Detecting the association between Salagundi (*Roudhola* teysmanii) and other vegetation at Salib Kasih tourism areas

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Abstract. Salagundi (*Roudhola teysmanii*) is a lesser-known species with great potentially. It was discovered at Salib Kasih Tourism Areas, Simorangkir Julu Village, North Tapanuli. At first, it was planted by the community around Tourism Areas because of its wood quality. Recently, the area was dominated by Pine, and thus Salagundi was not the main vegetation anymore. Salagundi will sustain if people understanding the use of space for each species. The purpose of this research was to detect the association between Salagundi and other vegetation. The analysis data of this research was vegetation analysis with line plot sampling. Contingency 2 x 2 was used as a method to detect the association between species. The result showed that there was a positive association between (1) Salagundi and Haudolok (*Syzigium racemosum*) at sapling and tree levels and (2) Salagundi and Pine (*Pinus merkusii*) at sapling and pole levels.

1. Introduction

Interaction between species is essential in studying the ecology of a species. Various factors, both biotic and abiotic, influence the distribution, abundance, and interaction of species [1]. The term relationship or interaction between species is known as association, thus it is essential to learn how the relationship/interaction of one species with another. Inter-species associations are useful for seeing relationships between species in space and time. This association will also have implications for an ecosystem and has an important role in conservation and restoration [2]

Salib Kasih Tourism Area is a spiritual tourism area located in hilly areas in Siatas Barita District, North Tapanuli Regency. This location covered with a variety of vegetation, one of which is Salagundi (*Roudhola teysmanii* Hook F.). Previously around 1976 reforestation had been done by planting pine (*Pinus merkusii*). On the opposite location, people began planting Salagundi around 23 ha in 1995 [3]. Salagundi is one of the lesser-known local species but has good wood quality, which is usually used by the local community as a house pillar.

At present, the Salagundi stand has been found in various species, and those that are visually dominating are pine. The existence of Salagundi needs to be preserved, because information about this species is limited, while this species has various kinds of advantages from the wood aspect [4,5]. Based on this, the purpose of this study was to detect the association between Salagundi and other constituent species. Understanding this relationship will be crucial information for its sustainability.
2. Material and Methods
This research was conducted in the Salib Kasih Tourism Areas, Siatas Barita District, North Tapanuli Regency. The location of the study is around 23 ha, using a pathway method for data collection [6]. Based on the Schmidt and Ferguson classification, this area belongs to the type B classification with an average rainfall of 2,000 to 4,000 mm per year. Minimum air temperature of 15o C and a maximum of 30o C with an average humidity ranging from 90-100% [7]. The research location is divided into four lanes with the direction of across the contour, with the distance between paths 50 m. Observations were made on subplots 2 x 2 m for seedlings, 5 x 5 m for saplings, 10 x 10 for poles and 20 x 20 for trees. Record in the tally sheet all types and numbers of seedlings and saplings; type, height, branch-free height and diameter for poles and trees. The data was then analyzed using vegetation analysis to obtain the Important Value Index (IVI) values of each species found [8]. Conducting Salagundi association analysis with other dominant species with IVI ≥10% using Contingency 2 x 2 [1,9,10] as follows:

\[
\begin{array}{c|cc|c}
\text{species B} & \text{Present} & \text{absent} \\
\hline
\text{species A} & a & b & m = a+b \\
& c & d & n = c+d \\
\hline
r & a+c & & \\
s & b+d & & \\
N & a+b+c+d & & \\
\end{array}
\]

Remarks: \(a = \) Presence of species \(A\) and \(B\) in sub plot, \(b = \) presence of species \(A\) only in a sub plot, \(c = \) presence of species \(B\) only in a sub plot, \(d = \) absence of species \(A\) and \(B\) in a sub plot, \(N = \) number total sub plot.

