Above Ground Biomass and Carbon Stock of Lianas along the Watershed Area of Pergau, Jeli, Kelantan, Peninsular Malaysia

IOP Conf. Series: Earth and Environmental Science **549** (2020) 012038 doi:10.1088/1755-1315/549/1/012038

Above Ground Biomass and Carbon Stock of Lianas along the Watershed Area of Pergau, Jeli, Kelantan, Peninsular Malaysia

Norashikin Fauzi[1*], Muhammad Aideed Ilias[1], Nazahatul Anis Amaluddin[1], Kamarul Hambali [1] and Mohd Firdaus Mohd Ridzuan[1]

[1] Faculty of Earth Science, Universiti Malaysia Kelantan Jeli Campus, Kelantan, Malaysia.

E-mail: ashikin@umk.edu.my

Abstract. A preliminary inventory on the above ground biomass and carbon stock of liana associated with landscape-scale fragmentation induced by the Pergau dam along the watershed area of Sungai Long II intake in Jeli, Kelantan was executed. A total of 67 liana individuals (≥1 cm dbh) was enumerated in 0.15 ha of surveyed plot. Lianas with dbh range between 0.06 to 0.95cm were found to be dominant in the inventory site, comprising 41.8% of the proportional abundance followed by 40.3% of lianas with dbh in the range of 1.05 to 1.94cm. The least encountered dbh of lianas were 3.82cm and 4.14cm respectively (1.5%). The total above ground biomass was estimated 37.9 t ha^{-1} within the inventory site. The contribution of liana biomass to total above ground biomass has been estimated 6.5%, extremely lower than the total above ground biomass contributed by the thirteen host trees (545.3 t ha^{-1}). Carbon sequestration by lianas was estimated 19.8 t C ha^{-1}, contributing 6.8% in response to level off high CO_2 whilst the carbon stock of the host trees was estimated 272.6 t C ha^{-1}. It could be suggested that ecosystems along the Sungai Long II in Pergau, Kelantan have been disturbed and this was based on the high abundance of liana. Although the above ground biomass of lianas was lesser than the host trees, the liana population size should be controlled and in equilibrium within the ecosystem. To ensure the stability of the ecosystem, regular silviculture treatment should be executed in the highly liana infected area.

1. Introduction

Previous investigations indicate that some liana species respond strongly to elevated CO_2 [1]. Liana response appears to level off at very high CO_2 levels, but the unique combination of increased growth rates of lianas under elevated CO_2 and increasingly disturbed forests due to human intervention is a situation requiring attention [2]. The assumption that disturbed forests ultimately can recover and regain biodiversity and ecosystem function, given sufficient time, may not be warranted if arrested succession takes over under CO_2 conditions not experienced previously [2]. Increase in liana abundance results in reduced tree growth and increased tree mortality thereby playing an important role in regional and global carbon cycle [3].

Despite the increasing liana abundance, importance of lianas for forest functioning and productivity is often overlooked as they are thought to contribute negligibly to woody structure and biomass [4].

However, biomass and productivity of forests could be underestimated by ignoring the contribution of lianas [1]. The contribution of liana biomass to total above ground biomass has been estimated to range between 3% and 17% across different tropical forests [5].

Across the Neotropics, studies have shown that the abundance and biomass of lianas is increasing [6]. If slow-growing high-carbon-storing tree species are particularly impacted by liana proliferation, this may lead to a reduction in tropical forest carbon storage [7]. Furthermore, because lianas allocate more carbon to leaf production than trunk growth, increasing liana abundance and biomass could shift the carbon balance in tropical forests from long-term carbon sequestration in woody biomass, towards more rapid turnover in leaves [3]. An increase in litterfall from lianas may also accelerate below ground carbon cycling through priming effects, further reducing total carbon storage within tropical forests [8].

This paper reports the finding of preliminary inventory on the above ground biomass and carbon stock of liana associated with landscape-scale fragmentation induced by the Pergau dam along the watershed area of Sungai Long II intake in Jeli, Kelantan.

