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Species Diversity of Understorey Vegetation in Pinewood (Pinus merkusii) Forest in RPH Sempor, BKPH North Gombong

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Abstract
Understorey plant is a type of basic vegetation under forest stands except for saplings. Understorey vegetation includes grasses, herbs, shrubs, and ferns. The presence of understorey vegetation can be used as an indicator of forest conditions and is expected to reduce disturbances to the forest. The purpose of this research is to determine the diversity and the dominance of understorey species under the pinewood stands based on pine ages in RPH Sempor, BKPH North Gombong. This research was conducted using a survey method and systematic sampling techniques at two different age groups pinewood forest of RPH Sempor, BKPH North Gombong. The result showed that the total understorey species found were 34 species from 21 families. The understorey species number found at the 25 years of pine forest was 22 species found and at the 45 years, there were 17 species. Based on the research that has been done, it can be concluded that the younger the age of pine stand, the more understorey species number. Evenness of the understorey species at two different ages of pine stand in RPH Sempor is evenly distributed, so there are no dominant species. The physicochemical factors measurement result showed that the canopy cover affected the temperature and humidity level, thus affecting the number of understorey individuals and the species number in each stand.
Key Words: *ages*, *diversity*, *pinewood*, RPH Sempor, *understorey*

INTRODUCTION

The pine forest area managed by *Badan Pemangkuan Kesatuan Hutan* (BKPH) North Gombong is 6,716.14 hectares (Selatan, 2021) and these areas were divided into some working plot that handled by some *Resort Pemangkuan Hutan* (RPH), especially Plot 80 and Plot 90. Both plots are located in Sempor village, Sempor district, Kebumen. Plot 80 and Plot 90 belong to the production forest area. Commercial forest are forest areas used to produce forest products. The products produced can be forest products in the form of wood or non-timber forest products. This type of forest is vast and is generally managed by private companies and local governments.

According to the head of BKPH North Gombong, Plot 80 was planted in 1976 and Plot 90 in 1996. The pine forest, which is a monoculture, has a very poor upper part of the plant. Visually, the elevation of the plant consists only of evergreens and understorey vegetation. According to (Sitompul, 2019), this is due to the shade of the pine trees. The shade of *Pinus merkusii* can affect the undergrowth in the form of both herbs, shrubs and grass under the stand.

Understorey plant is a kind of basic vegetation below the forest stand, excluding seedlings. Types of understorey are seasonal, annual, biennial, and perennial with a pattern that can occur randomly, clustered, and evenly distributed. Understorey vegetations can be grasses, herbs, shrubs, and ferns. The presence of understorey plants in the forest ecosystem has a major function in soil and water protection (Indriyani et al., 2017). The presence of understorey at beginning as an indicator of forest conditions, and is expected to reduce forest disorders (Yuniawati, 2013).

Understorey vegetation diversity is affected by the age-related canopies of the trees around the understorey vegetation (Rahmawati, *et al*., 2019). The result of the a higher number of undergrowth species in the younger pine forest in KPH of East Banyumas. The result showed that found 20 species of undergrowth in the 12-year-old pine stand, 18 species in the 24-year-old stand, and 15 species in the 29-year-old stand. Therefore, the wider the canopy cover, the less light will reach the forest floor (Pamungkas, 2017).

Based on the above explanation, it is known that understorey plays an important role as part of biodiversity. Therefore, it is necessary to conduct the research on species diversity of understorey vegetation in pinewood (*Pinus merkusii*) forest in RPH Sempor, BKPH North Gombong. The problems in this study are what is the condition of the understorey species diversity and which understorey species is predominant in pine forest stands based on the age of pine trees in RPH Sempor, BKPH North Gombong, Kebumen, Central Java. Based on these issues, the purposes of this research were to know the diversity and dominance of understorey species under the pinewood stands based on pine ages in RPH Sempor, BKPH North Gombong, Kebumen, Central Java.

MATERIAL AND METHOD

Material used was understorey species found in all research locations. The equipment used in this

research were thermohygrometer, Global Positioning System (GPS), wooden peg, ropes, stationary, plastic bag, label, lux meter, camera, identification book, notebook, soil tester, and measuring tape. The research was conducted in December 2021 until January 2022 located in Plot 80 and Plot 90 pinewood forest of RPH Sempor, BKPH North Gombong. Plot 80 pinewood forest has 45 years in age, while Plot 90 has 25 years in age. Both of them belonged to Sempor village, Sempor district, Kebumen regency, Central Java.

