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Stand structure and diversity of restored mangroves at abandoned pond in eastern coast of North Sumatra

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Stand structure and diversity of restored mangroves at abandoned pond in eastern coast of North Sumatra

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Abstract. Mangrove forests are one of the coastal wetland ecosystems and productive that functions as a buffer of life. However, in the last few decades, mangrove forests continue to be degraded or lost due to various human activities, especially the conversion of mangroves into ponds. Mangrove restoration on abandoned pond land has been carried out in recent years in eastern coast of North Sumatra. This study aimed to determine the diversity and structure of mangrove vegetation resulting from restoration on ex-pond lands on the eastern coast of North Sumatra. A total of 30 sample plots, each measuring 10m x 10 m, have been built at each age of stands from 5 years-old to 9 years-old and secondary forests. All trees with diameter (DBH) ≥ 2 cm in the sample plot were identified, measured DBH and height. The restored mangroves on the eastern coast of North Sumatra have high regeneration although the diversity was lower than secondary mangroves. A number of mangrove tree species were found growing in restored mangrove even though they were not planted. Therefore, the mangrove restorations have good impact on mangrove conservation. Some efforts to maintain mangrove forests from restoration and secondary forests need to be considered in order to avoid various disturbances.

1. Introduction

Indonesia has a variety of natural habitats that are rich in various types of ecosystems, plant and animal resources, and a large number of endemic species on each island. Therefore, Indonesia is known as the centre of world biodiversity [1, 2] as part of Sundaland region. The ecological functions of an ecosystem starting from the ocean as a heat barrier and the mechanism of heat exchange between the sea, soil and air, to the role of forests as the lungs of the world. Among the various natural habitats that are included mangrove ecosystems [3, 4] as one of the coastal wetland habitats.

Mangrove forests besides functioning physically as a barrier to coastal abrasion and tsunamis [3-5], the biological function of mangroves is to provide food ingredients for human life, especially fish, shrimp, shellfish and crabs, as well as energy sources for life on the coast such as plankton, nekton and algae [3, 6], supporting various ecosystem services, nutrient cycles, soil formation, timber production, fish breeding grounds, ecotourism and carbon storage [3, 6, 7]. Until 2014, Indonesia is recorded as a country that has the largest mangrove forest in the world, which is almost 30% of the total mangrove area in the world are growing in Indonesia [8]. In the last three decades, forest damage due to anthropogenic factors has increased significantly. The remaining mangrove forests are threatened due to clear cutting, land conversion, changes in hydrology, chemical spills and climate change [8-10].

At the end of the 1960s, Indonesia had lost more than 200,000 hectares of mangrove forests. Because of the government policy is to expand the ponds in the 1980s that it triggered the loss of mangrove area by 800,000 ha in just 30 years [10]. Meanwhile, around 60% of the mangrove forests on the east coast of North Sumatra were lost in the period 1977-2006, mainly due to the conversion into ponds [11].

The loss and degradation of mangrove forests will reduce mangrove productivity in supporting coastal ecosystems that will cause various environmental problems such as floods, seawater intrusion, coastal abrasion, decrease in volume and diversity of fish species caught [12-14]. Mangroves have good ability in resiliency after natural disaster [15-17], however the restoration actions are needed for anthropogenic disturbances. Mangrove restoration efforts on unproductive ponds or abandoned pond lands have been carried out in several areas on the eastern coast of North Sumatra after the 2004 tsunami. However, there is no data provided about the condition of the restored mangroves. Therefore, this study aimed to determine the diversity and structure of mangrove vegetation due to mangrove restoration activities at various ages of mangrove forest restoration on abandoned pond land in eastern coast of Sumatra.

2. Materials and Methods

2.1. Study sites and periods

The study sites was situated at the restored mangrove forests on abandoned pond land and secondary mangrove forests at Percut Sei Tuan District, Deli Serdang Regency of eastern coast of North Sumatra (Figure 1). The mangrove restorations were established by NGO, namely Yayasan Gajah Sumatra in several years after the 2004 Indian Ocean tsunami. There were several years-old of restored mangrove stands, i.e. from 5 years-old to 9 years-old in the areas. The fieldworks were conducted from June to November 2016.

