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Carbon Stock of Necromass in Harvested Forest of Gunung Basor, Kelantan

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Abstract: The information on the carbon sequestration potential and associated dynamics of necromass in the east coast of Malaysia particularly in Kelantan is scanty. No prior studies have been carried out to quantify the above ground biomass of necromass in Kelantan. The decrease of live tree biomass in response to selective timber harvesting within the vicinity may lead to an increase of necromass stock. Therefore, this study was executed to estimate the carbon stocks of necromass of harvested tropical forest. Necromass and carbon stocks were measured in two sampling plots of 200m^2 in Gunung Basor, Kelantan, Malaysia. All dead standing trees; trunks; dead trees on the ground; stumps with diameter >5 cm and length of >0.5m were sampled. The total necromass recorded within the study area was 124.4 Mg ha^{-1} whilst a total of 62.2 Mg ha^{-1} carbon stock was estimated from 12 different diameter size classes. Out of 803 necromass samples, the highest carbon stock (18.5 Mg ha^{-1}) was represented by 1% of fallen dead tree with dbh more than 55 cm. About 21% (n=169) necromass contributed the second largest pool of carbon stock (42.7 Mg ha^{-1}). Meanwhile, 79% (n=634) of necromass was accounted for the lowest carbon sock (1.0 Mg ha^{-1}) in the study area. The high necromass stocks in this study site may suggests that the flux of carbon dioxide by virtue to decomposition process may contribute to 30 to 40% of gross carbon dioxide efflux in the future. This study is vital in providing data on the carbon storage capacity of tropical forests in Kelantan and may as well aid in the decision making processes for sustainable forest management.

Keywords: Necromass, Carbon Stock, Harvested Forest

INTRODUCTION

Necromass is a term for dead portions of trees and branches. The death and subsequent decomposition of trees is an important component in the forest ecosystem carbon cycling and directly tied to the forest structure [6]; [9]. Carbon stored in necromass is one of the five carbon pools identified by the Intergovernmental Panel on Climate Change that should be measured and monitored for carbon book-keeping [26]. Accurate accounting of these pools is essential for mitigation, e.g. via REDD+ (reducing emissions from deforestation and degradation + enhancing forest carbon stocks).[16]

As carbon storage, much attention has been given to living above ground biomass as compared to woody coarse debris or necromass. The majority of studies investigating causes of spatial variation in biomass and carbon stocks of tropical forests remain focused on living trees [14]; [21]; [11], with the assumption that these represent the largest fraction of total above-ground biomass [17]. The dynamics of necromass production are poorly understood and quantified in tropical forest [7]. Yoda and Kira [27] estimated 22.5 Mg C ha^{-1} of necromass in Pasoh, Malaysia.

As tropical forests in Malaysia are crucial to carbon cycling and sequestering on a global scale, precise estimation is vital to ascertain the major role of necromass engages in contributing carbon stocks to conservation. The variation in necromass stocks depend on several factors such as topography affecting tree mortality [8] and the land use history and management of an area [7]; [12]. The practice of selective harvesting which is a major land use change process has eventually accelerated the necromass stocks in Malaysian tropical forests.

The information on the carbon sequestration potential and associated dynamics of necromass in the east coast of Malaysia particularly in Kelantan is scanty. No prior studies have been carried out to quantify the above ground biomass of necromass in Kelantan. The decrease of live tree biomass in response to selective timber harvesting within the vicinity may lead to an increase of necromass stock. Therefore, this study was carried out to estimate the biomass and carbon storage of necromass of harvested tropical forest in Gunung Basor,

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Kelantan, Malaysia. This study is vital in providing data on the carbon storage capacity of tropical forests in Kelantan and may as well aid in the decision making processes for sustainable forest management.

MATERIALS AND METHODS

Study area

The area of Gunung Basor is approximately 40,613 ha and 34,763 ha of Gunung Basor was gazetted as permanent forest reserve. Another 5,850 ha of Gunung Basor was targeted as production forest [15]. According to Kelantan Forestry Department (2003), Gunung Basor had been logged mostly in the late 1970s to 1980s by selective management system. The soil type varies according to the terrain conditions. The average maximum and minimum temperature of Gunung Basor is 32°C and 25°C with mean annual rainfall of 2750-3000 mm. Generally, there are three types of vegetation zonation in Gunung Basor, namely lowland dipterocarp, hill dipterocarp and montane forests. The study area was located on the hill dipeterocarp forest, 1045m asl.
(Source: Kelantan Forestry Department, 2003)

Figure 1: Map of the study area.

Sampling technique and field measurement

Two sampling plots of $200m^2$ (5 x40m) were established due to the convenience to layout and measure. Necromass was measured using a fixed area plot sampling. Necromass or coarse woody debris is often divided into categories (1) fallen or downed necromass and (2) standing dead woods or snags [10]. In this study, all dead standing trees; trunks; dead trees on the ground; stumps with diameter >5 cm and length of >0.5m were sampled. Each tree was measured for dbh (in cm) by using a diameter tape whilst the height (in m) was measured by using hypsonometer range. For subsequent analyses, to account for potential errors in dbh measurement, the measured tree dbh were binned into equal classes of 5 cm diameter each (e.g 0-5,5-10,10-15 cm).