Chi-square Test \((\chi^2)\) was used to find out whether there is an association, with the following formulation:

\[
\chi^2 = \frac{N(ad-bc)^2}{mnrs}
\]  

The value of \(\chi^2\)calc was then compared with the value of \(\chi^2\)tab at the degree of freedom = 1, at the test level of 5% (value of 3.84). If the value is \(\chi^2\)calc > \(\chi^2\)tab value, then the association is real. If the value of \(\chi^2\)calc <\(\chi^2\)tab value, then the association is not real [1]. Furthermore, to determine the level or strength of the association, the following formula is used:

\[
E(a) = \frac{(a+b)(a+c)}{N}
\]

Based on this formula, there are 2 types of associations, namely: (1) positive association, if the value of \(a\) > \(E\) (a) means that the type of partner occurs together more often than expected (2) negative association, if the value of \(a\) <\(E\) (a) means Type partners occur together less often than expected. To get the association level is done by calculating the value of the Association Index using the Jaccard Index formulation [1]:

\[
JI = \frac{a}{a+b+c}
\]

The closer to the value of 1, the more the association will be. Conversely, the closer to the value 0, the association will be even smaller, and there is no relationship.

3. Results and Discussion
The observations found that at the study site there were 17 species, with the main constituent species at the seedling level were Boji-boji (22.12%) Haudolok (43.16%), Pine (60.55%), Salagundi (22.62%) and Situlan (10.06%); at the sapling level were Boji-boji (20.54%), Haudolok (50%), Pinus (43.51%), Salagundi (30.38%) and Tinggiran (11.28%); at the pole level were Boji-boji (14.14%), Hapas-hapas (21.69%), Haudolok (46.68%), Nongkar-nangkir (15.32%), Pine (87.58%), Salagundi (43.25%), Situlan (19.42%) and Tinggiran (10.78%); at the tree level were Atarasa (14.21%), Hapas-hapas (20.07%), Haudolok (46.26%), Pine (113.58%), Salagundi (48.40%), Situlan (15.56%) and Tinggiran (11.09%). Based on these results, it shows that Pine, Haudolok, and Salagundi are species that occupy
the top 3 IVI. Pine is a species with the highest IVI for all growth rates. This highest IVI indicates that the area has suitable environmental conditions for pine, both biotic and abiotic. Pine is a prime species for reforestation activities since the 1960s [11]. As a pioneer species, Pine experienced an increase in population in disturbed areas, colonizing areas of the former fire or spreading at the site of the former fire. The intolerant character means demanding a lot of nature of the light, causing this pine to occupy the top canopy position in the forest, and there is a tendency to become a pure stand [12]. This tendency was also found in the Salagundi stand in the study area. The Haudolok has the second highest IVI at the seedling, sapling and pole level, but at the tree level, Salagundi has a higher IVI. Haudolok can grow both in undisturbed forest areas and in disturbed forest areas [13].

After the association analysis, showed that the association was only found in Salagundi-Haudolok and Salagundi-Pine. The results of the association calculation between Salagundi and other species can be seen in Table 1.

| No | Levels of growth | Association     | $\chi^2_{\text{calc}}$ | $\chi^2_{\text{tab}}$ | Association type | E(a) |
|----|------------------|-----------------|-------------------------|------------------------|------------------|------|
| 1  | Seedling         | Salagundi       | 0,35                    | 3,84                   | Na               | 6,97 |
| 2  | Seedling         | Salagundi       | 0,18                    | 3,84                   | Na               | 13,30|
| 3  | Seedling         | Salagundi       | 0,35                    | 3,84                   | Na               | 12,03|
| 4  | Seedling         | Salagundi       | 1,13                    | 3,84                   | Na               | 3,48 |
| 5  | Sapling          | Salagundi       | 0,02                    | 3,84                   | Na               | 10,73|
| 6  | Sapling          | Salagundi       | 4,03                    | 3,84                   | +                | 16,80|
| 7  | Sapling          | Salagundi       | 4,05                    | 3,84                   | +                | 18,67|
| 8  | Sapling          | Salagundi       | 0,15                    | 3,84                   | Na               | 5,60 |
| 9  | Pole             | Salagundi       | 0,03                    | 3,84                   | Na               | 6,93 |
| 10 | Pole             | Salagundi       | 0,03                    | 3,84                   | Na               | 6,93 |
| 11 | Pole             | Salagundi       | 0,001                   | 3,84                   | Na               | 14,18|
| 12 | Pole             | Salagundi       | 0,98                    | 3,84                   | Na               | 5,40 |
| 13 | Pole             | Salagundi       | 3,18                    | 3,84                   | Na               | 14,58|
| 14 | Pole             | Salagundi       | 0,91                    | 3,84                   | Na               | 6,93 |
| 15 | Pole             | Salagundi       | 0,06                    | 3,84                   | Na               | 4,58 |
| 16 | Tree             | Salagundi       | 0,07                    | 3,84                   | Na               | 2,30 |
| 17 | Tree             | Salagundi       | 1,16                    | 3,84                   | Na               | 3,45 |
| 18 | Tree             | Salagundi       | 4,34                    | 3,84                   | +                | 8,82 |
| 19 | Tree             | Salagundi       | 0,08                    | 3,84                   | Na               | 16,48|
| 20 | Tree             | Salagundi       | 0,38                    | 3,84                   | Na               | 2,30 |
| 21 | Tree             | Salagundi       | 0,78                    | 3,84                   | Na               | 1,92 |

