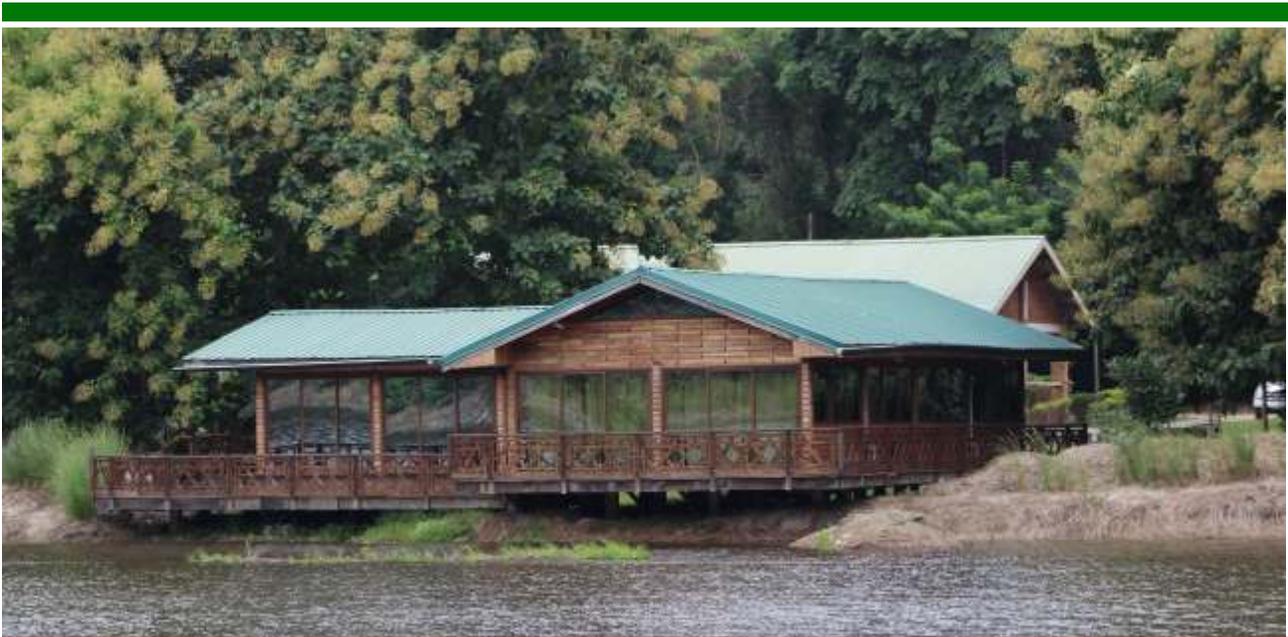FORESTRY RESEARCH INSTITUTE OF GHANA

Book of Abstracts 2017

2017 Refereed Journal Articles

and Conference papers

CSIR-FORESTRY RESEARCH INSTITUTE OF GHANA

BOOK OF ABSTRACTS

2017 REFEREED JOURNAL ARTICLES AND CONFERENCE PAPERS

2018

For more information, please contact:

The Director
CSIR-Forestry Research Institute of Ghana
U.P Box 63 KNUST
Kumasi, Ghana

Telephone
Director: +233-3220-60122
Offices: +233-3220-60123/60373
Website: www.csir-forig.org.gh
Email: director@csir-forig.gh

Compiled by:
Dr. Margaret Sraku-Lartey
Mr Emmanuel Sarpong

Foreword

We present to you the 2017 edition of CSIR-FORIG's Book of Abstracts. The 2017 edition now includes abstracts of conference papers presented during the year 2017. The articles published in this book cover biodiversity conservation and ecosystem services, forest improvement and productivity, wood industry and utilization, forest products and marketing, forest policy, governance and livelihoods and climate change among others.

The articles have already been published in various journals so all citations should be based on the original source detailed in the booklet. Full papers of the articles may be obtained from the original journals or from the author.

With adequate support, the Institute will continue to disseminate information on cutting edge technologies and methodologies that could contribute to sustainable management of forest resources for the benefit of society.

Prof. Daniel A. Ofori
Director, CSIR-FORIG

Table of Contents

ABSTRACTS OF CONFERENCE PAPERS

Introduction

The 2017 Book of Abstracts is a sequel to the 2016 edition. It is a compilation of scientific articles and conference papers written by CSIR-FORIG scientists in 2017. The publication is to create awareness by Selectively Disseminating the outputs of research which have been published in international and local journals during the year under review.

The publication is for non-commercial purposes and cannot be reproduced for any monetary gain. A total of 25 journal articles and 6 conference papers were published by scientists of CSIR-FORIG in peer reviewed journals worldwide. Some articles were joint publications with local and international partners and colleagues, while others were sole publications by scientists.

Each abstract has been arranged in alphabetical order and numbered chronologically. The name of each CSIR-FORIG scientist has also been highlighted in each abstract.

All sources have been duly acknowledged and follow the publishers' guidelines on the re-use of their journal articles.

1. Aabeyir, R., Agyare, W. A., Weir, M.J.C. & Adu-Bredu, S. (2017). Multi-Level land cover change analysis in the Forest-Savannah Transition Zone of the Kintampo Municipality, Ghana. *Journal of Natural Resources and Development 7: 1-11.*

This study presents a multi-level analysis of land cover change in the Kintampo Municipality of Ghana using Landsat TM, ETM + and Landsat 8 images from 1986, 2001 and 2014, respectively. The expected and observed annual rates of land cover change for the periods 1986 to 2001 and 2001 to 2014 were analyzed at temporal and intra and inter-land cover levels using post- classification change detection. The results reveal that the expected annual rate of land cover change for the time intervals is 2.55 %. The observed annual rate of change from 2001 to 2014 is 2.63 %, which is greater than the expected value. This shows that land cover changed faster than expected in this period. The observed intra-land cover gains and losses for woodland is 2.49 % which is less than expected for the change periods. This suggests that the observed gain and loss in woodlands are attributable to random changes. The inter-land cover level changes for both periods reveal that when woodland gained or lost, it did not target shrub/grassland. This shows that the process of gain or loss in woodland in both periods was random. This is an indication that woodland cover is sustained by a slow, natural regeneration process and not by anthropogenic activities. The findings highlight the relevance of multilevel land cover analysis in land cover assessment. The temporal level highlights the need to relate changes in land cover to anthropogenic activities for a better understanding of the changes. The study also revealed that multi-level land cover analysis can facilitate management decisions on whether to reduce loss in woodland or increase gain in woodland cover from shrub land.

2. Adele, C.M.J., Jardine, P.E., Adu-Bredu, S., Coe, A.L., Duah-Gyamfi, A., Fraser, W.T., Lomax, B.H., Malhi, Y., Moore, S., Owusu-Afriyie, K. and Gosling, W.D. (2017). The modern pollen– vegetation relationships of a tropical forest–savannah mosaic landscape, Ghana, West Africa. *Palynology: 1-15. Published online August 10, 2017. (http://dx.doi.org/10.1080 /01916122.2017.1356392).*

Transitions between forest and savannah vegetation types in fossil pollen records are often poorly understood due to over-production by taxa such as Poaceae and a lack of modern pollen-vegetation studies. Here, modern pollen assemblages from within a forest-savannah transition in West Africa are presented and compared,

their characteristic taxa discussed, and implications for the fossil record considered. Fifteen artificial pollen traps were deployed for 1 year, to collect pollen rain from three vegetation plots within the forest-savannah transition in Ghana. High percentages of Poaceae and Melastomataceae/Combretaceae were recorded in all three plots. *Erythrophleum suaveolens* characterised the forest plot, *Manilkara obovata* the transition plot and *Terminalia* the savannah plot. The results indicate that Poaceae pollen influx rates provide the best representation of the forest-savannah gradient, and that a Poaceae abundance of >40% should be considered as indicative of savannah-type vegetation in the fossil

Keywords: Pollen; Transitions; Poaceae; Savannah; Ghana; Palaeoecology; Bosumtwi.