The biomass of necromass was calculated by using the following equation:

$$\text{Biomass} = \pi \times D^2 \times h \times 0.5/40$$

Where, biomass was expressed as h = length, D= diameter, 0.5= specific gravity of tree [13].

Meanwhile, carbon stored in necromass was obtained as half of the dry mass, it was assumed that 50% of the dry mass was carbon [26].

RESULTS AND DISCUSSION

The total necromass recorded within the study area was 124.4 Mg ha^{-1} accounted by 803 samples. Figure 2 indicates the highest necromass (36.9 Mg ha^{-1}) was estimated in fallen dead tree with a large diameter tree range of 122.6 m. Whilst, the lowest necromass (2.0 Mg ha^{-1}) was accounted by dead trees with smaller tree diameters ranging less than 5 cm. Of these, 85.8 Mg ha^{-1} of necromass was estimated among the dead trees with diameter ranges in between 5 to 55 cm

A total of 62.2 Mg ha^{-1} carbon stock was estimated from 12 different diameter size classes. In Figure 3, out of 803 necromass samples, the highest carbon stock (18.5 Mg ha^{-1}) was represented by 1% of fallen dead tree with dbh more than 55 cm. Another 21% (n=169) necromass contributed the second largest pool of carbon stock (42.7 Mg ha^{-1}). Meanwhile, 79% (n=634) of necromass was accounted for the lowest carbon sock (1.0 Mg ha^{-1}) in the study area.

The estimates of necromass stock in harvested forest of Gunung Basor (124.4 Mg ha^{-1}) was out of the spectrum recorded for lowland tropical forests [1]; 26 Mg ha^{-1} [23] and 41 Mg ha^{-1} [8] previously found for lowland forests

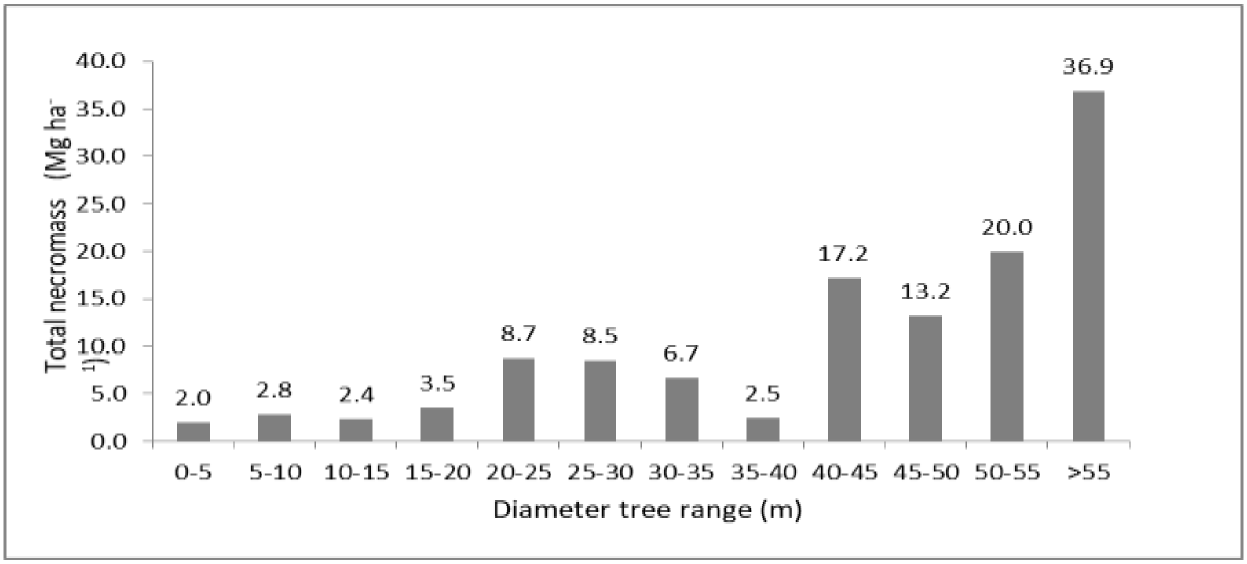

Figure 2: Total necromass of Gunung Basor harvested forest, estimated in different diameter sizes.

