, 2013. *Cedrela odorata* and *Tectona grandis* mortality on Quarm Farms. Report submitted to Quarm Farms. 10pp. CSIR-FORIG/CR/MMA.

Apetorgbor, M.M., D.E.K.A. Siaw and A. Gyimah, 2003. Decline of *Ceiba pentandra* seedlings, a tropical timber species, in nurseries and plantations. *Ghana Journal of Forestry* 11:(2)51-62.

Bosu, P.P., E.E. Nkrumah and K.P. Bandoh, 2015. Strategies for Forest Health Surveillance in Small-holder Plantations: The Case of the Community Forestry Management Project in Ghana. *Ghana Journal of Forestry* (Submitted).

Bosu, P.P. and M.M. Apetorgbor, 2009. Rising pest problems in forest plantations in Ghana. FORIG Technical Note No. 2. 9pp.

FAO, 2011. Guide to implementation of phytosanitary standards in forestry. FAO Forestry Paper 164. 165 pp.

FAO, 2010. Global Forest Resources Assessment 2010. Main report. FAO Forestry Paper 163. Rome. 378 pp.

FAO, 1994. Decline and dieback of trees and forests. A global overview. FAO Forestry Paper 120. 90 pp.

Forestry Commission, 2013. Draft Ghana National Forest Plantation Development Strategy 2015-2040.

Gbadegesin, R.A, J.O. Adegbehin and E.B. Tologbonse, 1999. Major diseases and pests of forest trees and their control in Nigeria. Extension Bulletin 178, Forestry Series No. 3. 28 pp.

Gibson, I.A.S., 1975. Diseases of forest trees widely planted as exotics in the tropics and southern hemisphere. Part 1. Important members of the *Myrtaceae, Leguminosae, Verbenaceae* and *Meliaceae.* Commonwealth Mycological Institute and Commonwealth Forestry Institute, University of Oxford, UK.

IPPC, 2012. IPPC National Phytosanitary Capacity Development Strategy. Secretariat of the International Plant Protection Convention, Rome. Available at: www.ippc.int/publications/

Lale, N.E.S., 1998. Neem in the Conventional Lake Chad Basin area and the threat of Oriental yellow scale insect (*Aonidiella orientalis* Newstead) (Homoptera:Diaspididae). *Journal of Arid Environments* 7(1).

Loupe D., A.A. Oteng-Amoako and M. Brink (eds), 2008. Plant Resources of Tropical Africa. Timbers. PROTA Foundation and CTA, Wagningen, Netherlands. Backhuys Publishers, Leiden, Netherlands. pp. 333-338.

Magalhães, J., 2010. Regional Sanitary and Phytosanitary Frameworks and Strategies in Africa. Standards and Trade Development Facility (STDF).

Mancini, F., M.M. Apetorgbor, J.R. Cobbinah and A. Ragazzi, 2001. Potential of fungal pathogens of seeds and seedlings of *Milicia excelsa* in 3 ecological zones of Ghana. *Journal of Plant Diseases and Protection* 108(1):31-38.

Ofosu-Asiedu, A., 1975. A new disease of Eucalyptus in Ghana. *Transactions British Mycological Society* 65(2):285-289.

Ofosu-Asiedu, A., 1988. Some destructive Diseases of Tree crops in Africa, South of the Sahara. Paper read at 5th ICPP Meeting 20-27 August 1988. Kyoto, Japan.

Ofosu-Asiedu, A. and P. Cannon, 1976.*Terminalia ivorensis* decline in Ghana. *Pest Articles and News Summaries* 22(2):239-242.

Omokhua, G.E., M.I. Godwin-Egein and V.C. Okereke, 2009. Fusarium Damping-off of two Timber Species (*Terminalia Ivorensis* A.Chev and *Nauclea Diderrichii* De Wild and Th.Dur) in the Nursery. *African Research Review* 3(4):275-282.

Roux, J., T.A. Coutinho, M.J. Wingfield and J-P. Bouillet, 2000. Disasess of plantation in the Republic of Congo. *South African Journal of Science* 96.

Roux, J. and M.M. Apetorgbor, 2009. First report of *Chrysoporthe cubensis* from *Eucalyptus* in Ghana. *New Disease Reports* 20.

