Journal of Sylva Indonesiana (JSI) Vol. 05, *No.* 02, 2022 | 113 – 123

Similarity Analysis of Understorey Plant Species in Forest Areas

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Abstract. Many forests have substantial understorey plants. These plants have an important contribution to soil and water conservation. The similarity index determines the resemblance of species structure and composition in a community. This research is aimed to see the impact and relationship of changes in the allocation of forest areas to the similarity of understorey species. The research was conducted using the line plot sampling method, sized 2 m x 2 m, with the understorey plants observed have been measured from germination to young plant (height 1.5 m). The number of plots in the plantation forest is 480 plots, protected areas 224 plots, and natural forest 96 plots. Determination of the number of understorey plots based on the minimum representative area curve. A Similarity Index was performed to analyze the data. The results indicated that there is an impact of changes in the forest area on the similarity of understorey species. It is known from the low similarity index value at the research location. It is due to the differences in environmental factors at the two locations such as air humidity, air temperature, the intensity of sunlight, and different patterns of forest area management.

Keyword: Forest Area, Protected Forest, Similarity Index, Understorey Composition, Understorey Plant,

Received 12 October 2021 | Revised 17 July 2022 | Accepted 20 July 2022

1 Introduction

The understorey is a plant community that composes a subterranean stratification near the soil surface. These plants are generally grasses, herbs, shrubs, or low shrubs. The understorey grows between the main trees which will strengthen the soil structure of the forest [1]. This ground cover can be functioned in infiltration and help to resist the direct fall of water. The understorey is also often used as an indicator of soil fertility and produces a sense of increasing soil fertility

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Published by Talenta Publisher
ISSN: 2622-5093 e-ISSN: 2622-5158 DOI : 10.32734/jsi.v5i02.7375
Journal Homepage: http://jsi.usu.ac.id

[2]. Many forests have substantial undergrowth plants. They also have a similar importance as the forest itself. The fine roots help conserve soil and water, preventing soil erosion, reducing runoff water and raindrops increasing organic matters in soil (green manure and mulch) [3].

Land cover change shows a transition process that describes the dynamics of land cover change in the long term. Changes in land cover on a large scale usually cause a large ecological impacts, including changes in the structure and composition of the forest. A simplification of the structure and composition in forest species can eliminate some plant species and often also eliminate local species and replace them with foreign species [4].

Therefore, there are many negative perceptions from environmental activists (non-governmental organizations) who think that the development of industrial plantation forests will have a negative impact on the environment in the form of reduced plant species diversity as a result of the conversion of its designation from natural forests to industrial forest plantations with Eucalyptus as the main plant and the allelopathic effect caused by produced on the environment. To answer these concerns, research is needed to find out whether there is a relationship between changes in forest use and the presence and similarity of understorey species.

The Similarity Index provides a resemblance of species structure and composition in a community, from 0% to 100% [5]. The value of 100% indicates high similarity and 0% demonstrates dissimilarity. This index determines the degree of similarity in the species composition of the two compared communities. According to former research [6], a high Similarity Index expresses high similarity between species in a community. This study aims to see the impact and relationship of changes in the allocation of forest areas to the similarity of understorey species.

2 Research Method

2.1 Study area and research duration

This research was conducted from April 2019 to April 2020 in Industrial Plantation Forest known as IUPHHK-HT PT. Toba Pulp Lestari, Tbk (Aek Nauli Estate, and Tele Estate), and forest areas (plantation, protected and natural forests) in Partungko Naginjang Village, Samosir Regency, and Aek Nauli Village, Simalungun Regency, North Sumatra Province (Figure 1). In this research, we observed 3 forest areas, namely (a) plantation forest, which has been planted with Eucalyptus plant, (b) protected forest, and (c) natural forest. Both forests are located side by side in the concession of PT. Toba Pulp Lestari, Tbk. Natural forest (control) is located about 20 km from the plantation and natural forests. The changes period of forest area up to the time that the research was conducted is 25 years.