The method that used in this research was a survey method with systematic sampling technique. Sampling was done in 8 locations, 4 locations on 25 years pine stand and 4 locations on 45 years pine stand by using square plots on one transect line as long as 200 m to the forest in each 25 and 45 years of pine stand. Square plots that were used are 2 m x 2 m in size as many as 20 plots for understorey sample. The distance between each location was 50 meters, started from 50 meters after the forest entrance until 200 meters away. In each of location, 5 square plots measuring 2 m x 2 m were placed to measure diversity, species similarity, and evenness of understorey. 4 plots measuring 2 m x 2 m were placed at each corner and a 2 m x 2 m plot was placed in the middle.

Variable observed were understorey species diversity, dominance, and ages of pinewood. The main parameters are the diversity, evenness, dominance, similarity, and canopy cover. Supporting parameters include altitude and location coordinate measurement, air temperature, light intensity, humidity, and soil pH.

Obtained data were consisted from species number and individual number of understorey, canopy cover measured with Glama application, and environmental factors such as altitude measured with GPS, temperature and humidity measured with thermohygrometer, light intensity measured with lux meter, and soil pH measured with soil tester.

The understorey species obtained were identified with the pictures and the identification keys in Sastrapradja & Afriastini (1979, 1980, 1981, 1985), and Van Steenis (2006). All of understorey species specimen then made into herbarium. Understorey vegetation data were analyzed using Shannon-Wiener diversity index (H'), Pielou evenness index (E), Importance Value Index (IVI), and similarity index (SI).

Understorey diversity was calculated using Shannon-Wiener diversity index (Shannon & Weaver, 1963), with the following formula:

$$H' = -\sum_{i=1}^{s} pi \ln pi$$

Note:
H : Shannon-Wiener diversity index
pi : Proportion of type *i* ($pi = \frac{ni}{N}$)
ni : Individual numbers on plot *i*
N : Total number of individuals of all species

Understorey species data evenness is calculated using Pielou index (Pielou, 1966), with the following formula:

$$E = \frac{H'}{Hmax}$$

Note:
E : Pielou evenness index
H' : Shannon-Wiener diversity index
H_{max} : *ln* S
S : Number of understorey species

Importance value index (IVI) of understorey is calculated using (Mueller-Dombois & Ellenberg, 1974), with the following formula:

IVI = Relative Frequency + Relative Density

Note:

$$\text{Frequency} = \frac{\text{Number of quadrates of species occurrence}}{\text{Total number of quadrates studied}}$$

$$\text{Relative Frequency} = \frac{\text{Frequency of a species}}{\text{Frequency of all species}} \times 100\%$$

$$\text{Density} = \frac{\text{Total number of a species individuals}}{\text{Total number of quadrates studied}}$$

$$\text{Relative Density} = \frac{\text{Density of a species}}{\text{Density of all species}} \times 100\%$$

Understorey composition similarity between both pine stands is calculated using Similarity index according to (Odum, 1993), with the following formula:

$$SI = \left(\frac{2C}{a+b}\right) \times 100\%$$

Note:
SI : Sorensen similarity index
C : Species in common between community a and b
a : Number of species in community a
b : Number of species in community b

RESULT AND DISCUSSION

Based on understorey vegetation observation results in pinewood (*Pinus merkusii*) forest at different stand ages in RPH Sempor, 34 species from 21 families were found. In 25 years of pine stand, 22 species were found and 17 species were found in 45 years of pine stand (Table 1). Understorey species number obtained higher in younger pine stand, and lower in older stand. This finding is consistent with Rahmawati *et al*. (2019), who found that higher understorey species number obtained in younger pine stand and lower in older stand.

The number of individual plants on the forest under shade is greatly affected by the canopy cover size and the transmitted light. The older tree has the wider canopy cover and it makes less transmitted light to the forest floor. Hence, light is a very important environmental factor as the main energy source for ecosystems and its availability is significantly related to understorey plant species richness (Dormann, *et al*., 2020).