Sidibe, B., 2009. Mission Report to Liberia (Monrovia) from January 30th to February 8th, 2009.

Tachie-Obeng, E. and N. Brown, 2004. Kola Nuts (*Cola acuminata* and *Cola nitida*) p. 87-112. In: Clark, L.E., C.H. Terry and T.C.H. Sunderland (Eds.). The Key Non-Timber Forest Products of Central Africa: State of the Knowledge. USAID Technical Paper No. 122.

Wagner, M.R., J.R. Cobbinah and P.P. Bosu, 2008. Forest Entomology in West Tropical Africa: Forest Insects of Ghana. 2nd Edition. Springer. The Netherlands. 244 pp.

Wingfield, M.J., B. Slippers, B.P. Hurley, T.A. Coutinho, B.D. Wingfield and J. Roux, 2008. Eucalypt pests and diseases: growing threats to plantation productivity. *Southern Forests* 70(2):139–144.

Appendices

APPENDIX 1. LIST OF EXPERTS INTERVIEWED/ CONSULTED.

Name	Institution/Address
Mr. Ebenezer Aboagye	Plant Protection and Regulatory Services Directorate, P.O. Box M.37, Accra
Mr. Hugh C.A. Brown	Director of Operations (Plantations), Forest Services Division, Forestry Commission, PO Box MB 434, Accra Ghana
Valerie Fumey-Nassah.	1. Resource Management Support Services Division, Forestry Commission, Kumasi. Ghana 2. African Plantations and Sustainable Development Kwame Danso, Ghana 3. Form Ghana Plantations, Akumadan, Ghana
Dr. Patrick Tshilenge Djim Kanana	Univdersite de Kinshasa, Faculté des Sciences Agronomiques, Departemeut de Phytotechair
Colonel Racine Diallo	Parc Forestier Hann, route des Peres Maristes, BP: 1831, Dakar, Senegal
Papa Sarr	Ministry of Environment and Sustainable Development, National Agency of the Great Green Wall, Vila No.16 Cite Gorgui III, Sacred Heart, Dakar, Senegal
El Hadji Omar Dieng	Chief Entomologist and Biological Control Programs, Crop Protection Directorate, Km 15, route de Ruffisque en Face Foirail, BP 20054, Thiaroye, Dakar, Senegal.
Dr. Paterne Diatla	ISRA, Senegalese Inst. for Agric. Res.
Sunday Moradeyo	Oyo State Government, Ministry of Natural Resources, Ministry of Agriculture Building, Secretariat, Ibadan, Nigeria
Dr. Elizabeth Ekpo	Forestry Research Institute of Nigeria P.M. 5054, Ibadan, Nigeria
Deni Bown	Flora & Medicinal Plants PMB 5320, Ibadan, Nigeria
Ladipo Olajide	Centre for Environment, Renewable, Natural, Resources Management Research and Development PMB 5052, Jericho, Ibadan, Nigeria.

Name	Institution/Address
Sama Gagare	CILSS/Centre Regional AGRHYMET, Departement Formation et Recherche B.P. 11011, Niamey, Niger
Mbaye Ndiaye	CILSS/Centre Regional AGRHYMET, Departement Formation et Recherche B.P. 11011/12625, Niamey, Niger
Gadage Aboubacar	Ministry of Environment, Urban, Sanitation and Sustainable Development, P.O. Box 578, Niamey, Niger
Moumouni Abou	Ministere de l'Agriculture, Centre National De Lutte Antiacrediehne, BP 2219, Niamey, Niger
Mallam Kano	Niamey, Niger
Dr. Ismaila Diallo	Chercheur, ISRA/CNRF; Président du Réseau Africain pour l'Observation de la terre et les Changements Climatiques
Michel Mbangilwa Mukombe	Ingénieur Agronome (Spécialisée en Gestion des ressources Naturelles); Kinshasa, DR Congo
Dr. Donald Midoko Iponga,	Chargé de Recherche (Cames); Institut de Recherche en Ecologie Tropicale (IRET), Centre National de la Recherche Scientifique et Technologique (CENAREST) BP 13 345, Libreville, Gabon
Ms. Emelie Legno	Institut de Recherche en Ecologie Tropicale (IRET), Centre National de la Recherche Scientifique et Technologique (CENAREST) BP 13 345, Libreville, Gabon