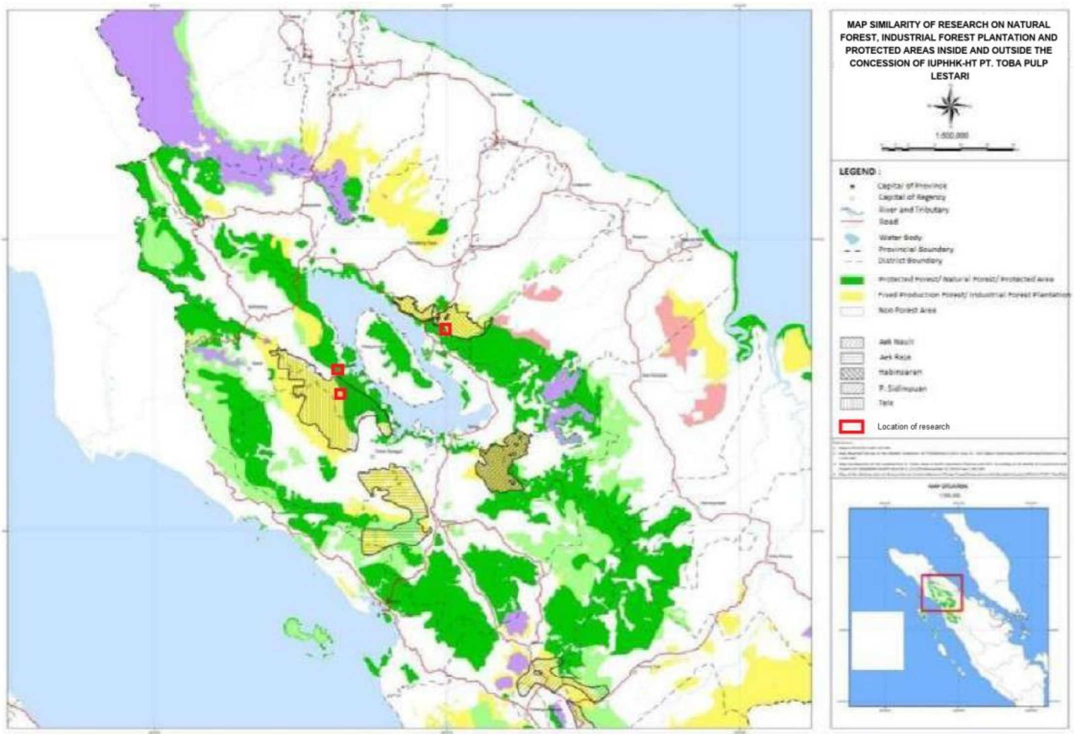

Figure 1 Map of research location in North Sumatra Province

Based on the administration, these research locations are in Aek Nauli Sector, Simalungun Regency, and Tele Sector in Samosir Regency. Located at an altitude from 250 m to 1850 m above sea level. The climate type is A (very wet), average rainfall 220 mm - 238 mm, humidity in the natural forest ranges from 25% - 98%, plantation forest area 44% - 84%, cultivated area 42% - 66%, light intensity in natural forest 6.4 - 89.3 lux meters, protected forest 41 – 91.7 lux meters, cultivated areas 30.8 – 39.2 lux meters. Natural forest pH ranges from 4.2 – 6.3, protected forest 5.1 – 6.6, and plantation forest area 4.4 – 6.4.

2.2 Research equipment

The types of equipment used in this research were Global Positioning System Garmin GPS MAP 64s, Lux meter Benetech GM1030C, hygrometer Sunway SW-572, machete, digital camera, compass, measuring tape, maps, tally sheet, stationery kit, and plastic bags.

2.3 Data collection

It is carried out through vegetation analysis activities to obtain data on the composition and structure of vegetation, by first calculating the number of sample plots to be measured using the minimum species area curve. The method of placing plots in paths uses the checkered line method. Each measuring plot is placed on the left and right and observed plants that have regenerated from germination to young plants (1.5 m high) [7]. For forest groups with an area of 1,000 ha or more, the sampling intensity used should be 2%, while if it is less than 1,000 ha, the sampling intensity should be 5% – 10%.