Table 1. Understorey diversity data found in 25 and 45 year of pine stand in RPH Sempor, BKPH North Gombong

No	Family	Species	Individual number in pine stand year	
			25	45
1	Acanthaceae	*Asystasia gangetica* (Nees) Ensermu subsp. *micrantha*	44	27
2	Arecaceae	*Licuala pumila* Blume	-	7
3	Begoniaceae	*Begonia hirtella* Link	-	91
4	Asteraceae	*Austroeupatorium inulifolium* (Kunth) R.King & H.Rob.	4	-
5		*Tridax procumbens* L.	-	63
6	Densntaedtiaceae	*Microlepia speluncae* (L.) T.Moore	14	-
7	Dioscoreaceae	*Dioscorea hispida* Dennst.	7	-
8		*Tacca palmate* Blume	13	-
9	Fabaceae	*Mimosa pudica* L.	91	-
10	Lygodiaceae	*Lygodium circinnatum* (Burm.fil.) Sw.	-	82
11		*Lygodium palmatum* (Bernh.) Sw.	33	-
12	Melastomataceae	*Clidemia hirta* (L.) D. Don	167	119
13		*Melastoma malabatrichum* L.	14	-
14	Osmundaceae	*Claytosmunda claytoniana* L.	8	-
15	Piperaceae	*Piper umbellatum* L.	-	18
16	Polypodiaceae	*Pyrrosia longifolia* (Burm.f.) C.V. Morton	76	-
17	Pteridaceae	*Pteris ensiformis* Burm. f.	73	-
18		*Pteris vittata* L.	73	-
19	Rubiaceae	*Exallage auricularia* (L.) Bremek.	12	-
20		*Hedyotis neesiana* Arn.	9	35
21		*Ixora parviflora* Lam.	3	-
22	Selaginellaceae	*Selaginella willdenowii* (Desv.) Baker	-	392
23	Tectariaceae	*Tectaria siifolia* (Wild.) Copel.	-	24
24	Thelypteridaceae	*Amblovenatum terminans* (Wall. ex Hook.) J.P.Roux	-	28
25		*Christella dentata* (Forssk.) Brownsey & Jermy	142	-
26		*Christella subpubescens* (Blume) Holttum	43	-
27	Urtiaceae	*Laportea interrupta* (L.) Chew	6	-
28	Verbenaceae	*Lantana camara* L.	4	9
29		*Stachytarpeta indica* (L.) Vahl	13	-
30	Vitaceae	*Cissus javana* D.C.	-	24
31		*Leea indica* (Burm.fil.) Merr.	-	14
32	Zingiberaceae	*Amomum compactum* Sol. ex Maton	73	35
33		*Alpinia galanga* (L.) Wild.	-	48
34		*Globba tricolor* Ridl.	-	94
		Total individual understorey number	922	1110
		Total understorey species number	22	17

Table 2. Shannon-Wiener diversity index (H') and Pielou Evenness index (E) measurement on understorey species in RPH Sempor, BKPH North Gombong

Index	Age (year)	
	25	45
Diversity index	2.57	2.27
Evenness index	0.83	0.8

The difference in the number of individuals and understorey vegetation species found in the two pine stands cannot be separated from human factors because both pine stands are production forests, where there are often human activities such as transporting pine sap, logging and transporting trees on a regular basis

The Shannon-Wiener diversity measurement of understorey species at RPH Sempor, BKPH North Gombong, shows differences at each different age. Diversity in the 25 years age is 2.57 and in the 45 years age is 2.27 (Table 2). This means that both research locations have moderate species diversity because H' value on each location was between 1-3. This is in accordance with Barbour *et al*. (1987), if the value of H' < 1 means low diversity, the value of H' between 1-3 means moderate diversity, the value of H' > 3 means high diversity. The high and low diversity index of a plant community depends on the number of species and

the individual number of each species. If this value is higher, the diversity in the community will increase and the community's constituent components become more stable (Garsetiasih & Heriyanto, 2007).

The evenness of understorey species in RPH Sempor, BKPH North Gombong can be stated to be even. This is because the evenness of undergrowth at each age is quite even, which is close to one. Evenness value at the age of 25 years is 0.83 and at the age of 45 years is 0.8 (Table 2). According to Ainiyah *et al*. (2017), if the evenness value is less than 0.5 then the distribution of individuals between species can be said to be low, if the evenness value between 0.5-0.75 the evenness is moderate and if the evenness more than 0.75 the evenness is high. According to Mawazin & Subiakto (2013), the higher the evenness value, the more stable the species diversity.

