ABSTRACT

There is considerable drive in many countries of West and Central Africa towards reforestation and rehabilitation initiatives that use trees. However, the occurrence of pests and diseases in Africa is having considerable impact on forest growth and yield and thus reducing profits from forests. Consequently, measures to protect forests from pests and diseases should be an integral part of sustainable forest management. The objective of the study was to evaluate the status and trends of forest and tree pests and disease management in the West and Central African regions with the view to proposing appropriate control measures, including development of protocols for pest and disease surveillance. A combination of literature review and expert surveys conducted in six countries, including Ghana, Nigeria, Niger, Senegal, Gabon and Democratic Republic of Congo were used to gather information on the topic. The results showed that pest problems in the WCA region are generally sporadic. In the humid zone of the sub-region, establishment of plantations of high-value indigenous timber species such as iroko (*Milicia excelsa* and *Milicia regia*) attacked by the gall-forming *Phytolyma lata*, and mahogany (*Khaya* and *Entandrophragma* spp.) attacked by the shoot borer *Hypsipyla robusta*, have been largely avoided. In the Sahel-Savanna zone, termites are the major pests of trees, affecting both indigenous and introduced species. In the mid-1980s, an outbreak of the oriental yellow scale insect *Aonidiella orientalis* (Hemiptera: Diaspididae) affected millions of neem (*Azadirachta indica*) in the countries of the Lake Chad Basin. However, pest trends are generally not that clear in the sub-region. Except for a few cases, endemic pests and disease problems have persisted for decades. A new trend is emerging where exotic species which have been widely planted due to their relative stability to pests now appear to be succumbing to attacks. Recent forest health surveys in Ghana, for example, revealed potentially serious stem canker infections on cedrela (*Cedrela odorata*), and *Amillaria* root diseases on teak (*Tectona grandis*) in plantations. Also, cases of what appears to be symptoms of blue gum chalcid (*Leptocybe invasa*) attacks have been observed in the region. Enhancing pest surveillance and management in the sub regions are recommended.

Keywords: Central Africa, diseases, pests, Ghana, surveillance, West Africa
RÉSUMÉ

Mots-clés : Afrique centrale, maladies, ravageurs, Ghana, surveillance, Afrique de l’Ouest

INTRODUCTION
Trees and forests constitute an inseparable component of the livelihood of the people in the West and Central African subregions. Forest-dwelling communities, as well as those living further away from forests, have depended directly or indirectly on forests for centuries. Globally, utilisation of tropical forest resources has generally been described as unsustainable, resulting in serious decline 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 urbanisation. Sustainable forest management practices include the application of good silvicultural techniques to utilisation 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 the West and Central African (WCA) region towards afforestation/reforestation (A/R) and restoration initiatives. However, several challenges hamper
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.

Today, exotic species such as eucalypts (Eucalyptus spp.), and teak (Tectona grandis) dominate planted forests of WCA, 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 and cedrela (Cedrela odorata), which have been widely planted because of their resilience to pests and diseases appear to be succumbing to attacks. The objective of the study was to evaluate the status and trends of forest and tree pest and disease management in the West and Central African regions with the view to proposing appropriate control measures, including development of protocols for pest and disease surveillance.

METHODOLOGY
This study involved six countries of West and Central Africa, namely Ghana, Nigeria, Niger, Senegal, Gabon and the Democratic Republic of Congo (DRC). Two main approaches were used to gather data for the study. First, a review of the literature on forest pests and diseases in the West and Central African (WCA) sub regions was conducted; whereby published literature which included referred journal articles, technical reports, bulletins, books, and various reports mainly from internet sources were reviewed. Information obtained was summarised 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 subregions to interview relevant experts (academicians, policy makers, managers, and industrialists) for firsthand information on past and/or current pests 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 Democratic Republic of Congo) were selected and visited (Fig. 1).

In each country, one-on-one interviews were conducted with identified experts using open-ended questionnaires. Prior to the field visit to each country experts/informants were identified through the African Forest Forum’s database of experts. The contact person was then requested to identify not less than three and more 10 persons to be interviewed. At least one of the experts was to be in the forest industry; another in forest policy and management and the other in academia, preferably in forest protection.