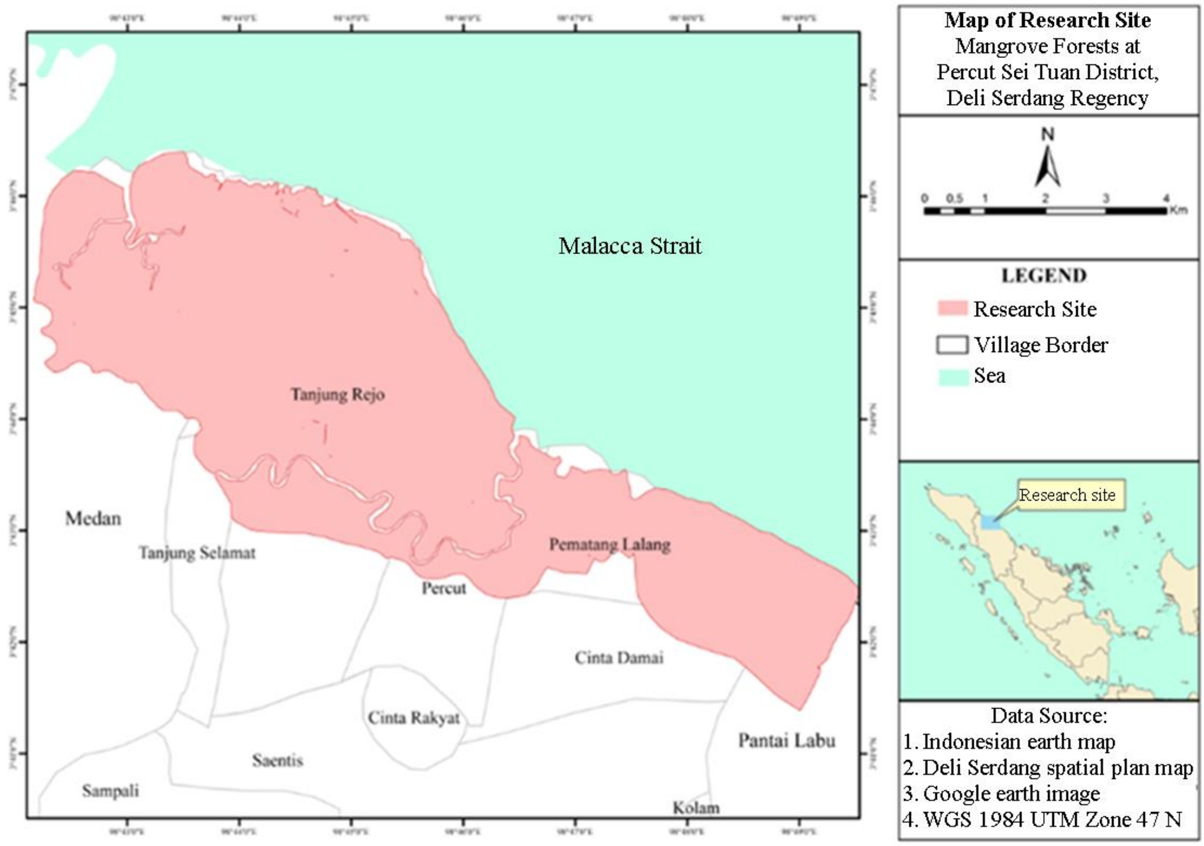

Figure 1. The research site of mangrove forests at eastern coast of North Sumatra. Some mangrove restorations were done in this area after the 2004 Indian Ocean tsunami as a form of awareness of the importance of mangroves.

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2.2. Method

Vegetation analysis were conducted at 30 sample plots, each size 10m by 10m that established at each restored mangrove stand (5-9 years) as well as secondary forests (Figure 2). The selection of plot sample within forest according was carried out systematic sampling with random start method. The distance between sample plots in each mangrove stand was 10 m. Each tree in the sample plot is classified according to the growth stages, namely 1) sapling stage that is 2.0-9.9 cm in DBH and 2) tree stage that the DBH is ≥ 10 cm. Each individual contained in each plot was identified, and its diameter (DBH) was measured, total tree height (TH) was estimated [4].