Table 3. Understorey IVI measurement in 25 and 45 years of pine stands in RPH Sempor, BKPH North Gombong

No	Family / Understorey species	Understorey IVI (%) in each pine stand age (year)					
		25			45		
		RF	RD	IVI	RF	RD	IVI
1	Acanthaceae						
	1) *Asystasia gangetica* (Nees) Ensermu subsp. *micrantha*	6.61	4.77	11.38	5	2.43	7.43
2	Arecaceae						
	1) *Licuala pumila* Blume	-	-	-	1.88	0.63	2.51
3	Asteraceae						
	1) *Austroeupatorium inulifolium* (Kunth) R.King & H.Rob.	3.31	0.43	3.74	-	-	-
	2) *Tridax procumbens* L.	-	-	-	7.5	5.68	13.18
4	Begoniaceae						
	1) *Begonia hirtella* Link	-	-	-	8.75	8.2	16.95
5	Dennstaedtiaceae						
	1) *Microlepia speluncae (L.) T. Moore*	1.65	1.52	3.17	-	-	-
6	Dioscoreaceae						
	1) *Dioscorea hispida* Dennst.	4.13	0.76	4.89	-	-	-
	2) *Tacca palmate* Blume	4.13	1.41	5.54	-	-	-
7	Fabaceae						
	1) *Mimosa pudica* L.	9.09	9.87	18.96	-	-	-
8	Lygodiaceae						
	1) *Lygodium circinnatum* (Burm.fil.) Sw.	-	-	-	8.75	7.39	16.14
	2) *Lygodium palmatum* (Bernh.) Sw.	6.61	3.58	10.19	-	-	-
9	Melastomataceae						
	1) *Clidemia hirta* (L.) D. Don.	14.05	18.11	32.16	11.25	10.72	21.97
	2) *Melastoma malabatrichum* L.	2.48	1.52	4	-	-	-
10	Osmundaceae						
	1) *Claytosmunda claytoniana* L.	2.48	0.87	3.35	-	-	-
11	Piperaceae						
	1) *Piper umbellatum* (L.)	-	-	-	3.75	1.62	5.37
12	Polypodiaceae						
	1) *Pyrrosia longifolia* (Burm.f.) C.V. Morton	0.83	8.24	9.07	-	-	-
13	Pteridaceae						
	1) *Pteris ensiformis* Burm. f.	3.31	7.92	11.22	-	-	-
	2) *Pteris vittata* L.	7.44	7.92	15.36	-	-	-
14	Rubiaceae						
	1) *Exallage auricularia* (L.) Bremek.	1.65	1.3	2.95	-	-	-
	2) *Hedyotis neesiana* Arn.	1.65	0.98	2.63	5.63	3.15	8.78
	3) *Ixora parviflora* Lam.	0.83	0.33	1.15	-	-	-
15	Selaginellaceae						
	1) *Selaginella willdenowii* (Desv.) Baker	-	-	-	12.5	35.32	47.82
16	Tectariaceae						
	1) *Tectaria siifolia* (Wild.) Copel.	-	-	-	3.13	2.16	5.29

The Importance Value Index (IVI) of plant species in a community is a quantitative parameter that shows the level of control (degree of dominance) of a plant species in the community. The plant species with the highest IVI value is the most dominant species in a community and indicates it has the highest number of relative frequency and density. The presence of a dominant plant species in an area shows the ability to adapt to the habitat and wide tolerance to environmental conditions (Itawarnemi, *et al*., 2021). *Clidemia hirta* (L.) D. Don. from Melastomataceae family is an understorey species on 25 years pine stand with the highest IVI, 32.16% (Table 3). The highest IVI on 45 years of pine stand belongs to *Selaginella willdenowii* (Desv.) Baker from the Selaginellaceae family, which is 47.82%. The dominance of a plant species in an ecosystem must be analyzed from the value of its species evenness index (E). If the value of the evenness index is high (close to one), then in an ecosystem the individual members of all plant species are in an even condition so that no one plant species is dominant. From this explanation, in the 25 years and 45 years pine stands, there is no dominant understorey species (Table 2).