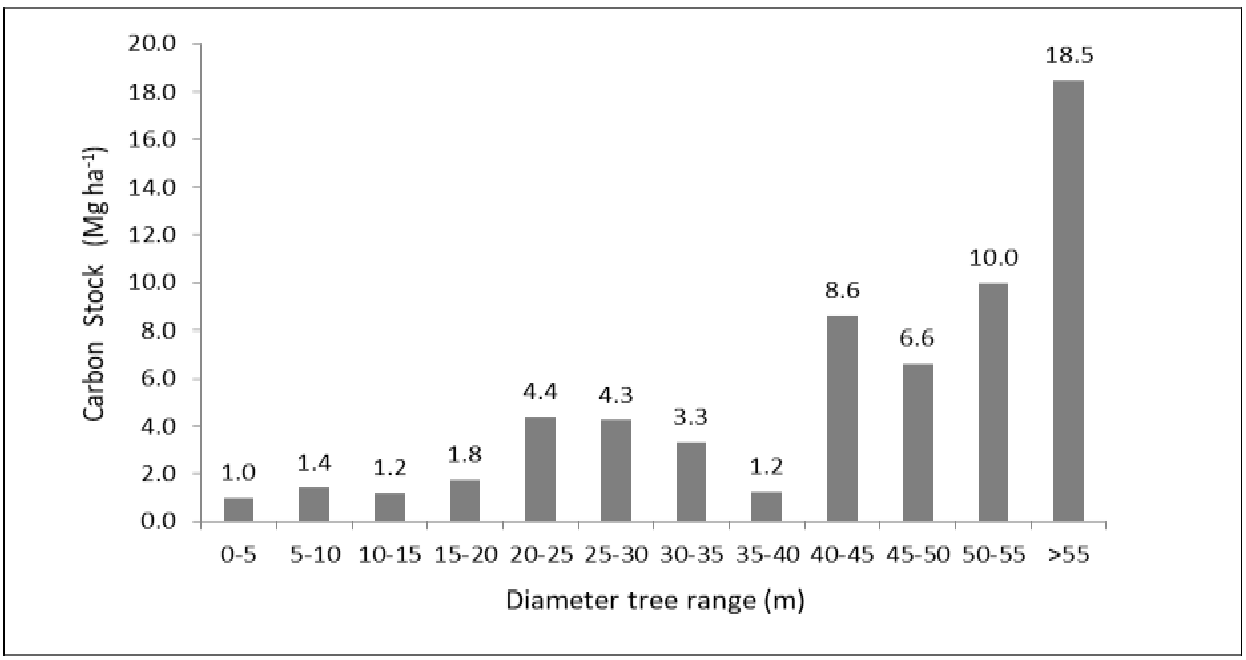

Figure 3: A carbon stock pool in different sizes necromass of Gunung Basor harvested forest.

in North Borneo. Gale [8] estimated necromass for pieces with > 20 cm diameter to be 45 Mg ha^{-1} in Belalong, Brunei; 41 Mg ha^{-1} in Danum, Sabah and 69 Mg ha^{-1} in Andalau, Brunei . According to Delaney *et al.* [5], deadwood mass in undisturbed moist tropical forests has been estimated to be less than 10%, 15% [24] and 19% [22] of total above ground biomass stocks.

On contrary, the analysis in this study indicates the dead tree mass in harvested forest of Gunung Basor was approximately 30 to 40% higher than undisturbed forests even though the reduced impact logging (RIL) management had been strictly imposed. The study site was once been logged in late 1990s and been left untouched for almost 28 years as to comply with Selective Management System (SMS). There were several factors that may contribute to the high accumulation of necromass stocks within the study site, such as slow rate of decomposition of certain necromass components or species. The moist temperature and sometimes due to torrential rain will gradually abate the decomposition process. Eventually, as the time goes by, the new fallen dead trees due to disease or natural disaster such as thunder strike will increase the accumulation of necromass stocks. Apart from that, the existence of previous harvested trails may also contribute to higher necromass stocks.

As meta-analyses suggest that selectively logged forests retain substantial biodiversity, carbon and timber stocks with once logged forest stands retaining 76% of their above ground carbon stocks one year after logging [20]. According to Berenguer *et al*. [2], large landscape assessments of above ground carbon changes along a disturbance gradient in tropical forests are rare. Carbon changes studies typically focus on assessments of either live tree or dead wood carbon [13]; [14]; [3]. Few studies that quantify both living and dead carbon stocks have often been carried out in primary forest stands alone [18] and [14]. According to Pfeifer *et. al* [19], the deadwood carbon stocks can represent a large proportion (>50%) of above ground carbon stocks in human modified forests. Comprehensive studies of tropical necromass in tropical forests need to include both standing dead and smaller size class measurements (< 10 cm diameter) due to those will collectively contribute a large proportion of the overall necromass pool [19].

CONCLUSION

The analysis in this study indicates the dead tree mass in harvested forest of Gunung Basor was approximately 30 to 40% higher than undisturbed forests even though the reduced impact logging (RIL) management had been strictly imposed. The high necromass stocks in this study site may suggests that the flux of carbon dioxide by virtue to decomposition process may contribute to 30 to 40% of gross carbon dioxide efflux in the future. The high percentage of necromass stock recorded in this harvested forest reflected the low carbon storage in live trees. The carbon stocks of necromass only comprise 50% of the dry mass as compared to the live trees. Further improvement for efficient implementation on RIL management should be highly considered. Nevertheless, several environmental factors may contribute to this high accumulation of necromass stocks. This study is vital in providing data on the carbon storage capacity of tropical forests in Kelantan and may as well aid in the decision making processes for sustainable forest management.

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