APPENDIX 2. INSECT PESTS OF TREES AND FORESTS IN WEST AND CENTRAL AFRICA (MODIFIED FROM WAGNER ET AL., 2008)

Pest species	Order: Family	Countries of occurrence	Host Species	Indigenous/ Introduced	Feeding habit	Forest type	Remarks
Achaea spp.			*Gmelina arborea*			Plantation, Natural Forest	Complete failure of plantations
Anafe venata		Ghana, Nigeria	*Triplochiton scleroxylon*	Indigenous	Defoliator		The larvae feed extensively on leaves often defoliating the tree
Analeptes trifasciata	Coleoptera: Bostrychidae	Ghana	*Ceiba pentandra, T. grandis, Bombax costatum, Eucalyptus alba, E. territicornis, Adansonia digitata,* etc.		Wood borer	Savanah	
Anomis Leona Schaus.	Lepidoptera: Noctuidae	Nigeria, Ghana	*Ceiba pentandra, Sterculia rhinopetala, Nesogordonia papaverifera, T. scleroxylon*		Defoliator		
Aonidiella orientalis	Hemiptera: Diaspididae	Nigeria, Niger, Cameroon, Chad	*Azadirachta indica*	Introduced	Sap feeder		
Apate monachus		Ghana	*Azadirachta indica, Terminalia ivorensis, Antiaris africana,* etc.	Indigenous			

Pest species	Order: Family	Countries of occurrence	Host Species	Indigenous/ Introduced	Feeding habit	Forest type	Remarks
Apate terebrans			*Tectona grandis, Cedrela odorata,Terminalia ivorensis, T. scleroxylon, Eucalyptus spp., Khaya senegalensis,* etc.	Indigenous			
Apion ghanaensis	Coleoptera: Apionidae	Ghana	*T. scleroxylon*		Fruit borer		
Auletobius kentzeni	Coleoptera: Curculionidae	Ghana	*T. ivorensis*				
Bruchidius uberatus	Coleoptera: Bruchidae	Sudan savannah	*Acacia nilotica*		Fruit borer		
Bunaea alcinoe		Nigeria	*Ekebergia capensis*				Larvae causes high incidence of attack
Catopyla dysorphnaea	Lepidoptera: Pyralidae		*Entandrophragma* spp., *Khaya* spp., *Lovoa trichiloides*		Fruits and seed feeder		
Diacrisia lutescens	Lepidoptera: Arctiidae	Ghana	*Senna siamea, Dalbergia sissoo, Eucalyptus camaldulensis, E. rudis, E. deglupta, E. torelliana, Gmelina arborea*		Defoliator		

Pest species	Order: Family	Countries of occurrence	Host Species	Indigenous/ Introduced	Feeding habit	Forest type	Remarks
Diclidophlebia eastopi	Homoptera: Psyllidae	Nigeria, Ghana, Côte d'Ivoire	*Triplochitin scleroxylon*	Indigenous	Sap feeder		Can cause serious damage to seedlings
Diclidophlebia xuani	Homoptera: Psyllidae	Cameroon	*Ricinodendron heudelotii*	Indigenous	Sap feeder		Cause serious damage to young plants
Doliopygus dubius	Coleoptera: Platypodidae	Ghana, Nigeria	*Terminalia superba*				
Epicerura pulverulenta		Ghana, Côte d'Ivoire	*Terminalia ivorensis*	Indigenous	Defoliator		
Eublemma sp.	Lepidoptera: Noctuidae		*Senna siamea, Eucalyptus spp., T. scleroxylon*		Flower and fruit feeder		
Eulophonotus obesus	Lepidoptera: Cossidae	Nigeria	*Triplochiton scleroxylon*	Indigenous	Wood borer		Wood borer. Can cause serious damage to adult trees
Euproctis fasciata	Lepidoptera: Lymantriidae	Ghana, Uganda	*Eucalyptus spp. Araucaria spp., Acacia spp.* in Uganda				
Godasa sidae	Lepidoptera: Arctiidae	Ghana, Nigeria	*Mansonia altissima, Cedrela odorata*	Indigenous	Skeletonizer	Plantations	Larvae polyphagous
Hypothenemus pusillus	Coleoptera: Scolytidae	Ghana, Nigeria, Sierra Leone.	*T. ivorensis, T. grandis, Cedrela odorata, G. arborea, Ceiba pentandra, A. africana*				