2. Methodology

2.1 Study area

The preliminary inventory was conducted in 0.15ha along the watershed area of Sungai Long Intake II in Pergau, Jeli, Kelantan. This watershed area is part of reservoir for Pergau Dam, operated by Tenaga Nasional Berhad after it was officially opened in 2003. The area represents the lowland vegetation with approximately 450m asl. Within the vicinity, the canopy was moderately wide and the emergents were approximately not exceeding 45m.

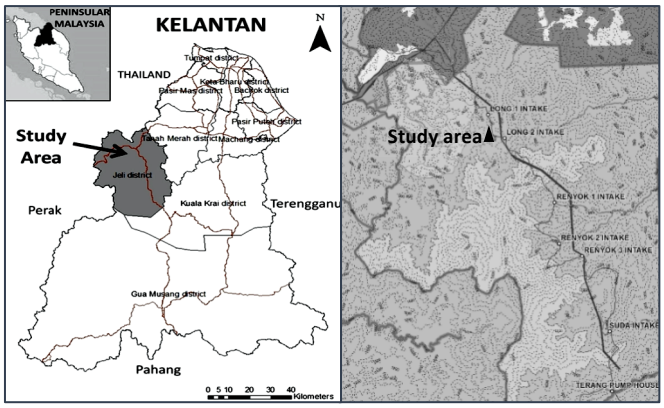

Figure 1. The location of study site along the watershed area of Sungai Long II Intake in Pergau, Jeli

2.2 Sampling method

The inventory of lianas was carried out in November, 2019, following the protocol by Gerwing and Farias [1]. All liana stems (ramets) ≥1 cm in dbh were inventoried and the dbh was measured with a caliper at 1.3 m above the ground. The tree mainly supporting a liana was recorded as its host tree. The diameters of all host trees (dbh ≥ 10 cm) were measured at 1.3 m above the ground.

2.3 Data analyses

The above ground biomass (AGB) of liana was estimated using an allometric equation developed by Patrick and Rahmad [9]. The liana allometric equations developed by latter could be used in both primary and secondary forests as they were not affected by forest type. A comparison of the best total

aboveground allometric equation developed by latter with previously published models indicated that the previous equations overestimated total above ground biomass of lianas by at least 29% [10].

All the dbh measurements were tabulated accordingly and AGB of liana was estimated using the equation below, developed by Patrick et.al. [10].

$$\text{Log}_{10}\,(\text{total biomass}) = c + \alpha(\log_{10} D)$$

D= diameter, c= 0.490±0.021, α= 1.090±0.027

3. Results

A total of 67 liana individuals (≥1 cm dbh) was enumerated in 0.15 ha of surveyed plot. Each of the lianas had been placed in a particular class to facilitate the processing of data. The classification of liana individuals had been made accordingly based on allometric equation by Patrick et.al. [10].

Table 1. Summary of allometric property and above ground biomass for 67 individual lianas in 0.15ha along the watershed area of Sungai Long Intake II, Pergau, Jeli.

Parameter	Minimum	Maximum	Mean
Diameter (cm)	0.06	7.13	1.45
Above ground biomass (t ha^{-1})	0.81	1.42	0.57

Lianas with dbh range between 0.06 to 0.95cm were found to be dominant in the inventory site, comprising 41.8% of the proportional abundance followed by 40.3% of lianas with dbh in the range of 1.05 to 1.94cm. Lianas that measured with dbh in the range of 2.07 to 2.73cm accounted for 10.4% of the proportional abundance. The least encountered dbh of lianas were 3.82cm and 4.14cm respectively (1.5%). Meanwhile 4.5% of lianas were measured with dbh > than 5cm. On average, liana abundance was inversely correlated with host tree abundance. Thirteen liana host trees were identified with dbh in the range of 2.99 to17.0cm.The host trees with the high dbh ≥15cm were observed to host lianas with the average dbh of 1.72cm.

The total above ground biomass was estimated 37.9 t ha^{-1} within the inventory site (Figure 2). The contribution of liana biomass to total above ground biomass has been estimated 6.5%, extremely lower than the total above ground biomass contributed by the thirteen host trees (545.3 t ha^{-1}). Carbon sequestration by lianas was estimated 19.8 t C ha^{-1}, contributing 6.8% in response to level off high CO_2 whilst the carbon stock of the host trees was estimated 272.6 t C ha^{-1}.