3. Akpalu, E. S., Adeyiga, G. K., Amooh, M. K., Kyereh, D. and Akpalu, M. (2017). Population density and diversity of trees on farmlands in three districts of the Upper East Region of Ghana: Implications for food security and ecosystem sustainability, *Journal of Agriculture and Ecology Research International, 10(3):1-11.*

Ghanaian farmers have been practicing farming since time immemorial and trees are a normal component of farmlands. However, the choice of particular tree species and their population on the farms is greatly influenced by the farmers' preferences and therefore, the utility value placed on particular tree species. This study was conducted to determine the number of trees per unit area of farmland, the diversity of the tree species, and the factors that influence farmers' decision to leave trees on their farms in three districts of the Upper East region of Ghana. It also seeks to determine any relationship between tree density and the yields of commonly cultivated crops in the study area. The area falls within the Guinea and Sudan savanna zones, characterized by a short unimodal rainfall regime (about 5 months) and a rather long dry season. Twelve communities (4 per district) were randomly selected and farmers were interviewed on their reasons for allowing trees on their farmlands as well as the yields of major crops cultivated. Ten farms in each community were also randomly selected and inventories of trees were conducted, where trees were identified, and enumerated. Farm sizes were also measured. Mean tree population densities on farms were 18.5, 18.4 and 25.9 trees per hectare in the Garu-Tempane, Bawku West and Kassena Nankana West districts respectively. A Shannon Weiner diversity index of 1.563, 1.195 and 1.551 were calculated for Garu-Tempane, Bawku West and Kassena Nankana West districts respectively. Forty-two (42) different tree species belonging to 23 families were encountered in Garu-Tempane district, 28 species from 18 families were encountered in the Bawku West district and 37 species belonging to 21 families in the Kassena Nankana West

district. *Azadirachta indica, Combretum molle, Diospyros mespiliformis* were the commonest on all farms. Factors that influenced farmers' decision to allow trees on their farms were shade (22%), fuelwood (18%), food (15%), medicine (13%), housing (13%), soil improvement (10%), erosion control (7%), fodder (1%) and others (1%). Crop yields were generally high in the Bawku West district and there was no significant relationship between tree population density and the yields of crops.

Keywords: Population Density; Species Diversity; Species Richness; Agroforestry; Tree-Crop; Interaction.

4. Annoh, C. E., Ewusie, E.A., Cobblah, M. A., Osae, M.Y., Boateng, B. A., Kwapong, P. K., Aidoo, K. and Bosu, P. P. (2017). Status and trends of monitoring insect pollinators in mango ecosystem in southern Ghana. *IJRDO-Journal of Applied Science 3 (2):1-14.*

Several insects including the bees and other animals like bats are estimated to boost pollination services of 35% of the world's food crops like mangoes, vegetables and medicinal plants. Researchers have shown declining trends of populations of some wild pollinators, particularly the honey bee. This study was to determine insect diversity, abundance and monitor seasonal trends of insect pollinators in the mango ecosystem of ten selected farms in the southern part of Ghana. In each farm, a radial transect of 10-meter diameter was constructed. Thirty small plastic pan traps were placed singly on 30 polyvinylchloride pipes fixed at 1-meter intervals. The pan traps filled with soapy water, were coloured of ten cohorts of florescent blue, yellow and white respectively. Monitoring was conducted during the flowering periods of the minor and major mango seasons of 2012 and 2013. A total of 2364 insects were trapped; the most abundant were dipterans (1435) largely made up of house flies. The hymenopterans (504) consisted of 418 bees and 86 wasps respectively. Blue (2.85) and white (2.09) coloured traps attracted bees more than yellow (1.62) coloured traps (p=0.89). The flies were most attracted to white traps (5.38) followed by yellow (4.35) and blue (3.61), the least (p=1.35). In farms close to natural vegetation bees declined from 3.00 per trap per week in 2012 major season through to 1.00 in 2013 major season. The declining trend of bees in this study underscores the need to manage and conserve wild pollinators for sustainable food productivity.

Keywords: Polyvinylchloride, Pollinators, Mango, Vegetation, Dipterans, Hymenopterans

5. Appiah-Kubi, E., Militz, H., Gellerich, A. and Kankam, C.K. (2017). Decay resistance of plantation grown Khaya ivorensis to brown-rot and white-rot fungi. *Ghana Journal of Forestry, 33:31-37.*

In Ghana, timber resources have dwindled as a result of overexploitation of popular commercial species such as African mahogany *(Khaya and Entandrophragma spp)*. For sustainable supply of wood development, government and industry have embarked on an accelerated plantation development programme. It is known, however, that properties of wood from natural stands, including durability, generally differ from wood obtained from plantation-grown timber due to higher proportion of juvenile wood in plantation-grown timber and differences in extractives. The aim of the study was to determine decay resistance of plantation mahogany timber to brown rot *(Gloeophyllum trabeum)* and white rot *(Trametes versicolor)* fungi. Tests were conducted according to CEN/TS 15083-1(2005). Mass loss of the specimens was assessed after 16 weeks of exposure to the test fungi. Mass loss as a result of brown rot fungus was 0.47% for plantation-grown wood and 1.51% for naturally-sourced wood. On the other hand, wood from plantation and natural mahogany trees had mass losses of 20.71% and 23.95% respectively, against white rot fungus and were classified as belonging to durability class 4 (slightly durable). Plantation-grown mahogany is therefore not inferior to naturally-grown mahogany and both can be utilized in same conditions.

Keywords: Natural Durability, Plantation-Grown Wood, Mahogany, Brown rot fungi, White rot fungi.

6. Asante, W. A., Dawoe, E., Acheampong, E. and Bosu, P.P. (2017). A new perspective on forest definition and shade regimes for REDD+ interventions in Ghana's cocoa landscape. *Ghana Journal of Forestry, 33:1-15.*

Efforts to use spectral characteristics to differentiate between various shade regimes in cocoa plantations in Ghana have generally been difficult. Therefore, the use of field-based approaches to provide a landscape level understanding of how the Ghana forest definition parameters play-out on the ground, and their implications for climate change mitigation interventions within the cocoa landscape of the High Forest Zone is very imperative. Using a replicated transect approach, biophysical data on dendrometric parameters of cocoa and shade trees were collected from ninety 1 ha plots, in ten cocoa growing districts within the cocoa landscape. The stocking density and other dendrometric parameters of upper canopy trees (UCT) on farms differed significantly between districts. Stem densities of UCT were highest at Offinso District (22.8 ± 1.7 stems ha-1) and lowest at Goaso District (16.2 ±3.00 stems ha-1). Crown cover ranged from 5.8 ±1.22 to 16.3 ±1.74 %

in the Asumura and Asempanaye Districts, respectively. The use of stem numbers alone would classify cocoa farms in only two of the 10 study districts, New Edubiase and Offinso landscapes, as having high shade. Results from this study also indicated an overall mean cocoa tree height of 6.3 m, which is higher than the height component of the national forest definition parameters. Clearly, for cocoa systems to meet the national forest definition threshold, the critical parameter was the tree height, based on the fact that the cocoa landscape in most areas are quite contiguous and easily meet the crown cover and land area parameters. Result from the study reiterates the need to consider the potential and implications of different cocoa systems as forests in the national REDD+ discussions. The study therefore concludes that cocoa systems could be referred to as forests, if the Ghana forest definition is to be applied in its strict sense. However, if cocoa trees are masked out because they are seen to be agricultural crops, then UCT or shade trees in the cocoa systems provide the best means to apply the forest definition. Also, given the current nature and extent of tree incorporation in the cocoa landscape, it is misleading to use stem numbers to indicate shade levels.