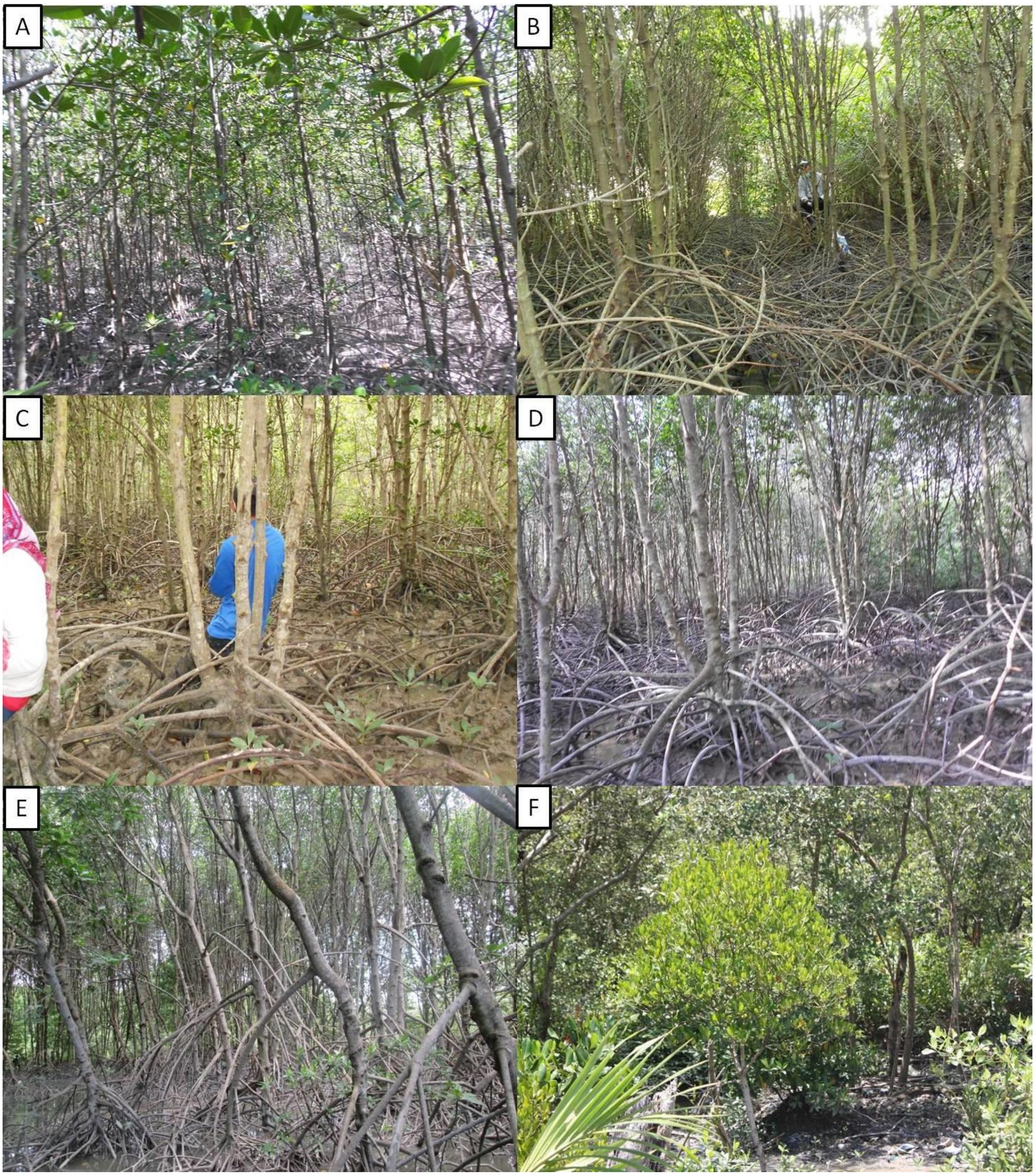

Figure 2. The scenery of mangrove forests at the study site: restored mangroves (A = 5 years-old, B = 6 years-old, C = 7 years-old, D = 8 years-old and E = 9 years-old) and secondary mangroves (F).

2.3. Data analysis
To find out the vertical structure (tree height class distribution) of the mangrove forests, each individual tree found in the sample plot is classified according to the high class with 2 m intervals. Whereas to determine the distribution of tree diameter (horizontal structure), each individual found in the sample plot is classified according to the diameter class at 3 cm intervals.

The Shannon-Wiener index (*H'*) [4, 18] was used to calculate the species diversity (*H'*). Analysis of diversity indices were executed by using the Multivariate Statistical Package (MVSP) program ver 13.3d by Kovach Computing Services [19] that a multivariate analysis software of ecological data.

