Estimation of liana infestation above canopy in Bukit Bakar recreational park, Kelantan using an unmanned aerial vehicle

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Abstract. A study on lianas estimation has been conducted in 1 ha plot at Bukit Bakar Recreational Park, Machang, Kelantan. Liana infestation on tree crowns was assessed from above by using an unmanned aerial vehicle (UAV), DJI Phantom-4 Pro which was manually piloted. Liana load carried by trees were determined by calculating the percentage liana cover (%LC) and measuring crown occupancy index (COI). Collection of image data by UAV had been captured and geo-tagged with GPS location. The value of crown occupancy index (COI) depends on the accuracy of the percentage liana cover (%LC). Fourteen host trees infested by lianas were identified. The value COI of 14 lianas-infested trees were in the range between 0 – 2, indicating low and moderate infestation. One point was recorded with very low liana load, nine points with moderate liana and four points with low liana load on tree crowns with 0.76% to 29.9% of liana cover respectively. The moderate and lower values obtained was probably due to the lesser of anthropogenic disturbance and natural disturbance that occurred after 40 years of selective management system logging. The liana infestation was distributed homogeneously. The lower liana COI obtained, indicates the ongoing progress of forest succession in Bukit Bakar that gradually hindered liana proliferation within the proximity. This method could promote the local authority in forestry management particularly in managing the tree crown occupancy of liana in the logged-over forest.

Keywords. liana infestation, liana load, drone, percentage liana cover, crown occupancy index

1. Introduction
Lianas are vital tropical forest elements and most prominent in the canopy in Malaysia. They peak in abundance, biomass and species richness [1]. The tree growth, survivals, forest biomass and net carbon uptake are reduced, due to their aggressive competition with trees and extensive leaf canopy. Lianas decrease tropical forest carbon take-up and limit forest carbon storage and sequestration [2]. Satellite and other airborne platforms give information or data too rough in estimating liana infestation [3]. The cost to do this task by using these two is expensive at very clear resolutions and difficult to be conducted [4].

Waite et al (2018) had executed a study on liana by using unmanned aerial vehicle (UAV) to assess liana infestation of tree canopies from above. It is known as drone, an aircraft without a pilot but controlled by human operator by using remote control. It is flexible, low-cost, high-intensity data collection and high-resolution remote sensing systems that are vital to capture the data of liana...
infestation. Data is captured at clearer temporal and spatial resolutions rather than satellite or other airborne platforms. The images of forest canopies would be captured. It includes image collection, processing and visual interpretation.

Liana abundance and biomass have increased over the last few decades [5]. In logged-over forest, it was found that liana infestation is heavy than undisturbed forest [6]. The abundance and diversity of lianas might be increased as the disturbance of tropical forest increases. This also can disturb the importance of ecosystem services. Lianas are plant that can affect the light availability by forming a monolayer of leaves over the tree crown [7]. Forest storage and carbon sequestration might decrease when liana infestation is high. Lianas pose a particular problem for managed forests, where they can substantially hinder carbon sequestration and forest restoration [8].

Several studies on liana had been conducted in permanent forest reserves in Kelantan by estimating above ground biomass and diversity using a conventional ways [9],[10]. Estimating liana infestation by establishing the plots on and counting the number of lianas on the ground is time consuming. Previous study by Waite et al., (2018) had shown that the estimation of liana infestation by using an unmanned aerial vehicle was efficient and timesaving. The focal point of this study was to estimate the abundance of liana load on tree canopies at Bukit Bakar recreational park using an unmanned aerial vehicle.

2. Methodology

2.1 Study Area

The study area was located at Bukit Bakar Recreational Park, Machang, Kelantan (Fig.1.0), latitude 5.73970N and longitude 102.24570E. It was located 9 km away from Machang town. Bukit Bakar Recreational Park (2019ft asl) received annual mean rainfall of 1300 millimetre with temperature between 24°C and 27°C. It comprises of lowland and hill dipterocarp forests within the permanent forest reserve of Ulu Sat.
2.2 Sampling Site
One hectare plot was established as a sampling site in Bukit Bakar recreational park. The coordinate of the sampling site was recorded by using Global Positioning System (GPS). Only trees hosted with lianas were included in the sampling.