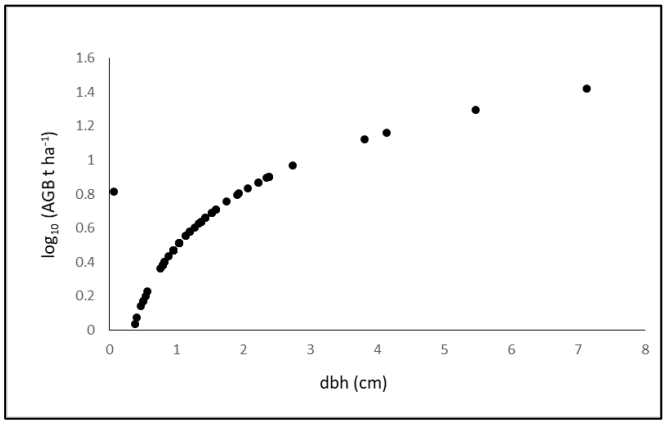

Figure 2. Above ground biomass of lianas in 0.15ha along the watershed area of Sungai Long Intake II, Pergau, Jeli.

4. Discussion

The liana infested 0.15 ha inventory plot, stored 14.4 times less AGB than in the host trees, a figure comparable to that described by Liddell et al. [5] who compared the contribution of liana above ground biomass across different tropical forests. The lower AGB in lianas could be associated with the less fertile soil in the vicinity as postulated by Schnitzer and Bonger [11]. It is suggested that the low AGB of lianas may be due to the less amount of nutrients stored in the stems. Nevertheless, a soil test was not conducted in this inventory. As this inventory only focused on a single patch along the watershed in Sungai Long II intake and therefore lacks of replication. This watershed area is part of reservoir for Pergau Dam and to date, it has been operated by Tenaga Nasional Berhad for 17 years. Schnitzer and Carson [12] have shown that liana density was positively correlated with pioneer tree density and that canopy height remained low for over 13 years in those gaps. Foster et al. [13] also showed that liana infested patches did not recover even after 14 years and may therefore be considered as an arrested succession.

Carbon sequestration by lianas was 13.7 times less than the host trees. Typically, for forests regeneration following deforestration, a recovery of 85% of the carbon stock contained in the initial old-growth forest is expected in about 80 years with a carbon accumulation rate close to 5Mg ha^{-1} $year^{-1}$ [14]. By contrast, in the liana-infested forest, carbon stock remained stable at carbon accumulation rate close to 40% of the high-canopy forest carbon stock over the past 20 years [15]. Lianas have already been found to have increased in dominance over recent decades even in undisturbed Neotropical forests, possibly due to climate or atmospheric changes [16]. Lianas may also be expected to benefit in coming decades, if tree mortality rates continue to rise [17], and/or if disturbances at regional scale become more frequent because of warming, leading potentially to more frequent extreme events [18].

Tymen et al. [15] postulated that the finding that tropical forests may turn into low AGB forests for decades is a cautionary tale for carbon cycle modellers because it could have a dramatic impact on the carbon storage ability of these forests in the future as it was already pointed out by van der Heijden et al. [19]. The untreated liana infested forest will gradually limits the net carbon sequestration capacity in the forest and may potentially induce the formation of liana infested canopy or emergent.

5. Conclusion

It could be suggested that ecosystem along watershed area along the Sungai Long II in Pergau had been disturbed, this was based on the high abundance of liana. Although the AGB of lianas was lesser than the host trees, nevertheless the liana population size should be controlled in equilibrium within the ecosystem. To ensure the stability of the ecosystem, regular silviculture treatment should be executed in the highly liana infected area.

Acknowledgements

We would like to express our appreciation to Tenaga Nasional Berhad for granting the permission to execute our preliminary inventory and administrative support. We also are grateful to the Dean of Faculty of Earth Science, Univesiti Malaysia Kelantan for logistic support during the inventory.

References

[1] Gerwing J J and D L Farias 2000 Integrating liana abundance and forest stature into an estimate of aboveground biomass for an eastern Amazonian forest. *J. Trop. Ecol.* **16** 327–36.