Keywords: Theobroma cacao, Shade Systems, Tropical Forest, Climate Change Mitigation, Monitoring

7. Bani, B. K., Damnyag, L. 2017. Farmers' willingness to pay for ecosystem services to enhance agricultural production in Sene East District, Ghana. *Small-Scale Forestry 16(4):451-467.*

This study investigated farmers' willingness to pay (WTP) by trading food crop as payment for the provision of ecosystem services (ES) to enhance agricultural production and factors influencing their WTP through integrating timber trees on their farmlands in Sene East district, Ghana. A total of 177 farmers were selected from six communities using stratified and simple random sampling. One-on-one interviews were conducted using structured questionnaires. The contingent valuation method was used to gather the data on farmers' WTP for the provision of ES. A multiple linear regression was run to test factors influencing farmers' WTP. The results showed that 59% of farmers were willing to pay for the provision of ES. Gender, age, educational status, farmers' perception to climate change and access to land significantly ($p < .001$) and positively influence farmers' WTP. This study identified difficulties in acquiring land, insecure tree tenure and indiscriminate logging as governance challenges that should be addressed to support farmers' WTP for the provision of ES to enhance agricultural production.

8. Borden K. A., Anglaaere, L. C. N., Adu-Bredu, S. & Isaac, M.E. (2017). Root biomass variation of cocoa and implications for carbon stocks in agroforestry systems. *Agroforestry Systems (doi 10.1007/s10457-017-0122-5).*

Cocoa *(Theobroma cacao L.)* root systems are typically assumed to contribute a small portion of carbon (C) to total C stocks in cocoa agroecosystems. Yet there are almost no direct measurements of cocoa coarse root biomass to support this assumption, presumably due to the difficulty of measuring coarse roots in situ and the risk to farmers' livelihoods. Instead, root biomass is commonly estimated using allometry based on forest data, which might not be accurate for perennial crops given their range of management conditions. In this study, we bridge conventional methods of quantifying coarse root biomass with non-destructive application of ground penetrating radar to estimate cocoa belowground biomass (BGB) and C stocks in an agroforestry system in Ghana. BGB was measured for cocoa grown with shade trees *(Entandrophragma angolense* or *Terminalia ivorensis*) and in monoculture. BGB estimates showed good accuracy, with a relative root mean square error of 7% from excavated plants. It was estimated that 15-year-old cocoa hold approximately 6.0 kg C plant- 1 in coarse root biomass and have a root to shoot ratio of approximately 0.23. However, the results indicate that proportionally more biomass was allocated to roots for cocoa grown in mixture with shade trees. Plot scale estimates show that cocoa roots contributed 5.4–6.4 Mg C ha- 1, representing 8–16% of C stocks in all live tree biomass (cocoa + shade trees), depending on shade tree management. Our findings illustrate a promising approach for non-destructive BGB inventories of perennial crops. It is highlighted that although commonly used pan-tropical allometric equations may broadly function in estimating BGB for cocoa, this approach assumes proportional allocation between aboveground biomass and BGB, which may translate into inaccuracies in C stock inventories across diverse cocoa agroecosystems.

9. Bosu, P. P., Acquah, E. and Boamah, R. O. (2017). Evaluation of four insecticides for the protection of Nauclea diderrichii seedlings against Orygmophora mediofoveata (Lepidoptera: Noctuidae) shoot borer damage. *International Journal of Tropical Insect Science (doi: 10.1017/S1742758417000236).*

Nauclea diderrichii (De Wild and Th. Dür.) (common name Kusia and trade name,

Opepe) is an evergreen tree found throughout the tropical rainforests of West Africa. It is heavily exploited for its timber and listed as vulnerable on the IUCN Red List of Threatened Species. The shoot borer *Orygmophora mediofoveata* Hamps, which attacks the nursery stage, has hampered attempts to establish *N. diderrichii* plantations in Ghana. This study examined the potential of four insecticides to protect *N. diderrichii* seedlings from *O. mediofoveata* attack and damage. Four insecticides–Pyrinex (chlorpyrifos), Dursban (chlorpyrifos), Cerox (dimethoate) and Golan (acetamiprid)–were applied to four-month-old *N. diderrichii* seedlings growing in full sunlight and under shade (80% of normal light), to evaluate their effects on incidence of attack, survival, severity of damage and growth. Insecticide treatment and light conditions had variable effects on the damage and growth of the seedlings after six months of evaluation. Seedling survival was not significantly influenced by the insecticide treatment. Percent survival of insecticide-treated seedlings did not differ significantly from that of control seedlings in full sun; however, under shade survival of treated seedlings was significantly higher than control seedlings. Nonetheless, control seedlings in full sun had higher survival (92.5%) than those under shade (62.5%). Insecticide-treated seedlings in full sun had lower incidence of shoot borer attack than those under shade. In full sun, dieback incidence following shoot borer attack was significantly lower for insecticide-treated than control seedlings. Growth in height and girth of seedlings was influenced positively by both insecticide and light, with girth especially being significantly lower under shade conditions. Currently, *N. diderrichii* seedlings are typically raised under shade; however, this study shows that raising seedlings in full sun with insecticide application could result in faster and better growth.

Keywords: *Nauclea diderrichii; Orygmophora mediofoveata;* D; acetamiprid; Chlorpyrifos.

10. Damnyag, L., Anglaaere, L.C.N., Tease, F., Bani, K.B., Bawuah, A.E. (2017). Analysis of farmers' willingness to pay for tree integration on farmlands in Ankasa Conservation Area, *Ghana. Ghana Journal of Forestry 33: 16-30.*

The study investigated farmers' willingness to pay to integrate trees on farmlands. It also identified governance arrangements required to support farmers in REDD+ policy response. A sample of farmers involved in indigenous timber species planting on farmlands in Ankasa Conservation Area were surveyed using closed ended questionnaire. Contingent valuation method was employed in the design of the questionnaire and the survey. Ordinary least squares regression technique was employed in the data analysis. The mean willingness to pay (WTP) to integrate timber tree species on a hectare of farmland is GHC887.08 (US$253.45). Farmer's age, gender and rights to own trees on farmlands were the significant factors

explaining willingness to pay for tree integration on farmlands. However, landholding status is statistically not significant and does not influence WTP. One important challenge to farmers in integrating trees on farmlands is lack of knowledge of silvicultural practices. Preferred measures to deal with the challenges include support to farmers to spray farms frequently against pest and diseases. Formalized and secured tree tenure for farmers is one of the most important governance arrangements required to support farmer tree integration on farmlands. The study recommends that for effective integration of trees on farmlands in support of REDD+ implementation, the state needs to let citizens know whom carbon rights are to be vested in, so as to encourage farmers with the intention to invest in timber tree planting on their farms.

Keywords: Farmland tree integration, willingness-to-pay, good governance arrangements, ordinary least square regression, REDD+.