Pest species	Order: Family	Countries of occurrence	Host Species	Indigenous/ Introduced	Feeding habit	Forest type	Remarks
Hypsipyla robusta	Lepidoptera: Psyllidae	Ghana, Nigeria, Togo, Cameroon Côte d'Ivoire	*Khaya ivorensis, K. anthotheca, K. grandifolia, K. senegalensis, Entandrophragma utile, E. cylindricum*	Indigenous	Shoot borer, also bores into fruits and seeds	Natural forest, Plantations	
Imbrasia spp.		DR Congo		Indigenous			
Lamprosema lateritialis	Lepidoptera: Pyralidae	Ghana	*Pericopsis elata*	Indigenous	Defoliator, leaf roller	Natural forest, Plantations, Savanah	
Lobobunaea phaedusa,		DR Congo	*Ricinodendron heudelotii*	Indigenous			
Monochamus raspator	Coleoptera: Cerambycidae						
Nanophyes sp. n. ituriensis	Coleoptera: Curculionidae		*Terminalia ivorensis*		Seed weevil		
Orygmophora mediofoveata	Lepidoptera: Pyralidae	Ghana, Nigeria, Togo	*Nauclea diderrichii*	Indigenous	Shoot borer	Natural forest, Plantations	Infestation levels of 30–80% recorded in Nigeria in the 1960s, more recently in nurseries in Ghana 60–80% of potted seedlings found to be destroyed.

Pest species	Order: Family	Countries of occurrence	Host Species	Indigenous/ Introduced	Feeding habit	Forest type	Remarks
Phreneta leprosa	Coleoptera: Cerambycidae		*Morus alba*				
Phryneta leprosa	Coleoptera: Lamiidae)	Ghana, Nigeria, also in some E African countries	*Milicia excelsa, M. regia*				
Phytolyma lata	Homoptera: Psyllidae	Ghana, Nigeria, Togo Cameroon, Côte d'Ivoire,	*Milicia excelsa*	Indigenous	Gall maker	Natural forest, Plantations	
Planococcoides njalensis	Hemiptera: Pseudococcidae	Ghana	*Tectona grandis, Terminalia ivorensis*		Sap feeder		
Platypus hintzi	Coleoptera: Platypodidae		*Casuarina spp. Eucalyptus spp.*				
Pseudophacopteron zimmermanni	Hemiptera: Psyllidae	Ghana, Nigeria	*Khaya anthotheca, K. grandifolia, K. ivorensis*		Gall maker		
Strepsicrates rhothia.	Lepidoptera: Tortricidae	Ghana	*Eucalyptus* spp.		Leaf roller and defoliator		
Trachyostus ghanaensis		Nigeria	*Triplochiton scleroxylon*	Indigenous	Wood borer		Can cause serious damage to adult trees
Tridesmodes ramiculata	Lepidoptera: Thyrididae	Ghana, Nigeria	*Terminalia ivorensis*	Indigenous	Shoot borer	Natural forest	
Xyloborus compactus	Coleoptera: Scolytidae	Ghana, Gabon	*Khaya ivorensis, Acoumea klaineana*				