Additionally, field trips to natural forest stands or plantation estates were undertaken to observe past or current forest pest/disease outbreaks in those countries. The choice of forest or plantation to visit was decided on by the contact person from each country. Criteria for selection was current or past outbreak of pest/disease and proximity or access to the site. 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 also visited (Table 1).
Table 1. Number of experts consulted and forest sites visited per country during the field survey

<table>
<thead>
<tr>
<th>Country</th>
<th>No. experts consulted</th>
<th>Forest site/plantation estate visited</th>
<th>Location of forest/plantation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ghana</td>
<td>8</td>
<td>APSD Plantation Estate</td>
<td>Kwame Danso</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FORM Ghana Plantation Estate</td>
<td>Akumadan</td>
</tr>
<tr>
<td>Nigeria</td>
<td>5</td>
<td>Bisrod Furniture Company</td>
<td>Ijebu-Ode, Ogun State</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Forest Demonstration Center)</td>
<td></td>
</tr>
<tr>
<td>Niger</td>
<td>4</td>
<td>Alhaji Eucalyptus Plantation</td>
<td>Dakar</td>
</tr>
<tr>
<td>Senegal</td>
<td>7</td>
<td>City Forest</td>
<td>Dakar Beach</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Casuarina plantation</td>
<td></td>
</tr>
<tr>
<td>Gabon</td>
<td>6</td>
<td>CENAREST Research Forest</td>
<td>Libreville</td>
</tr>
<tr>
<td>Congo DR</td>
<td>4</td>
<td>South Kwamouth REDD+</td>
<td>South Kwamouth</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Agroforestry Pilot Project</td>
<td></td>
</tr>
</tbody>
</table>
RESULTS AND DISCUSSION

Forest and tree pests and diseases: current trends and drivers. The findings presented include information obtained from the review of literature as well as responses obtained from interviewing the national experts. For clarity, the information has been discussed under three subheadings, namely, 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 exist in the WCA region, especially in West Africa. With the exception of few recorded cases, insect pests and disease pathogens generally did not cause long term problems in natural forest stands of West and Central Africa.

Endemic pests in the humid zone. In the humid tropical areas of WCA where there is high species diversity, outbreaks of pests and diseases rarely occur in natural stands. Insect pests and pathogens may well be present, and may damage or kill a few trees every now and then; however, they rarely 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 never been cause for concern. Indigenous tree species with serious endemic pest problems in the humid zone included, Iroko (*Milicia excelsa* and *M. regia*), African mahogany (*Khaya* and *Entandrophragma* spp), Afromosia (*Pericopsis elata*), obeche (*Triplochiton scleroxylon*), opepe (*Nauclea diderrichii*), and *Terminalia ivorensis* (Table 2). Endemic pest problems of these high-value timber species generally account for the persistent failure of indigenous species plantations in the subregion.

Iroko (*Milicia*) suffers severe attacks from the Iroko gall maker *Phytolyma* spp. (Hemiptera: Psyllidae) throughout the region and beyond (Wagner et al., 2008). *Phytolyma 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 susceptible, however, seedlings and actively growing saplings in young plantations are the most affected, often resulting in 100% failure. Another pest of serious regional and global significance is the mahogany shoot borer, *Hypsypyla robusta* (Lepidoptera: Pyralidae). This insect attacks species of the Meliaceae family in Africa, especially African mahoganies *Khaya* and *Entandrophragma*.

Planting of mahogany is currently a major challenge in the WCA region. Shoot borer attack on mahogany often results in damage and deformation and sometimes death of plants at the nursery and in young plantations. Other endemic pests of considerable importance include *Lamprosema lateriitialis* (Lepidoptera: Pyralidae) on *Pericopsis elata* (Afromosia), *Orygmosphora mediofoveata* (Lepidoptera: Noctuidae) on *Nauclea diderrichii* (Opepe/Kusia), and *Anafe venata* (Lepidoptera: Notodontidae), 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 the 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.

The impact of the *A. catacoloides* outbreak in the West African subregion was very pronounced. Apart from defoliating the main target tree species known locally as dahoma...
(Piptadeniasthmum africanum), larvae of the insects also damaged coffee trees, coconut palms, plantain and other wild flora. In addition, the outbreak led to the contamination of water by caterpillar excrements and bodies, rendering the water unsafe for consumption. At least 55 localities were affected, and thousands of people were reported to have fled their homes in the affected communities (Sidibe, 2009). This sudden outbreak of A. catacoloides 2009 on this scale and magnitude is an example of what could happen in the sub regions at any point in time, given the current fluctuating environmental conditions. It is a wake-up call to policymakers, environmentalists, foresters, investors, plant protectionists and the general population on the need for preparation for imminent pest and disease outbreaks in the two subregions.