11. Essien, C.; Via, B. K.; Gallagher, T.; McDonald, T.; Eckhardt, L. (2017). Sensitivity of acoustic tools to variation in equilibrium moisture content of small clear samples of Loblolly pine (Pinus taeda). *Journal of Indian Academy of Wood Science, 11pp. https://doi.org/10.1007/s13196-017-0202-1*

There are several types of acoustic tools commercially available for wood characterization, but they are generally classified into resonance and time-of-flight (ToF) tools. This classification is based upon the mode of velocity estimation for wood. In this study, we explored how the equilibrium moisture content of small clear wood samples (2.5 cm × 2.5 cm × 41 cm) affect the predictive capabilities of two types of acoustic tools namely a microsecond timer (ToF) and a resonance log grader (resonance). The results indicated the acoustic velocity is sensitive to equilibrium moisture content of loblolly pine, and sensitivity to EMC is similar for both type of tools. The acoustic velocity decreased by 32.9 and 28.8 m/s for ToF and the resonance acoustic tools respectively for a unit increase in EMC below fiber saturation point (FSP); 5.4 and 6.1 m/s respectively for a unit increase in EMC above FSP although the slope was statistically equivalent to zero. Also, the static MOE of the green samples was overestimated by 16% by both resonance and ToF tools with oven-dried density, while it was 72% when estimated with density at test. The insignificant slope coupled with better accuracy in MOE supports the hypothesis that the cell wall controls the acoustic velocity while the water in the lumen of the cell wall is insignificant. These results bring into question the standard use of green density to estimate acoustic MOE of live trees and oven dry density is instead recommended.

Keywords: Fiber saturation point; Acoustic velocity; Static modulus of elasticity; Time-of-flight

12. Essien, C., Via, B. K., Cheng, Q., Gallagher, T., McDonald, T., Wang, X. Eckhardt, L.G. (2017). Multivariate modeling of acousto-mechanical response of 14-year-old suppressed loblolly pine (Pinus taeda) to variation in wood chemistry, microfibril angle, and density. *Wood Science & Technology 51: 475 – 492 (doi : 10.1007/s00226-017-0894-9).*

The polymeric angle and concentration within the S2 layer of the softwood fiber cell wall are very critical for molecular and microscopic properties that influence strength, stiffness and acoustic velocity of wood at the macroscopic level. The main objective of this study was to elucidate the effect of cellulose, hemicellulose, lignin, microfibril angle and density on acoustic velocity and material mechanical properties of 14-year-old suppressed loblolly pine. Cellulose, hemicellulose and density are consistently the most important drivers of strength, stiffness and velocity. Cellulose and lignin are the highest and lowest contributor to velocity, respectively, with lignin acting as a sound wave dispersant, while cellulose is the most important conductor of sound wave at the molecular level, while hemicellulose acts as a special coupling agent between these components. The polymeric constituents are thus important drivers of sound wave propagation at the molecular level, while density played a subsequent role at the macro-scale.

13. Essien, C., Via, B. K., Acquah, G., Gallagher, T., McDonald, T., & Eckhardt, L. (2017). Effect of genetic sources on anatomical, morphological, and mechanical properties of 14-year-old genetically improved loblolly pine families   from two sites in the southern United States, journal, *Journal of Forestry Research. doi.org/10.1007/s11676-017-0584-3*

Tree improvement programs on loblolly pine (Pinus taeda) in the southeastern USA has focused primarily on improving growth, form, and disease tolerance. However, due to the recent reduction of design values for visually graded southern yellow pine lumber (including loblolly pine), attention has been drawn to the material quality of genetically improved loblolly pine. In this study, we used the time-of-flight (TOF) acoustic tool to assess the effect of genetic families on diameter, slenderness, fiber length, microfibril angle (MFA), velocity and dynamic stiffness estimated using green density (DMOEG) and basic density (DMOEB) of 14-year-old loblolly pine stands selected from two sites. All the 184 and 204 trees of the selected eight half-sib genetic families on sites 1 and 2 respectively were tested using TOF acoustic tool, and two 5 mm core samples taken at breast height level (1.3 m)used to for the anatomical and physical properties analysis. The results indicated a significant

positive linear relationship between dynamic MOEs (DMOEG and DMOEB) versus tree diameter, slenderness, and fiber length while dynamic MOEs negatively but nonsignificant correlated with MFA. While there was no significant difference in DMOEB between sites; velocity2 for site 1 was significantly higher than site 2 but DMOEG was higher for site 2 than site 1. Again, the mean DMOEG and DMOEB reported in the present study presents a snapshot of the expected static MOE for green and 12% moisture conditions respectively for loblolly pine. Furthermore, there were significant differences between families for most of the traits measured and this suggests that forest managers have the opportunity to select families that exhibit the desired fiber morphology for final product performance. Lastly, since the dynamic MOE based on green density (DMOEG), basic density (DMOEB) and velocity2 present difference conclusions, practitioners of this type of acoustic technique should take care when extrapolating results across the sites.

Keywords: Genetic families, Loblolly pine, Time-offlight, Resonance-based , Modulus of elasticity, Modulus of rupture.

14. Gosling W.D., Adele C.M. Julier A.C.M., Adu-Bredu S., Djagbletey G.D., Fraser, W. T., Jardine, P. E., Lomax, B. H., Malhi Y., Manu E.A., Mayle, F. E., Moore S. & (2017). Pollen-vegetation richness and diversity relationships in the tropics. *Journal of Vegetation History & Archaeobotany. doi 10.1007/s00334-017-0642-y.*

Tracking changes in biodiversity through time requires an understanding of the relationship between modern diversity and how this diversity is preserved in the fossil record. Fossil pollen is one way in which past vegetation diversity can be reconstructed. However, there is limited understanding of modern pollen-vegetation diversity relationships from biodiverse tropical ecosystems. Here, pollen (palynological) richness and diversity (Hill N1) are compared with vegetation richness and diversity from forest and savannah ecosystems in the New World and Old World tropics (Neotropics and Palaeotropics). Modern pollen data were obtained from artificial pollen traps deployed in 1-ha vegetation study plots from which vegetation inventories had been completed in Bolivia and Ghana. Pollen counts were obtained from 15 to 22 traps per plot, and aggregated pollen sums for each plot were >2,500. The palynological richness/diversity values from the Neotropics were moist evergreen forest=86/6.8, semi- deciduous dry forest=111/21.9, wooded savannah=138/31.5, and from the Palaeotropics wet evergreen forest=144/28.3, semi-deciduous moist forest=104/4.4, forest-savannah transition=121/14.1; the corresponding vegetation richness/diversity was 100/36.7, 80/38.7 and 71/39.4 (Neotropics), and 101/54.8, 87/45.5 and 71/34.5 (Palaeotropics). No consistent relationship was found between

palynological richness/diversity, and plot vegetation richness/diversity, due to the differential influence of other factors such as landscape diversity, pollination strategy, and pollen source area. Palynological richness exceeded vegetation richness, while pollen diversity was lower than vegetation diversity. The relatively high global diversity of tropical vegetation was found to be reflected in the pollen rain.

Keywords: Neotropics; Palaeotropics; Palynology; Pollen trap; Forest-savannah; Savanna

15. Guuroh, R.T., Linstädter, A., Ferner, J., Canak, K., Ruppert, J. C., Schmidtlein, S. (2017). Drivers of forage provision and erosion control in West African savannas – A macroecological perspective. Journal of Agriculture, *Ecosystems & Environment, 251:257–267.*
doi : http://dx.doi.org/10.1016/j.agee.2017.09.017.