Vegetation analysis was carried out by measuring plots for levels. The sampling intensity is 5%. The area of measuring plots is 2 m x 2 m, the distance between lines is 35 m and the distance between plots is 14 meters. The number of plots in the plantation forest is 480 plots, protected areas 224 plots, and Natural Forest 96 plots. The determination of the undergrowth plot number is calculated based on the minimum representative area curve. The forest area of each research location is 235 Ha of Plantation Forest, 110 Ha of Protected Area, and 48 Ha of Natural Forest. The variables observed and calculated in this study were plants at the seedling level.

2.4 Data Analysis

A measure of similarity was obtained by using [8]:

$$SI = \frac{2W}{a+b} \tag{1}$$

Where: SI: Similarity Index

W: lowest species number (<) in 2 communities compared

a,b: Quantitative value of all species in the communities

The similarity coefficient ranged from 0% to 100%. When the similarity reaches a value of 100%, high similarity has been approached. The Dissimilarity Index can be determined from this similarity value by the formula 100-SI.

3 Results and Discussion

3.1 Understorey Composition

The results of the analysis found the composition of understorey species in each forest area, among others, in the plantation forest area consisting of 98 plant species, the protected area consisting of 57 plant species, and the natural forest consisting of 33 plant species (Table 1). This composition indicates that the number of species tends to be higher in industrial plantation forests compared to protected areas and natural forests.

Table 1 Understorey composition

No	Plantation Forest	Protected Forest	Natural Forest
1	*Foeniculum vulgare* Mill	*Foeniculum vulgare* Mill	*Phaphiopedilum kolopakingii*
2	*Chrysopogon zizanioides*	*Acalypha hispida* Burm. F	*Dendrobium curmenatum*
3	*Dioscorea alata*	*Dioscorea alata*	*Litsea cubeba* Lour
4	*Dendrobium setifolium* Rid	*Cymbopogon citratus*	*Begonia fimbristipulata* Hance
5	*Cymbopogon citratus*	*Rhynchostylis retusa*	*Hedyotis purpurea*
6	*Rhynchostylis retusa*	*Bulbophyllum lobii*	*Selaginella doeder leinii*
7	*Morus alba*	*Commelina diffusa* Burm F.	*Plantago major* L
8	*Ageratum conyzoides* L	*Ageratum conyzoides* L	*Erica multiflora*
9	*Amaranthus spinosus*	*Dieffenbachia amonea*	*Clidemia hirta* (L.) D.