Table 2. Major insect pests in the humid forest zone of West and Central Africa

<table>
<thead>
<tr>
<th>Insect pest species</th>
<th>Order: Family</th>
<th>Countries of occurrence</th>
<th>Host species</th>
<th>Feeding habit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anaphe venata</td>
<td>Lepidoptera: Notodontidae</td>
<td>Ghana, Nigeria</td>
<td><em>Triplochiton scleroxylon</em></td>
<td>Defoliator</td>
</tr>
<tr>
<td>Analeptes trifasciata</td>
<td>Coleoptera: Cerambycidae</td>
<td>Ghana, Nigeria, Sierra Leone, Benin, Cote d'Ivoire</td>
<td><em>Ceiba pentandra, Tectona grandis, Bombax costatum, Eucalyptus alba, E. terrificornis, Adansonia digitata, Anacardium occidentalis, etc.</em></td>
<td>Stem borer, mainly in the savannah zone and dry forest</td>
</tr>
<tr>
<td>Apatite monachus</td>
<td>Coleoptera: Bostrichidae</td>
<td>Ghana</td>
<td><em>Azaadirachta indica, Terminalia ivorensis, Anacara africana, various other species</em></td>
<td>Stem borer</td>
</tr>
<tr>
<td>Apatite terebrans</td>
<td>Coleoptera: Bostrichidae</td>
<td>Ghana</td>
<td><em>Tectona grandis, Terminalia ivorensis, Cedrela odorata, T. scleroxylon, Eucalyptus spp., Khaya senegalensis, various other species</em></td>
<td>Stem borer</td>
</tr>
<tr>
<td>Diclidophlebia eastopi</td>
<td>Homoptera: Psyllidae</td>
<td>Nigeria, Ghana, Cote d'Ivoire</td>
<td><em>Triplochiton scleroxylon</em></td>
<td>Sap feeder</td>
</tr>
<tr>
<td>Hypsispyla robusta</td>
<td>Lepidoptera: Psyllidae</td>
<td>Ghana, Nigeria, Togo, Cote d'Ivoire, Cameroon</td>
<td><em>Khaya ivorensis, K. anthotheca, K. grandifoliola, K. senegalensis, Entandrophragma utile, Eucalyptus cylinricum</em></td>
<td>Shoot borer, also bores into fruits and seeds</td>
</tr>
<tr>
<td>Lamprosema lateritalis</td>
<td>Lepidoptera: Pyralidae</td>
<td>Ghana</td>
<td><em>Pericopsis elata</em></td>
<td>Defoliator, leaf roller</td>
</tr>
<tr>
<td>Orygmonopora mediofoveata</td>
<td>Lepidoptera: Noctuidae</td>
<td>Ghana, Nigeria, Togo</td>
<td><em>Nauclea diderrichii</em></td>
<td>Shoot borer</td>
</tr>
<tr>
<td>Phytolyma lata</td>
<td>Homoptera: Psyllidae</td>
<td>Ghana, Sierra Leone, Liberia, Cote d'Ivoire</td>
<td><em>Milicia regia</em></td>
<td>Gall maker</td>
</tr>
<tr>
<td>Phytolyma fusca</td>
<td>Homoptera: Psyllidae</td>
<td>Ghana, Nigeria, Togo, Cameroon</td>
<td><em>Milicia excelsa</em></td>
<td>Gall maker</td>
</tr>
</tbody>
</table>
Major insect pests of exotic species. In addition to the problems encountered on indigenous species, introduced or exotic species such as *Gmelina arborea* (gmelina), *Cedrela odorata* (cedrela), *Tectona grandis* (teak) and several species of Eucalyptus, which are widely planted in the sub-region often succumb to insect pest attacks. In the humid zone, *G. arborea* suffer severely from attacks by *Achaea* and *Apophyllia* species which records show resulted in significant damage in Nigeria (Loupe et al., 2008). Teak and cedrela are perhaps the most commonly planted species in the humid zone of the WCA region, mainly in Ghana, Togo, Nigeria, and Cote d’Ivoire. These two species do not have much 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 (Bosu and Apetorgbor, 2009). 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 suffer attacks from another species of *Apate* (*A. monachus*) and other bark borers, especially when the trees are under stress. Unlike teak, cedrela usually 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, including 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, incidence of pests in the savannah woodlands are not common, except for perhaps the routine outbreak of the desert locust (*Shistocerca gregaria*) in the Sahel zone that though are major problem on agricultural crops also affects trees. Trees planted for shade, avenue or woodlots are very important in this zone. Common tree species in the savannah often planted for shade include neem (*Azadirachta indica*), *Terminalia mantaly*, *T. catappa*, and *Eucalyptus* spp. Nearly all of these are also commonly planted in towns and cities in the humid zone. *Terminalia mantaly* grows quite vigorously, with nearly evergreen leaves and beautifully spreading canopy, and is almost the tree of choice in cities in WCA. 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 tree pest problem in the Sahel region of recent memory 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 square kilometers, causing significant damage to neem and other host trees. In Niger and several other countries in the Sahel region, where neem...
is a very important tree, 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. 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, among which are E. camaldulensis, E. territicornis, and E. alba. The objectives for planting include pulp, poles, amenity or wood fuel. Worldwide, Eucalyptus are highly susceptible to pests and diseases, and in Africa the blue gum chalcid (BGC) Leptocybe invasa is causes 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 Eucalyptus in plantations. In Senegal, the observation was made in a small plot located within the city of Dakar, while 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. A more recent survey conducted in eucalypt plantations in 2018 have confirmed the occurrence of BGC at Agogo and Drobonso in the Ashanti of Ghana (Wondafrash et al., unpublished).