[2] Burnham R J 2004 Alpha and beta diversity of lianas in Yasun´ı National Park, Ecuador. *For. Ecol. Manage.* **190** 43–55.

[3] van der Heijden G M F, Powers J S and Schnitzer S A 2015 Lianas reduce carbon accumulation and storage in tropical forests in *Proceedings of the National Academy of Sciences*. 2015 Oct 27;112(43):13267-71

[4] Sruthi M. Krishna Moorthy, Kim Calders, Manfredo di Porcia e Brugnera, Stefan A. Schnitzer and Hans Verbeeck 2018 Terrestrial Laser Scanning to Detect Liana Impact on Forest Structure. *Remote Sens*. **10** 810
[5] Liddell M, Nieullet N, Otavia and Freiberg M 2007 Assessing the aboveground biomass of a complex tropical rainforest using a canopy crane. *Austral Ecology* **32**(1) 43 – 58.
[6] Phillips O L, VaÂsquez MartõÂnez R, Arroyo L, Baker T R, Killeen T and Lewis S L 2002 Increasing dominance of large lianas in Amazonian forests *Nature* **418** 770-4.
[7] Schnitzer S A, Bongers F and Wright S J 2011 Community and ecosystem ramifications of increasing lianas in neotropical forests. *Plant Signal Behav*. **6** 598-600.
[8] Sayer E J, Heard M S, Grant H K, Marthews T R. and Tanner E V J 2011. Soil carbon release enhanced by increased tropical forest litterfall. Nat Clim Chang.
[9] Patrick A-F P, Rahmad Z B 2013 Development of allometric equations for estimating above-ground liana biomass in tropical primary and secondary forests, Malaysia *International Journal of Ecology* **2013** 1-9
[10] Patrick A-F, Zakaria, B. Rahmad and Robyn J B 2017. Intercontinental comparison of liana community assemblages in tropical froetss of Ghana and Malaysia. *Journal of Plant Ecology*. **10**(6) 883-94.
[11] Schnitzer S A and Bongers F 2002 The ecology of lianas and their role in forests. *Trends in Ecology & Evolution,* **17** 223–230.
[12] Schnitzer S A and Carson W P 2010 Lianas suppress tree regeneration and diversity in treefall gaps. *Ecology Letters*, **13** 849–57.
[13] Foster J R, Townsend P A and Zganjar C E 2008 Spatial and temporal patterns of gap dominance by low-canopy lianas detected using EO-1 Hyperion and Landsat Thematic Mapper. *Remote Sensing of Environment* **112** 2104–17.
[14] Bonner M T, Schmidt S and Shoo L P 2013 A meta-analytical global comparison of aboveground biomass accumulation between tropical secondary forests and monoculture plantations. *Forest Ecology and Management* **291** 73-86.
[15] Tymen B, Maxime R M, James W D, Sophie F, Ted R F, Natalie N, Oliver L P, Benjamin L T, Jerome V and Jerome C 2016. Evidence for arrested succession in a liana infested Amazonian forest *Journal of Ecology* **104** 149-159.
[16] Laurance W F, Andrade A S, Magrach A, Camargo J L C, Valsko J J, Campbell M, Fearnside P M, Edwards W, Lovejoy T E and Laurance S G 2014 Long-term changes in liana abundance and forest dynamics inundisturbed Amazonian forests. *Ecology* **95** 1604–11.
[17] Brienen, R.J.W., Phillips, O.L., Feldpausch, T.R., Gloor, E., Baker, T.R., Lloyd, J. et al. 2015. Long-term decline of the Amazon carbon sink. *Nature* **519**(7543) 344–348.
[18] Davidson, E.A., de Ara-ujo, A.C., Artaxo, P., Balch, J.K., Brown, I.F., Bustamante, C. et al. 2012 The Amazon basin in transition. *Nature* **481** 321–328.
[19] van der Heijden, G.M.F., Schnitzer, S.A., Powers, J.S. & Phillips, O.L. 2013 Liana impacts on carbon cycling, storage and sequestration in tropical forests. *Biotropica* **45** 682–692.