Rangelands' ability to provide ecosystem services (ESs) depends on ecosystem properties and functions, which are interactively driven by biophysical and land-use drivers. In West Africa's savanna rangelands, the relative importance of these drivers for ES supply is still poorly understood, hampering the identification of appropriate management strategies. In this context, trade-offs between the ES of forage provision and the regulating ES of erosion control are of particular importance. Taking a macroecological perspective, we aimed at detecting consistent patterns in ES drivers and identifying good predictors. The study area comprises a steep gradient of climatic aridity across West Africa's Sudanian savannas from northern Ghana to central Burkina Faso, in combination with local gradients of land-use intensity and topo- edaphic conditions. We used aboveground biomass, metabolisable energy and metabolisable energy yield as proxies for forage provision, and the cover of perennials in the grass layer as a proxy for erosion control. Linear mixed-effect models and model selection were used to test relationships between multiple environmental variables and ES proxies. We found differential responses of ES proxies to environmental drivers. Vegetation properties were important for all ESs. Antecedent rainfall was the most important predictor of aboveground biomass, while plants' phenology and land-use were most important for metabolisable energy. Environmental variables (such as aridity, soil properties and grazing intensity) mediated via vegetation properties were the most important predictors of erosion control followed by the direct effect of climatic aridity. Our finding that antecedent rainfall was more important for forage provision than climatic aridity implies that the effects of long-term climatic aridity may in a given year be overridden by current season's precipitation particularly in case of a good rain year. The observed importance of land-use and vegetation

properties implies that well- conceived adaptation strategies could mitigate potential negative effects of climate change.

16. Julier, A. C. M., Jardine, P.E., Adu-Bredu, S., Coe, A.L., Duah-Gyamfi, A., Fraser, W.T., Lomax, B.H., Malhi, Y., Moore, S., Owusu-Afriyie, K. & Gosling, W.D. (2017). The modern pollen– vegetation relationships of a tropical forest–savannah mosaic landscape, Ghana, West Africa. *Palynology, doi: 10.1080/01916122.2017.1356392*

Transitions between forest and savannah vegetation types in fossil pollen records are often poorly understood due to over-production by taxa such as Poaceae and a lack of modern pollen-vegetation studies. Here, modern pollen assemblages from within a forest-savannah transition in West Africa are presented and compared, their characteristic taxa discussed, and implications for the fossil record considered. Fifteen artificial pollen traps were deployed for 1 year, to collect pollen rain from three vegetation plots within the forest-savannah transition in Ghana. High percentages of Poaceae and Melastomataceae/Combretaceae were recorded in all three plots. *Erythrophleum suaveolens* characterised the forest plot, *Manilkara obovata* the transition plot and *Terminalia* the savannah plot. The results indicate that Poaceae pollen influx rates provide the best representation of the forest-savannah gradient, and that a Poaceae abundance of >40% should be considered as indicative of savannah-type vegetation in the fossil record.

17. Moore, S., Adu-Bredu, S., Duah-Gyamfi, A., Addo-Danso, S.D., Ibrahim, F., Mbou, A.T., de Grandcourt, A., Valentini, R., Nicolini, G., Djagbletey, G., Owusu-Afriyie, K., Gvozdevaite, A., Oliveras, I., Ruiz-Jaen, M.C., Malhi, Y. (2017). Forest biomass, productivity and carbon cycling along a rainfall gradient in West Africa. *Global Change Biology, 24(2):e496-e510, doi.10.1111/gcb.13907.*

Net Primary Productivity (NPP) is one of the most important parameters in describing the functioning of any ecosystem and yet it arguably remains a poorly quantified and understood component of carbon cycling in tropical forests, especially outside of the Americas. We provide the first comprehensive analysis of NPP and its carbon allocation to woody, canopy and root growth components at contrasting lowland West African forests spanning a rainfall gradient. Using a standardized methodology to study evergreen (EF), semi-deciduous (SDF), dry

forests (DF) and woody savanna (WS), we find that (i) climate is more closely related with above and belowground C stocks than with NPP (ii) total NPP is highest in the SDF site, then the EF followed by the DF and WS and that (iii) different forest types have distinct carbon allocation patterns whereby SDF allocate in excess of 50% to canopy production and the DF and WS sites allocate 40%–50% to woody production. Furthermore, we find that (iv) compared with canopy and root growth rates the woody growth rate of these forests is a poor proxy for their overall productivity and that (v) residence time is the primary driver in the productivity-allocation-turnover chain for the observed spatial differences in woody, leaf and root biomass across the rainfall gradient. Through a systematic assessment of forest productivity we demonstrate the importance of directly measuring the main components of above and belowground NPP and encourage the establishment of more permanent carbon intensive monitoring plots across the tropics.

Keywords: Africa; allocation; biomass; carbon cycle; net primary productivity; rainfall gradient; residence time; tropical forests.

18. Naah, J-B.S.N., Guuroh R.T. & Linstädter, A. (2017). Factors influencing local ecological knowledge of forage resources: Ethnobotanical evidence from West Africa's Savannas. *Journal of Environmental Management, 188: 297–307, http://dx.doi.org/10.1016/j.jenvman.2016.11.064.*

Recording local ecological knowledge (LEK) is a useful approach to understanding interactions of the complex social-ecological systems. In spite of the recent growing interest in LEK studies on the effects of climate and land use changes, livestock mobility decisions and other aspects of agro-pastoral systems, LEK on forage plants has still been vastly under-documented in the West African savannas. Using a study area ranging from northern Ghana to central Burkina Faso, we thus aimed at exploring how aridity and socio-demographic factors drive the distributional patterns of forage-related LEK among its holders. With stratified random sampling, we elicited LEK among 450 informants in 15 villages (seven in Ghana and eight in Burkina Faso) via free list tasks coupled with ethnobotanical walks and direct field observations. We performed generalized linear mixed-effects models (aridity- and ethnicity- based models) and robust model selection procedures. Our findings revealed that LEK for woody and herbaceous forage plants was strongly influenced by the ethnicity-based model, while aridity-based model performed better for LEK on overall forage resources and crop- related forage plants. We also found that climatic aridity had negative effect on the forage- related LEK across gender and age groups, while agro- and floristic diversity had positive effect on the body of LEK. About 135 species belonging to 95 genera and 52 families were cited. Our findings shed more light on how ethnicity and environmental harshness can markedly shape

the body of LEK in the face of global climate change. Better understanding of such a place- based knowledge system is relevant for sustainable forage plants utilization and livestock production.

Keywords: Agro-pastoralists; Burkina Faso; Forage plants; Free list; Ghana; Local ecological knowledge

19. Nero, B. F. (2017). Urban green space dynamics and socio-environmentali inequity: Multi- resolution and Spatiotemporal Data Analysis of Kumasi, Ghana. *International Journal of Remote Sensing, 38(23): 6993-7020.*

Urban green spaces (UGS) are crucial for urban sustainability and resilience to environmental vulnerabilities but are often relegated in cities in the global south. This article analysed the spatio-temporal change, composition, extent, and distributional inequities associated with UGS in Kumasi, Ghana. Spatial techniques and Gini index were combined in the assessment. Kumasi UGS coverage is currently 33% but declined fourfold faster in recent years (2009–2014) than previously (1986–2002). The over-all accuracy of the change maps: 1986–2014 and 2009–2014 were, respectively, 0.96 ± 0.02 and 0.97 ± 0.02. The Shannon entropy for built-up sprawl in 1986 and 2014 were 0.80 and 0.99, respectively. The UGS area per capita for 2009 ($R2= 0.50, p= 0.049$) and 2014 ($R2= 0.53, p= 0.0398$) were moderately correlated with socioeconomic conditions of sub-metropolises. The Gini coefficient for both vegetation and tree cover was 0.26. UGS cover is plummeting and somewhat unevenly distributed across Kumasi. Strategic planning for UGS can ensure ample availability, equity in access, and resilience to climate-related vulnerabilities.