In Senegal it was reported that a filao worm (Thyridopterix spp) outbreak was recorded on a plantation of Casuarina established along the beach between Dakar and St. Louis, in 2011 (El Hadji Omar Dieng, DPV Dakar, pers. comm.). The attack affected nearly 1,153 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 (pers. comm., 2015), tree mortality of between 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. A termite expert at the University of Dakar has indicated that termite-related tree mortality has increased in recent times, affecting species of Eucalyptus, Casuarina, Balanites, Acacia, and several other planted trees. He believes the increase is not necessarily the result of climate change, rather he attributes it to increased tree planting and awareness, as the problem has always been there (Ndiaye and pers. Comm., 2015).

**Diseases of trees and forests.** Diseases affecting trees and forests in WCA 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.

Damping-off in the nursery is common throughout the subregion 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 have caused considerable havoc to planted forests (FAO, 1994; Agyeman and Safo, 1997; Apetorgbor and Roux, 2015) (Table 3). Also, host plant dieback associated with attack by the insect Phyholyma spp. and Orygmophora mediofoveata have been recorded on Milicia spp., and Nauclea diderrichii, respectively (Table 3). Root diseases and cankers are also gradually becoming serious in planted forests in the sub-region, especially in Ghana.

Of the major tree diseases, dieback of T. ivorensis, G. arborea and decline of A. indica were recorded several decades ago, between 1970 and 1990. The occurrence of dieback on T. ivorensis in Ghana and Cote 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 for the establishment of 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 generally associated with environmental and nutritional stresses. Fortunately, *T. superba* is not affected and is currently planted widely in West Africa.

**Dieback** of *C. pentandra* is another disease with major impact on regeneration of the host species. It was first observed in Ghana in experimental trials at the Bobiri Forest Reserve in 1996 and is not yet reported in other WCA countries. Unlike dieback of *T. ivorensis*, *Ceiba dieback* affects hosts at nursery stage. It can cause significant damage to seedlings, and can persist throughout the growing stages of the plant. Without proper care and maintenance the likelihood of a 100% mortality at the nursery is high. *Colletotrichum capsici* was the causal agent of the disease (Leaf spot and anthracnose) whereas under favourable conditions, *F. solani* and *L. theobromae* were found to be associated with dieback of stem in the field, however, infected plants of two years old and above often recover from the attack. *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. According to Gbadegesin et al. (1999), 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 high, with infection rates of up to 40% in plantations, while in Cote d’Ivoire and Nigeria, *Armillaria mellea*, *Chaetophoma* sp., *Polyporus* sp., and *Thanatephorus cucumeris* were reported as causal agents.