2.3 Data collection
The data images of liana infestation above canopy in Bukit Bakar recreational park were captured by using UAV- DJI Phantom 4 Pro. The drone was operated to fly 60 meters above the ground. In this study, two methods were used to classify liana load carried by tree crown, namely percentage of liana cover (%LC) and crown occupancy index (COI). The COI expresses liana load in the tree crown on a simple 5-point ordinal scale: (0) no lianas in the crown, (1) 1%–25%, (2) 26%–50%, (3) 51%–75%, and (4) >75% of the crown covered by liana leaves [11]. This index is widely used in liana research and accurately measures liana loads at both the individual tree and site level with little interobserver bias [17].

3. Results
3.1 Liana infestation
Image data of tree crowns were collected by UAV. Trees without liana infestation and lianas-infested trees could be recognized and identified clearly under the orthomosaic resolution 1.97inch/pixel of DroneDeploy application. In Figure 2.0, lianas infested trees were marked with red polygon. The estimation founded in 1 ha area was 14 lianas-infested trees. In 1 ha-plot area, each lianas infested on different hosts.

![Figure 2. An aerial view of liana infestation marked with red polygon in 1 ha plot in Bukit Bakar recreational park, Kelantan.](image)

Based on the observation, the canopy gaps could be seen at canopy level. Canopy gaps are sites of intense competition between lianas and trees. The vegetation of liana infestation on the tree crowns could obviously be seen. Figure 3.0 indicates the percentage of liana cover (%LC) and crown occupancy index (COI). Point 1,5,6,7,8,10,12,13 and 14 had the value 1, point 2,3,4 and 11 had the value 2 and point 9 had the value 0 of COI. COI was measured by determined the percentage of liana...
cover at five-point scale: (0) no lianas or very little in the crown, (1) 1–25%, (2) 26–50%, (3) 51–75%, and (4) >75% of the tree crown covered by liana leaves [11].

Figure 3. The percentage of liana cover (%LC) and crown occupancy index (COI) in 1 ha sampling plot in Bukit Bakar recreational park, Kelantan.

4. Discussion
Lianas constitute approximately 30% of the woody individuals and lower crown occupancy index within the range of 1 and 2 in Bukit Bakar recreational park. This recreational park has been left undisturbed after 40 years of selective logging before it was gazetted as recreational park. Mascaro et al. (2004) showed that approximately 50 years after selective logging in their study area in Costa Rica, no significant differences in liana density, diversity, or mortality between primary forest and areas that were selectively logged were observed. On the contrary, our findings indicate lower liana infestation in this study site.

Liana abundance is not necessarily dependent on disturbance, but rather on the extent to which the disturbances affect host species [12]. Van der Heijden et al. (2015) already underlined this by stating that the success of lianas mainly depends upon successful infestation of a host tree. Nevertheless, no real evidence for the hypothesis of [12] has been found and more research is necessary to corroborate this hypothesis. Additionally, the succession stage in which the forests are at the moment of investigation will also play a role as liana density decreases with on-going forest succession [13].

Furthermore, not only the fitness of a tree to serve as a host tree will increase the chance of lianas growing on that tree, also the presence of one liana close to the tree can increase this probability [14]. In this study 21.4% of all trees in sampling plot carried at least 1 liana. These values are lower than in other studies, such as 86% found in a study site in Bolivia [15], 88% in a reserve in Ghana [12] and a value of 63 ± 9.1 %, in Amazonian forest [16]. The lower value obtained was probably due to the lesser of anthropogenic disturbance and natural disturbance that occurred 40 years ago. Moreover, [17]
mentioned that there are interspecific differences in liana responses to different types of logging. As forest succession progresses, the canopy increases in height and continuity, reducing the habitat suitability for lianas for two reasons: first, energetic costs associated with ascent may reduce liana capacity to climb a great distance to the canopy, second, lianas are mostly light demanding [18] and in closed canopies of late forests, they are only able to establish and grow in tree gaps [1].

5. Conclusion
Executing a study of liana infestation in a recreational forest that has been left undisturbed for almost 40 years using an unmanned aerial vehicle has proven to be an efficient technique of monitoring. This technique could promote the local authority in forestry management particularly in managing the tree crown occupancy of liana in the logged-over forest. This findings from this study, significantly indicate that the percentage of liana infestation and crown occupancy index on the host trees within 1 ha plot in recreational park after 40 years of selective logging was lower. The liana infestation was distributed homogeneously. In addition, neither a link with natural disturbance over the years was traced back. Therefore, a comprehensive long term studies on lianas should be executed in the future.

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