3. Results and Discussions

3.1. Forest structure
The stand density of mangrove forests in research site varied from 1,692 ind/ha to 2,990 ind/ha (Figure 2). The highest stand density was found in the restored mangrove with 6 years-old, followed by the secondary mangrove (2,888 ind/ha) and the restored mangrove with 5 years-old (2,691 ind/ha). The lowest stand density was found in the restored mangrove with 8 years-old due to high anthropogenic disturbance, such as illegal cutting (Figure 4). Based on information by local people, the illegal activities occurred by local communities for fishing, housing and fuel wood. Therefore, the high impact of the illegal activity was experienced by the older stands that have more suitable size trees. The disturbance causes decreasing the mangrove conditions [4], including structure and diversity [19, 20].

The tree height of mangrove forests both restored and secondary mangroves in the study site was varied from 3.0 m to 12.9 m (Figure 5). The stand density based on tree height class varied between stand age (restored mangroves) and secondary mangroves. Lower high class (3.0-4.9 m) dominated at the young stand (5 years-old). Then, the middle high class (5.0-6.9 m) was found dominated the 6 years-old and 7 years-old of restored mangroves. Subsequently, the restored mangroves with 8 years-old and 9 years-old and secondary mangroves were dominated the higher high class, i.e. 7.0-8.9 m.

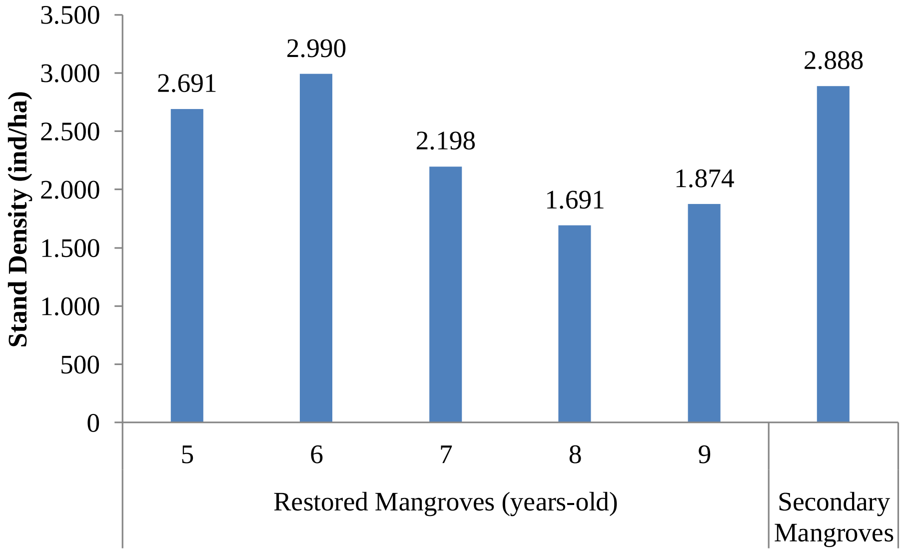

Figure 3. Stand density of mangrove forests both restored (based on stand age) and secondary mangroves in the study site.

Figure 4. Illegal cutting of mangrove trees has been occurred in restored mangrove forests.

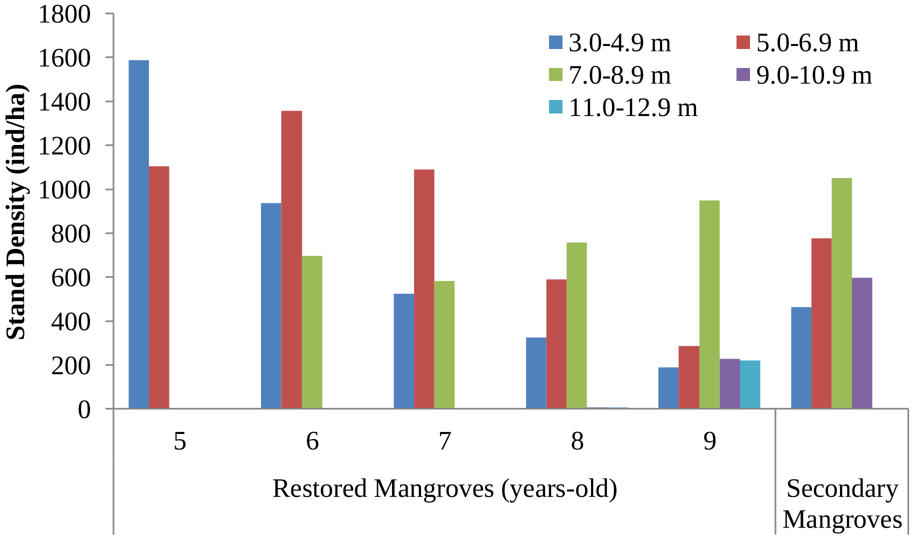

Figure 5. Vertical structure of mangrove forests both restored (based on stand age) and secondary mangroves in the study site