In addition to outbreak 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 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 *Azadirachta indica* decline is the loss of older foliage. The foliage loss gives the normally dense crown 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, neem decline has also not been clearly associated with any biotic agents. Although several fungi such as *Nigrospora sphaerica* and *Curvularia ragrostidis* have been recovered from neem with symptoms of decline, they have been shown as secondary pathogens.

**Emerging diseases on teak and cedrela.** Teak and cedrela are two introduced species which have been grown extensively in the high forest zone of West Africa without major concern for pests and diseases. However, a survey of plantations has shown signs of disease infections with potentially serious consequences observed in Ghana (Bosu and Apetorgbor, 2009; Bosu et al., 2015). 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, canker of the stem were observed on Cedrela. At the Anwhiaso Forest Reserve where the infection was first reported, spread of the disease was halted with sanitation thinning and selective application combination of fungicides and insecticides on infected trees. Consistent monitoring of pest and disease in plantations of teak and cedrela will be needed to ensure the success of plantation development in the sub region.

**Mollusc or snail pests.** The incidence of snail (*mollusc*) pests in nurseries and newly established plantations appear to be increasing in the WCA region. In Nigeria, at the Bisrop Plantation Estate, it was reported that a serious outbreak of a snail pest was experienced in a Cedrela odorata plantation, resulting in 100% mortality of the saplings. According to the plantation manager, snails first consumed the leaves on the seedlings and saplings and afterwards attacked the young stems rasping off the bark and 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

<table>
<thead>
<tr>
<th>Host tree</th>
<th>Disease type</th>
<th>Causal pathogen (s) or Predisposing factors</th>
<th>Countries of occurrence</th>
<th>Host species Indigenous or Introduced</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Azadirachta indica</em></td>
<td>Decline</td>
<td>No pathogen associated with decline. Caused by environmental/ nutritional stresses</td>
<td>Cameroon, Chad, Mali, Niger, Nigeria</td>
<td>Introduced</td>
</tr>
<tr>
<td><em>Casuarina equitosifolia</em></td>
<td>Dieback</td>
<td>Associated with soil nutrition limitations</td>
<td>Benin</td>
<td>Introduced</td>
</tr>
<tr>
<td><em>Cedrela odorata</em></td>
<td>Root rot, Stem canker</td>
<td><em>Armillaria</em> sp., <em>Stem borer, Apate terrebrans, Fusarium solani and Lasiodiplodia theobromae are associated opportunistic pathogens</em></td>
<td>Ghana</td>
<td>Introduced</td>
</tr>
<tr>
<td><em>Ceiba pentandra</em></td>
<td>Dieback</td>
<td><em>Fusarium solani, Lasiodiplodia theobromae, Colletotrichum capsici</em></td>
<td>Ghana</td>
<td>Indigenous</td>
</tr>
<tr>
<td><em>Gmelina arborea</em></td>
<td>Dieback and root diseases</td>
<td><em>Gibberella fujikuroi, Sclerotium rolfsii, Armillaria mellea, Chaetophilma spp., Polyporus sp. and Thanatephorus cucumeris.</em></td>
<td>Ghana, Cote d’Ivoire, Nigeria</td>
<td>Introduced</td>
</tr>
<tr>
<td><em>Terminalia ivorensis</em></td>
<td>Dieback</td>
<td>No pathogen associated with dieback. Caused by environmental/ nutritional stresses</td>
<td>Ghana, Cote d’Ivoire</td>
<td>Indigenous</td>
</tr>
<tr>
<td><em>Tectona grandis</em></td>
<td>Root disease</td>
<td><em>Armillaria</em> spp., <em>Phellinus noxius, Phaeolus manihotis</em></td>
<td>Ghana, Nigeria, Cote d’Ivoire, Benin</td>
<td>Introduced</td>
</tr>
</tbody>
</table>
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* which survived the fire, re-sprouted 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. 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.

**Impact of pests and diseases on indigenous forest trees.** 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, incidences like that 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 fully developed in the region. Oftentimes, the impact of pests and diseases is hardly noticeable if present in naturally occurring forest stands. However, on few occasions outbreaks in natural stands have had a significant impact on the forests with corresponding socioeconomic impacts on local communities. The outbreak of *A. catacoloides* in West Africa in 2009 is a good example. Otherwise, major effects of forest and tree pests and disease in the sub region 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 most indigenous species plantations, and the resultant shift towards the planting of in exotic species. 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 Iroko (*Milicia excelsa* and *Milicia regia*) as a major export timber in the region, this has not been realized (Cobbinah and Wagner, 2000). Stakeholders are still apprehensive when it comes to 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 (*Opuni-Frimpong et al.*, 2005).