20. Nero, B. F., Callo-Concha, D., Anning, A., Denich, M. (2017). Urban green spaces enhance climate change mitigation in cities of the global south: The case of Kumasi, Ghana. *Procedia Engineering, 198: 69 – 83.*

Urban green spaces (UGS) contribute to mitigate climate change impacts via carbon
sequestration and offer several co-benefits in cities. This contribution, however, is omitted in most national and regional carbon stock estimates, and related literature in the global south is – at best – fragmentary. Therefore, this paper quantifies and maps the distribution of UGS above and below-ground carbon pools in Kumasi, Ghana. Vegetation carbon stocks were estimated using allometric equations for trees and destructive sampling for crops and other herbaceous plants. Soil organic carbon (SOC) was determined to a depth of 60 cm. Satellite imagery and GIS were used to map and extrapolate carbon stock estimates to a citywide scale. In the metropolitan area of Kumasi, a total of 3,758 Gg of carbon is

stored above (vegetation) and below-ground (roots and soil). On average, 239 Mg C ha-1 is stored in trees and 81 Mg C ha-1 in the soil. Crops and herbs hold <1% of the total stock. There is no correlation SOC and tree C stocks (r=0.1073, p=0.2982). Vegetation carbon stocks differ among UGS (p=0.0071). The highest SOC stocks are in cemeteries (111 Mg C ha-1) and home gardens (105 Mg C ha-1) while the lowest (46 Mg C ha-1) occur under natural forest relics. No significant differences were observed in soils under all other UGS types. SOC stock dynamics within and between depths differ among UGS types (p<0.0001). Above and below-ground carbon stocks in Kumasi are quite enormous and sensitive to the UGS type. UGS should be accounted for in urban planning and included in national and regional carbon budgets. These findings complement the global carbon budget datasets and are relevant to urban climate change policy.

Keywords: Carbon sequestration; green space types; belowground; aboveground

21. Nero, B. F., Campion, B. B., Agbo, N., Callo-Concha, D. and Denich, M. (2017). Tree and trait diversity, species coexistence, and diversity-functional relations of green spaces in Kumasi, Ghana. *Procedia Engineering, 198: 99 – 115.*

Conserving biodiversity in cities is essential to halting global biodiversity loss. Nevertheless, there is paucity of data on the underlying mechanisms shaping species assemblages and species/trait diversity-productivity relationships in urban landscapes. The objectives of this study were to; 1) compile tree species diversity of different green space (GS) types, (2) describe the theoretical basis of species co-existence and 3) examine the links between species and life history trait diversity to GS and species productivity (carbon storage) in Kumasi, Ghana. Stratified sampling and species abundance models were combined in this study. About 176 tree species in 46 families were recorded within Kumasi. About 96 species were in a natural forest located towards the outskirts of the city. Home gardens, institutional compounds, and public parks had the highest species richness of 76, 75 and 71, respectively while urban rangelands and farmlands were the least species rich with 6 and 23, respectively. Species richness (S) in the peri-urban (mean ndvi >0.2, S=142) and core urban (mean ndvi<0.2, S=108) areas were significantly different ($X2$ =15.7, p< 0.0001, n=1). Native species richness was lowest in the core urban area and highest in the neighbouring natural forest. The geometric series model best fitted the tree assemblage of the city, depicting a species impoverished and environmentally hash landscape. Pioneers and anthropochory dispersed species were the most abundant suggesting that this urban landscape is shaped by both environment and social filters. Plant species diversity and distribution depend on the type of green space and portrays a perturbed landscape in early seres of succession with the overall ecosystem function sustained by both species and life

history trait diversities.

22. Ochoa-Hueso, R., Maestre, F.T., Eldridge, D.J., Delgado-Baquerizo, M., Soliveres, S., Bowker, A. M., Gross, N., Le Bagousse-Pinguet, Y., Quero, L.J., García-Gómez, M., Valencia E., Arredondo, T., Beinticinco, L., Bran, D., Cea, A., Coaguila, D., Dougill, J. A., Espinosa, I.C., Gaitán, J., Guuroh, R.T., Gusman, E., Gutiérrez, J.R., Hernández, R.M., Huber-Sannwald, E., Jeffries, T., Linstädter, A., Mau, R.L., Monerris, J., Prina A., Pucheta, E., Stavi, I., Thomas, A.D., Zaady, E., Singh, B.K., (2018). Soil fungal abundance and plant functional traits drive fertile island formation in global drylands, *Journal of Ecology, doi: 10.1111/1365-2745.12871.*

Dryland vegetation is characterized by discrete plant patches that accumulate and capture soil resources under their canopies. These "fertile islands" are major drivers of dryland ecosystem structure and functioning, yet we lack an integrated understanding of the factors controlling their magnitude and variability at the global scale. We conducted a standardized field survey across 236 drylands from five continents. At each site, we measured the composition, diversity and cover of perennial plants. Fertile island effects were estimated at each site by comparing composite soil samples obtained under the canopy of the dominant plants and in open areas devoid of perennial vegetation. For each sample, we measured 15 soil variables (functions) associated with carbon, nitrogen and phosphorus cycling and used the relative interaction index to quantify the magnitude of the fertile island effect for each function. In 80 sites, we also measured fungal and bacterial abundance (quantitative PCR) and diversity (Illumina MiSeq). The most fertile islands, i.e. those where a higher number of functions were simultaneously enhanced, were found at lower elevation sites with greater soil pH values and sand content under semiarid climates, particularly at locations where the presence of tall woody species with a low-specific leaf area increased fungal abundance beneath plant canopies, the main direct biotic controller of the fertile island effect in the drylands studied. Positive effects of fungal abundance were particularly associated with greater nutrient contents and microbial activity (soil extracellular enzymes) under plant canopies. Synthesis. Our results show that the formation of fertile islands in global drylands largely depends on: (1) local climatic, topographic and edaphic characteristics, (2) the structure and traits of local plant communities and (3) soil microbial communities. Our study also has broad implications for the management and restoration of dryland ecosystems worldwide, where woody plants are commonly used as nurse plants to enhance the establishment and survival of beneficiary species. Finally, our results suggest that forecasted

increases in aridity may enhance the formation of fertile islands in drylands worldwide.

Keywords: aridity; drylands; fertile islands; fungal abundance; multiple threshold approach; plant functional traits; relative interaction index; soil properties.