As be seen at Figure 5, the 5 years-old stand was dominated by high class of 3.0-4.9 m with density of 1587 ind/ha, followed by class of 5.0-6.9 m (1104 ind/ha). Subsequently, the stands of 6 years-old and 7 years-old were dominated by high class of 5.0-6.9 m, while the stands of 8 years-old, 9 years-old and secondary mangroves were dominated by class of 7.0-8.9 m. The results indicated that the increasing age of restored mangroves, the vertical structure is more like natural stands.

There were 5 (five) diameter classes of mangrove stands at the research site (Figure 6). Almost the diameter class of 6.0-9.9 cm were dominated all stands both restored and secondary mangroves. It means all stands of mangroves in the areas were regenerating stages, dominated by sapling stage. Subsequently, most of the higher diameter class that more than 10 cm (Figure 6) were decreasing. This is due to cut (Figure 4) by local community for several purposes.

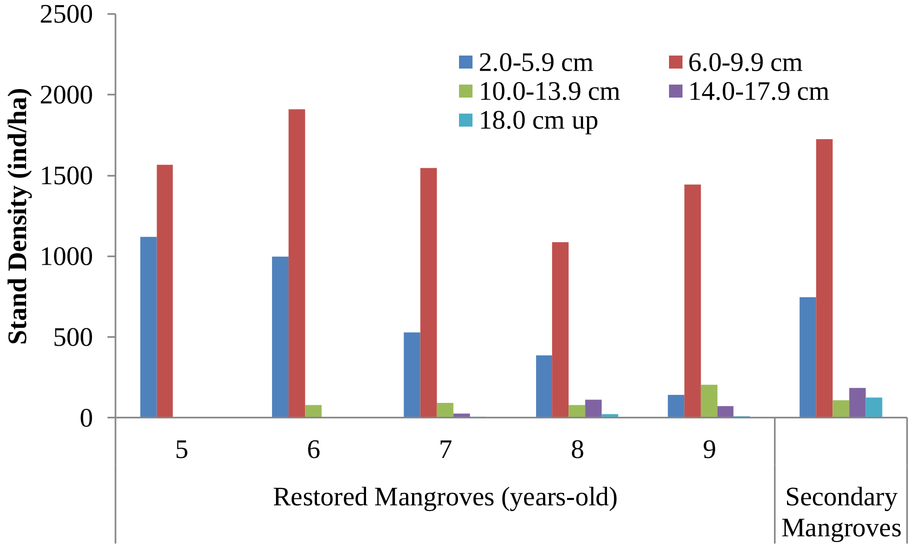

Figure 6. Horizontal structure of mangrove forests both restored (based on stand age) and secondary mangroves in the study site

3.2. Species diversity

Almost the species diversity of restored mangroves in all stages at the research site were classified as low species diversity (H' < 1.0), except stand of 8 years-old stand that classified as medium species diversity (1.0 ≤ H < 2.0) (Figure 7). The species diversity of secondary mangroves was categorized medium. Therefore, some actions are needed to maintain the species diversity of the mangroves and the anthropogenic disturbance should be stopped.