Traditionally, diseases and pests of trees and forests have had the most impact on indigenous species in the humid forest zone (Wagner *et al.*, 2008)). However, exotic species which were hitherto considered somewhat “immune” are becoming increasingly vulnerable to pest outbreaks due to several reasons. Firstly, increased international trade has been proven to increase the introduction and spread of invasive pests 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.

Secondly, widespread planting of certain exotic species often increases the likelihood of native pests adapting to these exotic species. 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. Teak is currently the most widely planted timber species and constitutes at least 70% of planted forests in Ghana (FC, 2013).
Thirdly, the impact of global climate change phenomenon 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. Pests and disease outbreaks of varying intensities continue to be recorded on previously “secure” exotic species such as Eucalypts, Tectona, Cedrela, Gymelina and Azadirachta.

The approach used to contain the A. catacoloides outbreak in West Africa should be documented and improved for future outbreaks in the sub regions. The roles played by the governments of affected countries, the Economic Community of West African States (ECOWAS), International Institute of Tropical Agriculture (IITA), and the involvement of several international research and academic institutions.

**Pests 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 serious effect on agriculture crops, other insects such as Analeptis and Apatte species also cause considerable damage to trees. The oriental scale insect outbreak on neem resulted in the death of over one million trees, and covered an area of over one million square kilometers in the Lake Chad Basin countries (Lale, 1988).

Nurseries of Eucalyptus species 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. For example, a visit to the FORM Ghana Plantation Estates as part of the study revealed that the Company spends approximately GH¢3,000.00 (approximately US$780.00) per week on pesticides to control snail damage on African mahogany seedlings at the nursery stage. At the African Plantations and Sustainable Development (APSD) Plantation Estate, also in Ghana, it was reported that the Company has a breeding programme in place to ensure that superior clones of Eucalyptus are continually being selected for planting, in order to minimise 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 in the sub-region. Oftentimes, 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 few years of initiation, unless no major pest or disease outbreak occurs.

**CONCLUSION AND RECOMMENDATIONS**

Major insect pests and diseases of forests and trees in West and Central Africa occur on valuable 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 *Tectona grandis* and *Cedrela odorata* and various species of *Eucalyptus* spp. have been grown for many decades without much pest problems in the sub region. However, a new trend is 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 sub region. In their native range, teak for example, suffer severely from defoliation by *Hybalaeguera* (Lepidoptera:
Hyblaeidae), and Cedrela from the other strains of the mahogany shoot borer Hypsipyla grandella (Lepidoptera: Pyralidae). 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 climate change phenomenon which most experts believe could exacerbate pest and disease problems around the world, WCA countries should take steps to prevent the introduction and spread of pests and diseases.

Countries in the two sub-region 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 has been slow, at best. 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 on pests of agricultural concern have all contributed to the current situation.

Increased pest surveillance and surveys followed by prompt management is required and so the following have been suggested:

i. National governments should develop the laws and legislations required for the implementation of phytosanitary and in particular surveillance systems at national and regional levels;

ii. Member countries should increase the capacity of their national plant protection organisations to make it possible for effective surveillance and control of forest pests and diseases. Additionally, the capacity of the technical staff should be upgraded whiles the necessary tools and equipment should be provided and/or regularly updated;

iii. Stakeholders in the forestry sector should be sensitised about threats of forest pests in the sub-region and the need to include surveillance in their programmes and operations; and

iv. Member countries should develop national protocols and guidelines for the implementation of surveillance programmes. To increase stakeholder appreciation and involvement of the entire process, the drafting, testing and implementation of these protocols should involve all, or as many, relevant national experts and institutions as possible.

Since private investors are interested in putting their money into high value, short-rotation exotic timber species it will be prudent for national governments and institutions in the region to focus more attention to indigenous species that have both socioeconomic, cultural and environmental benefits to the countries and the region. Strategies such as enrichment planting, agroforestry systems, and management of natural regeneration on farms could be more cost effective and culturally acceptable approaches to ensuring sustainable production of many of these susceptible indigenous species.

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STATEMENT OF NO-CONFLICT OF INTEREST
The authors declare that there is no conflict of interest in this paper.

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