23. Owusu, F.W.; Appiah, J. K.; Essien, C.; Brentuo, B., Foli, E. (2017). Some wood machining properties of submerged timber species from the Volta Lake in Ghana. *Ghana Journal of Forestry, 33: 60 – 73.*

The efficient utilization of submerged timber harvest from the Volta Lake in Ghana requires adequate understanding of their wood working properties. This study was undertaken to determine some machining properties of logs from four timber species that were harvested from the Lake. These machining properties indicate the ease of working with the logs and the degree of surface quality generated. The preparation of test specimens (using ordinary carpentry tools), testing, evaluation and grading of the specimens were done in accordance with the American Society for Testing and Materials (ASTM) D143 and 1666-87. In decreasing order, the percentage ripped surfaces that were charred were *Cylicodiscus gabunensis* (4.80%), *Manilkara multinervis* (4.13%), *Diospyros mespiliformis* (4.04%) and Erthropheleum guineense (3.20%). Cross-cutting was fairly easy for all the four species. Shaping, boring and turning qualities increased with increasing spindle speed; however, the turning operation period increased as spindle speed decreased. The major defect observed was chipped/torn grain. With boring, 45-65% of 28 mm diameter holes in all the wood specimens resulted in various degrees of charring. The average amount off-size of the holes bored was bigger with coarse textured species than the fine textured. Consistently, the machining surface quality performance of *D. mespiliformis* was better than the three other timber species. The blunting effect of the timber species was classified as satisfactory. Surface quality foe the four timber species generated by three spindle speeds were rated medium to high. The results indicate that the four timber species are machine able and could be used where shaping, boring and turning operations are necessary. The results are comparable with timber from natural forest/terrestrial sources of Ghana based on the same rating.

Keywords: Submerged timber; Volta Lake; wood surface quality; wood machining properties

24. Prescott, C. E., Corrao, K., Reid, R., Zukswert, A., Addo-Danso S. D. (2017). Changes in mass, carbon, nitrogen and phosphorus in logs decomposing for 30 years in three Rocky Mountain coniferous forests. *Canadian Journal of Forest Research, 47: 1418-1423.*

Estimates of decomposition rates of coarse woody debris (CWD) and fluxes of nutrients therein are essential components of carbon (C) and nutrient budget models. In a 30-year field experiment, we periodically measured mass remaining and nutrient concentrations in log segments of pine, spruce, and fir in natural, mature coniferous forests in Alberta, Canada. The predicted turnover times (t95; years) were 43–44 years for pine, 42–60 years for spruce, and 38–46 years for fir. Extrapolating from best-fit models, we predict that decomposition of these logs would be complete within 50–60 years. The ratio of carbon to nitrogen (C:N) declined for most of the decomposition period, and ratios of the three species converged at <200 at 90% mass loss. Net release of N occurred only after logs had lost 90% of their original C and C:N had declined to <200. The ratio of carbon to phosphorus (C:P) declined and converged at 500–1000 at 90% mass loss. There was no evidence of net P release from logs even at 90% mass loss. It may be possible to estimate the amounts of N and P that will be incorporated into decaying logs based on the extent to which their initial C:N differs from 200 and their initial C:P differs from 500. Keywords: coarse woody debris, decomposition, mass loss, nutrient, turnover

25. Sossou, H. S., Asomaning, J. M., Gaveh, E. A, Sarkodie-Addo, J. and Sodedji , A.F.K.(2017). Assessment of seed vigour tests for determining the physiological potential of Tetrapleura tetraptera (Schum. & Thonn.). *Journal of Experimental Agriculture International, 192 : 1-10, 2017.*

Seed vigour tests were conducted to identify differences in physiological potential among seed lots of Tetrapleura tetraptera (Schum. & Thonn.) with the potential to perform well after sowing and/or during storage. The present study aimed at investigating rapid vigour testing methods for estimating the relative physiological potential of T. tetraptera (Schum. & Thonn.) to provide relevant information to guide its domestication and ex-situ conservation. Eight (8) seed lots of T. tetraptera were subjected to the accelerated ageing and the electrical conductivity tests to determine their physiological potential. For the accelerated ageing tests, the traditional accelerated ageing (TAA)and the salt-saturated accelerated ageing (SSAA) tests were performed. In the TAA tests, seed lots were exposed to 100% RH at 38 and 41°C for 48, 72 and 96 h, respectively. In the SSAA tests, seed lots were exposed to saturated NaCl solution with RH of 76% at temperatures and durations similar to the TAA tests. For the electrical conductivity tests, leachates conductivity

of the 8 seed lots, were measured after 20 seeds of each lot had been placed in beakers and soaked in 50 ml of de-ionized water for 1,2,3,4,5,6, and 24 h at room temperature (24-28°C). Seed moisture content was determined and seed germination tests of seed lots were conducted before and after the accelerated ageing tests. Seedling root, shoot and total length as well as seedling dry weights were also recorded after accelerated ageing and germination of the seeds. The experimental design was 8 x 7 factorial (lots x soaking period) for the conductivity test and 8 x 2 x 3 factorial (lots x temperature x exposure time) for the accelerated ageing tests, in a completely randomized design. Results showed that seed emergence and seedling length were effective to distinguish the physiological quality of T. tetraptera seeds while seedling dry weights were not. Accelerated ageing test influenced the percentage of germination, but showed low sensitivity in lots differentiation. For the electrical conductivity test, 24 h was the most promising soaking period for effective stratification in determining the physiological quality of T. tetraptera seed lots and was significantly correlated with seed emergence (-0.76, p < 0.01) and seedling length (r = -0.72, p < 0.01). Electrical conductivity test may therefore be a more feasible option for vigour testing of T. tetraptera seeds.

Keywords: Seed quality testing; Tetrapleura tetraptera; vigour; seed storability; ex -situ conservation.

ABSTRACTS OF PAPERS PRESENTED AT CONFERENCES

26. Addo-Danso, S. D., Prescott, C. E. (2017). *Fine-root morphological traits in tropical forest ecosystems in relation to rainfall and temperature*, Book of Abstracts, Paper Presented at the 125 IUFRO Anniversary Congress, 18-22 September 2017, Freiburg, Germany. Published by Forstliche Versuchs- und Forschungsanstalt (FVA) Baden-Württemberg, ISBN 978-3-902762-88-7

Root traits, including specific root length (SRL-root length per unit dry mass), specific root area (SRA-root surface area per dry mass), and root tissue density (RTD-root dry mass per volume) are regarded as important indicators of environmental changes. Here, we compiled 69 observations from forests across the tropics, and used regression analysis to determine patterns in fine-root SRL, SRA and RTD in relation to annual rainfall and mean annual temperature (MAT). We observed differential responses in traits to annual rainfall and MAT. Annual rainfall and MAT explained < 2 % of the variations in SRL and SRA across the tropics. Mean annual temperature was the most significant factor, explaining 69 % of the

variance in RTD. When the data were separated into Paleotropical (Africa and Asia) and Neotropical (Central and South America) forests, all the traits declined with increasing MAT, RTD and SRL declined with increasing annual rainfall in the Paleotropics, and RTD increased with MAT in the Neotropics. The results suggest that rainfall and MAT influence RTD, but not SRL and SRA. However, the response of root traits to climate may differ among regions. This has implications for resource acquisition and C dynamics of forests in tropical regions.

Keywords: Root traits, specific root length, tropical forest

27. Pentsil, S., Mensah, J.K., Sparkler, S.B., Appiah-Kubi, E., Essien, C., Asiedu-Opoku, E., Appiah, N. and Konto, C. and Acquah Biritwum, S. (2017). Effect of climate change on household food security and livelihood, Ghana. Book of Abstracts, International Conference on Climate Change & Sustainable Development in Africa (ICCCSDA, 2017). Organized by the University of Energy and Natural Resources (UENR) at Sunyani, 25th – 28th July, 2017. pp 50- 51.