No	Plantation Forest	Protected Forest	Natural Forest
			Don
10	*Fimbristylis umbellaris*	*Myriophyllum aquaticum*	*Hoya latifolia* G.Don
11	*Begonia fimbristipulata* Hance	*Blue potatobush*	*Nepenthes gracilis* Korth.
12	*Hyptis brevispes* Mart & Gal	*Plantago major* L	*Amorphophallus muelleri* Blume
13	*Myriophyllum aquaticum*	*Brachiaria distachya* (L.) Stapf	*Etlingera elatior* R. M. Smith
14	*Papaver somniferum*	*Clidemia hirta* (L.) D. Don	*Galinsoga parviflora* Cav
15	*Blue potatobush*	*Pavetta indca*	*Sporobolus diander* (Retz.) P.Beauv
16	*Oxallis corniculata* Linn	*Zingiber officinale*	*Alpinia galangal* (L.) Willd.
17	*Physalis peruviana* Linn	*Colacasia sp*	*Solanum ningrum*
18	*Centella asiatica*	*Amorphophallus muelleri* Blume	*Marchantia polymorpha*
19	*Plantago major* L	*Senecio vulgaris* L	*Aerobrysis longissima*
20	*Ipomoeae batatas* L	*Etlingera elatior* R. M. Smith	*Lycopodium cernuum*
21	*Aerva lanata* (L) Juss ex Schult	*Croton hirtus* L'Hér.	*Nephrolepis biserata*
22	*Erechtites valerianifolia*	*Alpinia galangal* (L.) Willd.	*Asplenium nidus*
23	*Brachiaria distachya* (L.) Stapf	*Marchantia polymorpha*	*Phymatosorus scolependria*
24	*Trevesia sundaica* Miq	*Hepaticopsida sp*	*Pandanus tectorius*
25	*Compositae Bidens* Pilosa	*Maranta arundinacea.*	*Dicranopteris linearis*
26	*Clidemia hirta* (L.) D. Don	*Ardisia crispa*	*Calamus erectus* Roxb
27	*Acalypha hispida* Burm.	*Crotalaria juncea*	*Pennisetum purpureum*
28	*Melastoma polyantum* BI	*Angiopteris avecta*	*Melastoma malabathricum*
29	*Calamus sp*	*Cycas rumphii*	*Piper aduncum* L.
30	*Phylloscopus humei*	*Lycopodium cernuum*	*Adiantum tenerum*
31	*Imperata cylindrica* Raeusch	*Nephrolepis biserata*	*Adiantum venustum*
32	*Curcuma aeruginosa* Roxb	*Stenochlaena palustris* Bedd.	*Emilia sonchifolia*(L.) DC. ex Wigh
33	*Zingiber officinale*	*Asplenium nidus*	*Derris elliptica*
34	*Panicum italicum* L.	*Pandanus tectorius*	
35	*Juncus effesus*	*Amomum lappaceum*	
36	*Asclepias curassavica* L	*Paspalum conjugatum* Berg	
37	*Senecio vulgaris* L	*Mimosa pudica* Linn	
38	*Boreria alata*	*Cyperus sp.*	
39	*Rumex crispus*	*Calamus erectus* Roxb	
40	*Diospyros whyteana*	*Chrysopogon aciculatus*	
41	*Saxifrage stolonifera* Meerb	*Pennisetum purpureum*	
42	*Lantana camara* Linn	*Digitaria filiformiiis* (L) Koeler	
43	*Alpinia galangal* (L.) Willd.	*Setaria sphacelata*	
44	*Solanum ningrum*	*Cyperus rotundus*	
45	*Anthocerotopsida*	*Rhodoleia teysmannii* Miq.	
46	*Marchantia polymorpha*	*Cichorium intybus* L.	
47	*Hepaticopsida sp*	*Melastoma malabathricum*	
48	*Aerobrysis longissima*	*Solanum tarvum*	
49	*Phyllanthus urinaria* Linn	*Crassocephalum crepidioides* (B) S.Moore	
50	*Artemesia vulgaris*, L	*Piper aduncum* L.	
51	*Origanum vulgare* L	*Conyza sumatrensis*	
52	*Tithonia diversifolia*	*Aglaonema sp*	
53	*Angiopteris avecta*	*Molineria latifolia*	
54	*Cyclosorus aridus* (Don.) Ching	*Chloranthus elatior* Link	
55	*Nephrolepis biserata*	*Toxicodendron radicans*	
56	*Stenochlaena palustris* Bedd.	*Derris elliptica*	
57	*Lycopodium cernuum*	*Dendrobium crumenatum*	