Similarity index is a parameter used to determine the relative similarity of species composition and structure between the stands being compared (Hilwan & Masyrafina, 2015). According to Akoto *et al*. (2015), if the Sorensen similarity index value is lower than 0.75, then the paired communities share different species composition, but if the index is closer to 1, then the paired communities share similar species composition. Therefore, the species similarity tests (Table 4) revealed a clear distinction of species composition between 25 and 45 years of pine stand.

Table 4. Sorensen similarity index (%) measurement on understorey species in RPH Sempor, BKPH North Gombong

Stand Age	25 years	45 years
25 years	-	25

Sorensen similarity index obtained in 25 and 45 years of pine stand is 25% (0.25) and it is much lower than 0.75. Therefore, the understorey similarity level of both location is low. Thus make this value indicates that the species composition in 25 and 45 years of pine stand is relatively different

Environmental factors measurement showed that the altitude and humidity was inversely proportional to the results of measurements of air temperature. Air humidity decreased at the lower altitude and younger pine stand age, but the air temperature increased. Air humidity increased at higher altitude and older pine stand age, but the air temperature is decreased. This statement is in line with Siregar *et al*. (2021), who stated that the air temperature will be lower when altitude increases, but the humidity increases. The 25 years pine stand's altitude range between 73.5-95 m, temperature range between 28.9-31 ºC with humidity range between 69-77.2%. The 45 years pine stand's altitude range between 142-247 m, temperature range between 26.32-27.89 ºC and humidity range between 83.5-87.6%. (Table 5).

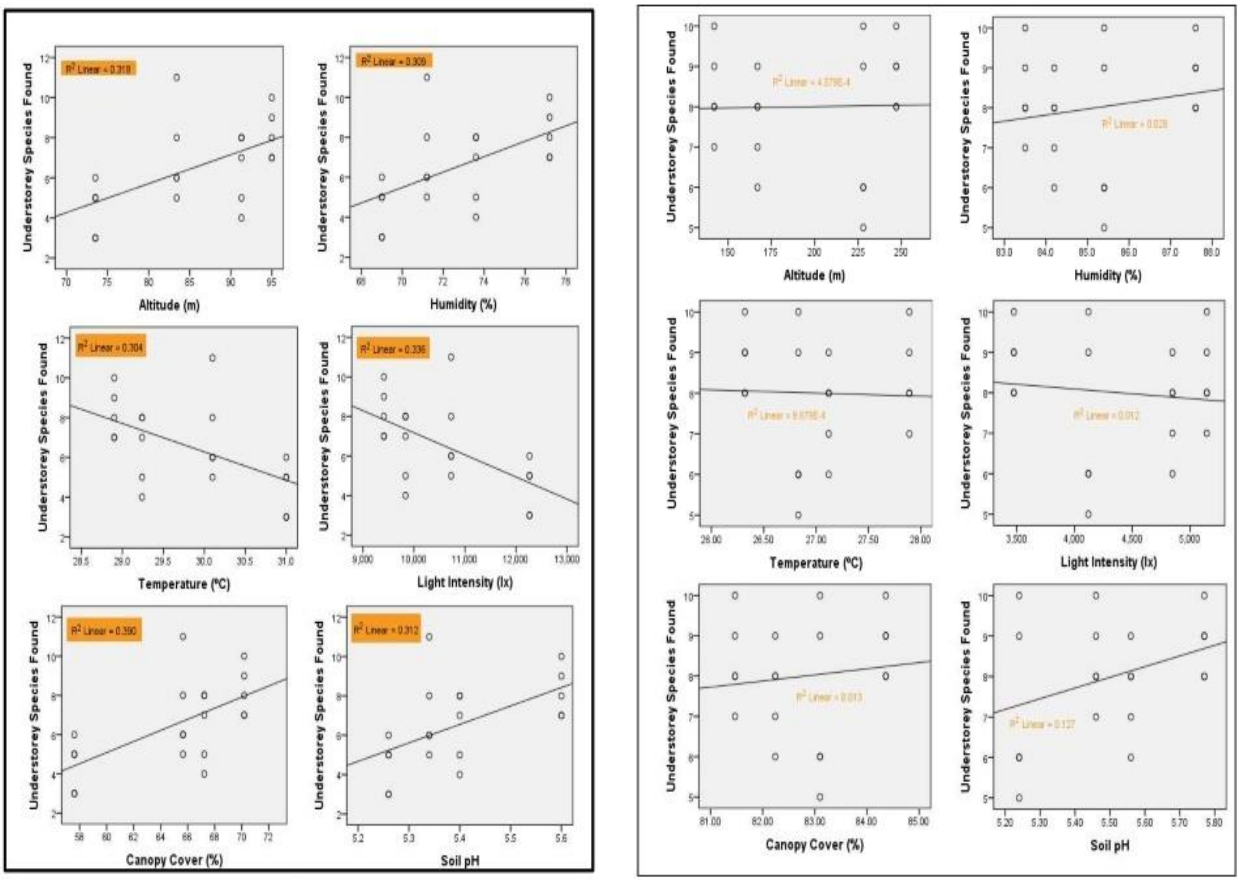
Table 5. Environmental factor measurements on understorey species in RPH Sempor, BKPH North Gombong