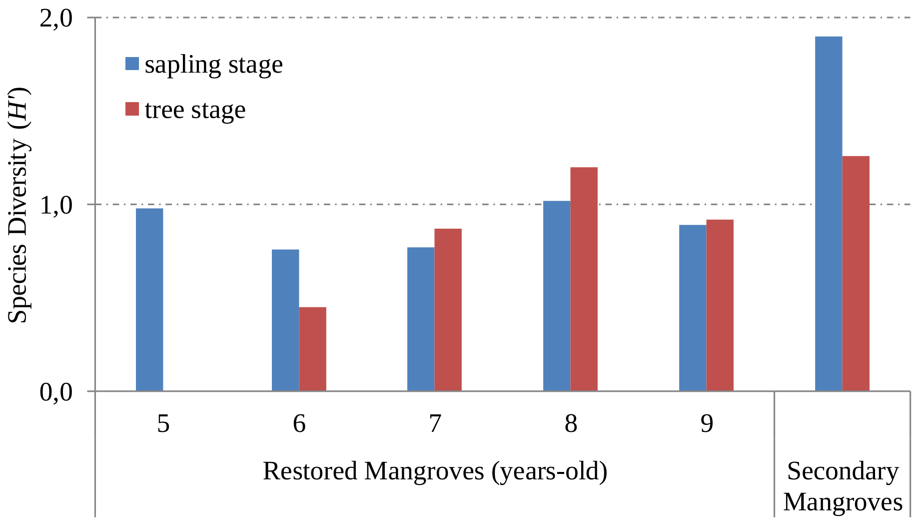

Figure 7. Species diversity at each stage of mangrove forests both restored (based on stand age) and secondary mangroves in the study site.

4. Conclusions

Increasing the age of the restoration forest stand will be followed by changes in the stand structure both vertical and horizontal. The older stands of restored mangroves are more like natural stands of mangroves. Some illegal activities has threatened the mangroves both restored and secondary mangrove forest in the area. Therefore, the appropriate forest protections are needed. The local community should be more involved in mangrove forest protection and conservation.

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References

[1] Myers N, Mittermeier RA, Mittermeier CG, Da Fonseca GA, & Kent J 2000 Nature, 403(6772), 853.
[2] Mittermeier RA, Turner WR, Larsen FW, Brooks TM, & Gascon C 2011 Global biodiversity conservation: the critical role of hotspots Biodiversity hotspots: distribution and protection of conservation priority areas eds FE Zachos, & JC Habel (Berlin: Springer) pp 3-22.
[3] Onrizal 2015 The Recovery of Coastal Vegetation of Northern Sumatra After Earthquakes and Tsunamis in 2004 and 2005 (Doctoral dissertation, Universiti Sains Malaysia).
[4] Onrizal, & Mansor M 2016 Biodiversitas Journal of Biological Diversity, 17(1), 44-54.
[5] Onrizal, Kusmana C, and Mansor M 2009 Wetland Science, 7(2), 130-134.
[6] Neogi SB, Dey M, Kabir SL, Masum SJH, Kopprio G, Yamasaki S, & Lara R 2017 Asian Journal of Medical and Biological Research, 2(4), 488-507.
[7] Murdiyarso D, Purbopuspito J, Kauffman JB, Warren MW, Sasmito SD, Donato DC, ... & Kurnianto S 2015 Nature Climate Change, 5(12), 1089.
[8] Hamilton SE, & Casey D 2016 Global Ecol Biogeogr, 25, 729–738.
[9] Richards DR, & Friess DA 2016 PNAS, 113(2), 344-349.
[10] Ilman M, Dargusch P, Dart P, & Onrizal 2016 Land Use Policy 54, 448–459
[11] Onrizal 2010 Jurnal Biologi Indonesia, 62, 163–172
[12] Onrizal, Purwoko A, & Mansor M 2009 Impact of mangrove forests degradation on fisherman income and fish catch diversity in eastern coastal of North Sumatra, Indonesia. In: International Conference on Natural and Environmental Sciences 2009 ICONES'09. Banda Aceh, Indonesia, 6–8 May 2009
[13] Primavera JH 2005 Science, 310(5745), 57-58
[14] Walters BB, Ronnback P, Kovacs JM, Crona B, Hussain SA, et al. 2008 Aquatic Botany 89, 220–236.
[15] Onrizal, & Mansor M 2018. IOP Conference Series: Earth and Environmental Science, 126(1), 012121
[16] Onrizal, Ahmad AG, & Mansor M 2017 IOP Conference Series: Materials Science and Engineering, 180(1), 012045.
[17] Onrizal O, Mansor M, & Sulistiyono N 2015 International Journal of Agriculture System, 3(2), 213-221.
[18] Ludwig JA, & Reynolds JF 1988. Statistical Ecology. A Primer on Methods and Computing. (New York: John Wiley and Son).
[19] Onrizal & Kusmana C 2008 Biodiversitas, 9(1), 25-29
[20] Onrizal, Sulistiyono N & Afifuddin Y 2016 Abdimas Talenta, 11, 64-69