No	Plantation Forest	Protected Forest	Natural Forest
58	*Pandanus tectorius*		
59	*Euphorbia hirta* Linn		
60	*Centella asiatica* Linn		
61	*Paspalum conjugatum* Berg		
62	*Urena lobata*		
63	*Eleocharis dulcis*		
64	*Mimosa pudica* Linn		
65	*Eupatorium riparium*		
66	*Calamus erectus* Roxb		
67	*Calamus occidentalis*		
68	*Eleusine indica* L. Gaertn.		
69	*Pennisetum setaceum* (Forssk.) Chiov		
70	*Pennisetum purpureum*		
71	*Laportea ducumana*		
72	*Eragrostis cilianensis*		
73	*Chrysopogon aciculatus*		
74	*Borreria laevis* (Lamk) Griseb.		
75	*Digitaria filiformiiis* (L) Koeler		
76	*Brachiaria mutica*		
77	*Hedyotis corymbosa*		
78	*Panicum repens* L		
79	*Calamus sp*		
80	*Salvia officinalis*		
81	*Oplismenus compositus* (L.) P. Beauv.		
82	*Nasturtium montanum*		
83	*Cichorium intybus* L.		
84	*Hydrocotyle sibthorpioides* Lamarck		
85	*Melastoma malabathricum*		
86	*Sida rhombifolia*		
87	*Solanum sarrachoides*		
88	*Crassocephalum crepidioides* (B) S.Moore		
89	*Piper aduncum* L.		
90	*Calanthe sylvatica*		
91	*Fragaria vesca*		
92	*Molineria latifolia*		
93	*Adiantum caudatum* L.		
94	*Toxicodendron radicans*		
95	*Eurya acuminata*		
96	*Indigofera tinctoria*		
97	*Cyperus esculentus*		
98	*Curcuma aeruginosa* Roxb		

The composition difference of the plant species number in each forest area has thought to be caused by the management pattern of the forest area. It includes industrial plantation forests which are managed all the time (dynamically) by humans, starting from the preparation stage for the planting of staple crops (monoculture), plant maintenance, and harvesting. When compared to other management areas, namely protected areas and natural forests, it tends to be static. There are no human activities in the management of these forest areas, except the ecological factors of each plant species, plant species adapting to their environment, and the kinship factor between each species (association) and species, the distribution of each type of understorey, breeding patterns (pollen seeds and the influence of wind (nature) and human factors in seed dispersal [9].

The tendency for high total species variation in industrial plantation forests is caused by the open canopy of this Eucalyptus tree. Therefore, the opportunity for sunlight to reach the forest floor causes high stimulation of understorey plants, seeds, rhizomes, and seeds to quickly germinate and grow up. This difference in forest area management is thought to affect the diversity of understorey species in each forest area because the ecosystem conditions have also changed. According to [10], the diversity of understorey is influenced by environmental factors such as light intensity, soil pH, temperature, air humidity, and topography, and the changes that occur are influenced by the type of shade trees [11].

The type of distribution of understorey in non-plantation areas is not much different from the type of distribution of understorey in forest plantations, this is due to the presence of plants in natural forests that reproduce by seeds from parent plants, gradation of the microenvironment or kinship between species, both positive and negative [12]. According to [13], the factors that can affect the spatial distribution pattern of living things are (a) vectorial, namely, factors produced by environmental actions (soil type, wind, light, and water intensity), (b) social factors, namely factors related to the behavior of organisms such as territorial, (c) active co-factors, namely factors related to intraspecific interactions, and (d) stochastic factors, namely factors that result from random variations in several previous factors.

One of the plants found in the three research locations is Senduduk (*Melastoma malabathricum*). This plant usually grows wild in places with sufficient exposure to sunlight, including fields that are not too arid, mountain slopes, cliff edges, and forest edges. This plant has fruit that is favored by forest animals and birds, causing the wide distribution of the fruit. The population habitat is in the forest area with an open canopy following the physical conditions of population growth [14]. In addition to the population, there is also rattan (*Calamus erectus* Roxb) found at the three research sites. Rattan generally grows in swampy areas, dry land, to mountainous land. Rattan plants live in clumps and grow spreadly in hilly areas and mountainous areas. The types of plants found in industrial plantation forest areas are supported by land suitability and interactions between each species [15].

Daun sendok (*Plantago major*), harendong bulu (*Clidemia hirta*), and lengkuas hutan (*Alpinia galangal*) are also plants found in the three research sites. According to [16], these species produce chemical compounds and in general, these plant species reproduce through seeds and spores. These plants contain secondary metabolites, including flavonoids, polyphenols, phenolic acids, and chemical compounds of other secondary metabolites. Because they contain chemical compounds, these plants are not affected by changes in land use. There are also paku kawat (*Lycopodium cernuum*) scattered in the three research sites. This plant has a stem morphology resembling a wire with sporangium that comes out in the axils of the leaves. This plant releases spores as a means of propagation [17]. The dispersal of the seeds is carried out by the force of the wind. So that these plants can be easily spread in the study area.