APPENDIX 3. DISEASES OF FORESTS AND TREES IN WEST AND CENTRAL AFRICA

Type of disease	Causing agent	Host species	Distribution of disease	Natural/ Plantation/ Farmland	Age	Disease severity	Literature cited
Canker	*Cryptodiaporthe* spp., *Diplodia* and *Lasiodiplodia* spp.			Plantation	Trees	Severe/Minor	Gbadegesin *et al.*, 1999
Canker	*Rigidoporus lignosus*			Plantation	Trees	Severe/Minor	Gbadegesin *et al.*, 1999
Canker	*Cryptodiaporthe* spp., *Diplodia* and *Lasiodiplodia* spp.	*Terminalia* spp.	Nigeria	Plantation	Trees	Minor	Gbadegesin *et al.*, 1999
Damping off	*Fusarium oxysporum*	*Nauclea diderrichii*	Nigeria	Nursery	Seedlings	Severe/Minor	Omokhua *et al.*, 2009
Damping off	*Gibberella fujikuroi, Athelia rolfsii*	*Gmelina arborea*	Gambia, Sierra Leone	Nursery	Seedlings	Severe/Minor	Prota Timbers 1
Damping off	*Pythium* spp.	*Eucalyptus* spp.	Nigeria	Nursery seedlings	Seedlings	Severe/Minor	Gbadegesin *et al.*, 1999
Damping off	*Fusarium* spp.	*Pinus* spp.	Nigeria	Nursery	Seedlings	Severe	Gbadegesin *et al.*, 1999
Dieback	*Botryodiplodia theobromae, Poria* spp., *Corticium* spp.		Benin, Ghana	Plantation	Saplings	Minor	Loupe *et al.*, 2008
Dieback	*Lasiodiplodia theobromae*	*Milicia excelsa*	Ghana	Plantation	Seedlings		Apetorgbor *et al.*, 2003
Dieback	*Fusarium solani* and *Lasiodiplodia theobromae*	*Ceiba pentandra*	Ghana	Plantation/ farmland	Saplings	Minor	Apetorgbor *et al.*, 2003
Dieback	*Coniothyrium sphaeropsis*			Plantation	Saplings	Severe/Minor	Gbadegesin *et al.*, 1999

Type of disease	Causing agent	Host species	Distribution of disease	Natural/ Plantation/ Farmland	Age	Disease severity	Literature cited
Leaf spot	*Colletotrichum capsici*				Seedlings	Severe/Minor	Apetorgbor *et al.*, 2003
Leaf spot diseases	*Uredo tesoensis*, *Thanatephorus cucumeris*				Seedlings	Minor	Loupe *et al*., 2008
Root diseases	*Athelia rolfsii*		Sierra Leone, Gambia, Nigeria	Plantation	Trees	Severe/Minor	Omokhua *et al*., 2009
Root diseases	*Thanatephorus cucumeris*, *Chaetophoma* spp., *Polyporus* spp., and *Armillaria mellea*		Nigeria and Côte d'Ivoire	Plantation	Trees	Severe	Loupe *et al*., 2008
Root diseases	*Phellinus noxius Uredo tesoensis*	*Khaya ivorensis*	Côte d'Ivoire, Ghana, Togo, Benin, Nigeria	Plantation	Trees	Severe/Minor	Omokhua *et al.*, 2009
Root rot	*Armillaria* spp.	*Cedrela odorata*	Ghana	Plantation	Saplings (2-4 yrs.)	Severe	Apetorgbor and Roux, 2015
Root rot	*Fomes lignosus* and *F. noxius*	*Cola nitida* and *C. acuminata*	Central Africa Republic	Plantation	Trees	Severe/Minor	Tachie-Obeng and Brown, 2004
Root rot	*Lasiodiplodia theobromae*	*Celtis zenkeri*		Plantation	Saplings	Minor	Prota Timbers 1
Root/ butt rot	*Armillaria* spp., *Phellinus noxius, Phaeolus manihotis, Ganoderma* spp. and *Rigidoporus lignosus*	*Tectona grandis*	Côte d'Ivoire, Benin, Ghana, Nigeria, Tanzania	Plantation	Trees, >10yrs	Minor in some cases	Loupe *et al*., 2008
Smut rust	*Mycosyrinx nonveilleri*	*Triplochiton scleroxylon*	Nigeria	Plantation	Saplings	Minor	Omokhua *et al*., 2009

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A platform for stakeholders in African forestry

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United Nations Avenue, Gigiri.
P.O. Box 30677-00100, Nairobi, Kenya
Tel: +254 20 722 4203
Fax: +254 20 722 4001
E-mail:exec.sec@afforum.org

Website: www.afforum.org.
Twitter @ africanff.
Facebook / African Forest Forum.
LinkedIn / African Forest Forum (AFF).