Environmental Factors	Pine Stand Age	
	25	45
Altitude (m)	73.5-95	142-247
Air temperature (ºC)	28.9-31	26.32-27.89
Air humidity (%)	69-77.2	83.5-87.6
Light Intensity (lx)	9410-12265	3476-5145
Canopy Cover (%)	57.61-70.18	81.47-84.36
Soil pH	5.12-5.34	5.24-5.77

Air temperature and humidity measurements will affect the light intensity level. Based on canopy cover and light intensity measurements, it was found that the older the pine stand ages, the wider the canopy cover of that pine stand and conversely the lower the light intensity entering the forest floor at the older age of the pine stand. The 25 years pine stand has the light intensity range between 9410-12265 lx and the canopy cover range between 57.61-70.18%. The 45 years pine stand has the light intensity range between 3476-5145 lx and the canopy cover range between 81.47-84.36% (Table 5). The impact of increased canopy cover on the understorey diversity is the 25 years of pine stand has the higher understorey diversity than the 45 years of pine stand. These measurement results have the same similarities with research conducted by Rahmawati *et al*. (2019), who found that a 24 years pine stand had 9000 lux light intensity and 60.3% canopy cover, meanwhile a 29 years old pine stand had 8000 lux light intensity and 63.4% canopy cover.

Soil pH measurement in both research location obtained ranges between 5.12-5.34 in the 25 years pine stand and 5.24-5.77 in the 45 years pine stand (Table 5). Understorey plants have species-specific responses to soil acidity (Chen & Ma, 2013). Another studies suggested that invasive species can become more abundant (Huebner, *et al*., 2014), and native understorey compositions are altered (Horsley, *et al*., 2008). Plant diversity often declines with decreasing soil pH, but nutrient (N) enrichment by atmospheric deposition can counteract diversity loss due to acidification (Simkin, *et al*., 2016). The low pH obtained in both pine forest is caused by the litter of conifer according to (Yun & Abdiyani, 2019). The pine has a needle-shaped leaf litter (conifer) with low alkaline levels and made acidic subsoil conditions.

Scatter Plot graphic in the 25 years pine stand (Figure 1) showed that altitude, humidity, canopy cover, and soil pH had a positive linear correlation with understorey species found. This means that if altitude, humidity, canopy cover, and soil pH value had



a. b.

Figure 1. Scatter plot graphic between environmental factors and understorey species found
Information: a. 25 years pine stand; b. 45 years pine stand

declined, so the understorey species found would also decrease and vice versa. Temperature and light intensity showed that these two environmental factors have a negative linear correlation with the understorey species found. This means that if temperature and light intensity value had increased, so the understorey species found would increase.

Scatter plot graphic in the 45 years pine stand (Figure 1) showed that only soil pH had enough positive correlation with understorey species found. Altitude, humidity and canopy cover had a small positive correlation. The correlation size could be seen from the R2 value obtained. If the value is closer to 0.05, so it can be said that it has less correlation. Temperature and light intensity had a small negative correlation with understorey species found.

CONCLUSION

Understorey diversity at difference pine stand ages in RPH Sempor, BKPH Gombong Utara showed that understorey species number obtained higher in younger pine stand, and lower in older stand. In 25 years of pine stand, 22 species were found and 17 species were found in 45 years of pine stand. The evenness of understorey species in RPH Sempor,

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