Undoubtedly, climate change has a negative effect on agricultural production and this is increasingly escalating in vulnerable regions like Ghana where agric is not mechanised to guarantee an all year round harvest. This study sought to assess perception of communities about climate change and to explore changes in farming systems that have sustained food crop production in the study areas. A mixed method approach was used which allowed a combination of interviews and personal observations supported with literature review. Six communities were selected from the Brong Ahafo Region and participation was limited to only household heads. Other stakeholders consulted include representatives of Ghana Metrological Agency, Ministry of Food and Agriculture, Environmental Protection Agency, District Assemblies and some environmental NGOs. The results show that variables like gender, age and educational status had little influence on perception of climate change. To sustain and improve the current level of production, respondents utilized either mixed cropping or shifting cultivation. The results also revealed that in the long run, it was mainly cost but not access which prevented respondents from using agricultural inputs to increase production. In addition, farmers diversified income sources by engaging in alternative livelihood activities to cope with crop failure. Household food security was found to be primarily dependent on women and is therefore useful to implement measures that would encourage and assist more women especially widows and female headed households to increase production. In summary, without planned intervention, respondents were sceptical about the region's food security in the future.

Keywords: Climate change, farmers, food security, livelihood and Ghana

28. Essien, C., Via, B. K., Cheng, G., Gallagher, T., McDonald, T. and Eckhardt, L. (2017). Multivariate modelling of acousto-mechanical response of fourteen-year-old Loblolly Pine (Pinus taeda) to variation in wood chemistry, microfibril angle, and density. Paper presented at the 71th Forest Products Society International Convention at Starkville, Mississippi, USA, 26-28th June 2017 p.23

Polymeric angle and concentration within the S2 layer of a softwood fiber cell wall are critical for molecular and microscopic properties that influence strength, stiffness, and acoustic velocity of wood at the macroscopic level. The main objective of this study was to elucidate the effect of cellulose, hemicellulose, lignin, microfibril angle, and density on acoustic velocity and material mechanical properties of 14-yr-old suppressed loblolly pine. Cellulose, hemicellulose, and density are consistently the most important drivers of strength, stiffness, and velocity. Cellulose and lignin are the greatest and least contributors to velocity, respectively, with lignin acting as a sound wave dispersant. Cellulose is the most important conductor of sound waves at the molecular level, whereas hemicellulose acts as a special coupling agent between these components. The polymeric constituents are thus important drivers of sound wave propagation at the molecular level, whereas density plays a subsequent role at the macro-scale.

Keywords: Microfibril angle, hemicelluloses, lignin, acoustic velocity

29. Essien, C., Via, B. K., Cheng, G., Gallagher, T., McDonald, T. and Eckhardt, L. (2017). Applying discriminate analysis and acoustic tool to assign loblolly pine families into susceptibility classes. Proceedings of the International Non-destructive Testing and Evaluation Symposium. Madison, Wisconsin USA. September 12 – 15, 2017, 7pp.

Loblolly pine is one of the most important tree species in the south-eastern United States. However, root-feeding fungi continue to be one of the major challenges confronting pine production in this country. Little information exists on the use of rapid non-destructive wood quality assessment techniques to differentiate between families susceptible and tolerant to root-feeding fungi. In this study, we explore the possibility of using an acoustic tool and statistical techniques to differentiate between 17-year-old loblolly pine trees susceptible and tolerant to root-feeding fungi. Results indicate that the effects of root-feeding fungi on wood quality properties differ widely between the families studied. The acoustic tool was successfully used to differentiate between the susceptible and tolerant families.

Keywords: Discriminate analysis, Root-feeding fungi, acoustic tools

30. Obiri, D. B., Marfo, E., Nutakor, E., Cobbinah, J., Treue, T and Hall-Smith, C. (2017). The economic significance of forests in household primary health care in Ghana. (Paper presentation, 3RD FLARE annual meeting, 29th September- 2nd October 2017, Stockholm, Sweden

That, forests are natural pharmacies cannot be underscored. In Ghana 70% of the population particularly, rural communities depend on herbal medicines including collections from the forests for their health needs. However, forests provisioning role in primary health care has rarely been quantified. Empirical knowledge on the nature and extent of reliance on plant products harvested from forests as medicnes is required to guide sustainable forest management planning. This paper estimates the economic significance of the medicinal values of forests to households on the fringes of wet and dry forests in Ghana and draws implications for forest mangement decisions and pro-poor policy interventions. Data was gathered from quarterly questionnaire surveys of 600 rural households over one year and analysed descriptively and quantitatively. Results indicate that households generally, rely on forest resources mainly for subsistence and exploit these resources throughout the year but more frequently during the lean period i.e. first and second quarters. Dependency on forests for medicines is quite high as 94% and 82% of medicines collected are consumed by households in dry and wet forest areas respectively. Six and eighteen percent of medicinal collections in the wet and dry forest areas respectively are sold mainly by men from households in the middle income class. The forest is the principal land use system accounting for 60% of the medicinal collections. Further, medicines constitute 5% and 6% of products collected from wet and dry forests respectively. The major plant parts collected are barks, leaves, seeds and fruits for treating a wide range of conditions but predominantly, aches/pains, fevers, infections, anaemia, infertility/impotency and mental disorders. Eighty-four percent of the medicinal collections are from forests under high and medium restriction of access. US$330 and US$ 500 in annual gross value were estimated for household medicinal collection in the wet and dry forest areas respectively. It is recommended that medicinal species be among priority plants for national programs aimed at forest restoration including those for climate mitigation/REDD+ interventions. Integration of medicinal species in land-use systems outside restricted forests including croplands, fallows and home gardens will make them more readily available, reduce forest tenurial conflicts and contribute to reducing deforestation.

Keywords: Forests dependency, medicinal plants, forest management, forest governance, REDD+

23

31. Ofori, D.A., Peprah, T., Jamnadass, R., Rutatina, F., Asomaning, J., Ebanyenle, E., Korang, J. Tsobeng, A., Ndangalasi, H.J. (2017). Public-Private Partnerships for sustainable agroforestry and business innovations in Africa: Allanblackia species as a case study. Book of Abstracts, 125 IUFRO Anniversary Congress, 18-22 September 2017, Freiburg, Germany. Published by Forstliche Versuchs- und Forschungsanstalt (FVA) Baden-Württemberg, ISBN 978-3-902762-88-7, P551

Seed oil from multipurpose Allanblackia tree species, found in West, East and Central Africa, is the most economic important product of the species. Demand for seed oil (>100,000 tons/ year) exceeds supply from wild collection (210 tons/ year). This warrants the need for domestication and conservation of the species to ensure sustainable supply of seed oil. Public-Private Partnership (Novella Partnership) was established in 2002, to drive the domestication of the species in four pilot countries. Activities include community sensitization, genetic diversity analysis, conservation, participatory selection, development of propagation methods and agroforestry systems, supply chain and market development. No variation was observed in fruit shape and seed yield among populations but fruit size, yield and shape varied significantly within populations of *A. parviflora.* Obovate fruit shape has more oil (53%) than the rest. Significant variation in oil content among trees was observed in *A. parviflora* and *A. stuhlmannii* as well as between pink and white flowered trees. Propagation methods {seed germination (75%), rooting of stem cuttings (82%), grafting (79.8%) and air layering (72%)}have been developed. Supply chain is established in Ghana, Nigeria and Tanzania. Income from 14 products made from Allanblackia floribunda in Cameroon, is $3,000 /year. In Tanzania, 3907 farmers have received Euro 600,000 from sale of 3,300 kg of Allanblackia nuts. Development of BECEL Gold from Allanblackia oil by Unilever and the short term income from Allanblackia products have inspired domestication of the species.