3.2 Similarity of undergrowth plants in plantation and protected forests

We found 40% similarity between plants in plantations and protected forests. The results can be seen in (Table 2). The results showed that the similarity expressed by those forests was low, resulting in dissimilarity, as [11] stated in their research that there were 3 categories of community similarities: high (SI 75%), moderate (50% < SI < 75%) and low/dissimilar (25%).

Table 2 Similarity analysis of plants in plantation and protected forests

Site		C	SI	SI (%)
Plantation forest (98 species)	Protected forest (57 species)	31	0.4	40

3.3 Similarity of undergrowth plants in plantation and natural forests

The similarity of plants found in plantation and natural forests was 21.37% (Table 3). According [18] have been also classified this similarity: very high (IS > 75%), high (IS > 50 – 75%), low (IS > 25 – 50%) and very low (IS < 25%). From these categories, we can say that these forests demonstrated very low similarity.

Table 3 Similarity analysis of plants in plantation and natural forests

Site		C	SI	SI (%)
Plantation forest (98 species)	Natural forest (33 species)	14	0.214	21.37

3.4 Similarity of undergrowth plants in protected and natural forests

We recorded 33.33% similarity of plants grown in protected and natural forests (Table 4).

Table 4 Similarity of plants in protected and natural forests

Site		C	SI	SI (%)
Protected forest (57 species)	Natural forest (33 species)	15	0.3333	33.33

This finding showed low similarity between plants observed in those forests [19]. The results above indicated a similarity index < 50%. Ecologically, each forest demonstrates dissimilar composition. According [20] agreed that this different composition was contributed by different climates, and different species of plants resulted from adaptation and tolerance abilities developed by species in the plantation forest (homogenous climate), protected forest (heterogenous climate), and natural forest (heterogenous climate).

According to [21] confirmed that sunlight/shade is an important factor affecting the growth of undergrowth plants. We found 29 similar species in plantation and protected forests, 14 similar species in plantation and natural forests, and 15 similar species in natural and protected forests. The similarity index value is influenced by the number of plants and species observed between 2 compared communities. The higher number of similar species found between the 2 communities indicates a higher similarity index [22].

In the field, we observed that a higher similarity index was revealed by plantation and protected forests, resulting from intersecting and nearer locations between those forests (±20 km). The nearing forest tends to have similar plants, due to the possibility of seeds or pollen carried by the wind, insects, birds, and pollinators. Also, the topography, animal feces, and debris fraction contributed to this similarity. The low similarity index recorded in this research was greatly affected by the distance of forests observed, the changes in land use, and forest management differences. These differences describe the altered structures of plants in the forest areas caused by the silvicultural technique. It is applied by clearcutting the forest to have artificial regeneration (tree planting, preservation, precommercial and commercial thinning, removing and replacing new crops to improve plant quality and growth) [23]. In this forest, the Eucalyptus plant has been prunned to enhance the growth of young plants, particularly plants requiring abundant sunlight to improve the species diversity in plantation forest [24].

Diversity in communities is often caused by the different environmental factors between communities. The controlled harvesting system of Eucalyptus stimulates natural regeneration, activating the germination of plants through adequate sunlight exposure to improve the plants' growth [25]. The clearcutting technique followed by proper replanting and preservation will increase the sustainable harvest rate. The research of [26] revealed that several environmental factors such as humidity, temperature, and sunlight intensity have a great impact on vegetation, where these factors influence its growth and distribution.

4 Conclussion

Based on the results of the study, it can be concluded that there is an impact of changes in the forest area on the similarity of understorey species. It is known from the low similarity index value at the research location. It is due to the differences in environmental factors at the two locations, such as air humidity, air temperature, the intensity of sunlight, and different patterns of forest area management.

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