Remarks: +: Positive Association; Na: No Association was found; $\chi^2_{\text{calc}}$: Calculation of chi-square; $\chi^2_{\text{tab}}$: Significant Level 5%, df = 1.

Positive associations were found, both in the Salagundi-Haudolok and Salagundi-Pine associations. Positive associations indicate that there is tolerance for living together with their partners and that there is a reciprocal relationship that is mutually beneficial, especially in the distribution of living space [10]. This statement is in line with [14,15] which states that in addition to the influence of interaction on a community, each type of plant gives each other a place to live in the same area and habitat.

The composition of species and species associations were largely influenced by environmental variables in each type of vegetation and each time period, but changes in species associations usually occur more quickly [2]. Salagundi stands were planted in 1995, in approximately 23 years, various environmental changes occurred. It is also possible that changes in the composition and association of species in these areas also occur. Associations between species can be beneficial and also harmful. These relationships can occur related to shade, pollination and other ecological activities that occur in a species. Changes in the relationship will ultimately affect the composition and distribution of species.
in areas. As environmental changes accelerate, we may see fewer but unique relationships among species [2].

The Association Index Value calculated on the type of association found to be classified as very low to low [9,10]. More information can be seen in Table 2.

**Table 2.** The association index value between Salagundi and other species at various growth rates

| No | Levels of growth | Association | JI  | Remarks |
|----|------------------|-------------|-----|---------|
| 1  | Seedling         | Salagundi   | Boji-boji | 0.24 | Low     |
| 2  | Seedling         | Salagundi   | Haudolok | 0.30 | Low     |
| 3  | Seedling         | Salagundi   | Pine     | 0.24 | Low     |
| 4  | Seedling         | Salagundi   | Situlan  | 0.07 | Very low|
| 5  | Sapling          | Salagundi   | Boji-boji| 0.28 | Low     |
| 6  | Sapling          | Salagundi   | Haudolok | 0.25 | Low     |
| 7  | Sapling          | Salagundi   | Pine     | 0.28 | Low     |
| 8  | Sapling          | Salagundi   | Tinggiran| 0.14 | Very low|
| 9  | Pole             | Salagundi   | Boji-boji| 0.12 | Very low|
| 10 | Pole             | Salagundi   | Hapas-hapas| 0.12 | Very low|
| 11 | Pole             | Salagundi   | Haudolok | 0.22 | Very low|
| 12 | Pole             | Salagundi   | Nongkar-nangkir | 0.04 | Very low|
| 13 | Pole             | Salagundi   | Pine     | 0.19 | Very low|
| 14 | Pole             | Salagundi   | Situlan  | 0.16 | Very low|
| 15 | Pole             | Salagundi   | Tinggiran| 0.08 | Very low|
| 16 | Tree             | Salagundi   | Atarasa  | 0.07 | Very low|
| 17 | Tree             | Salagundi   | Hapas-hapas| 0.07 | Very low|
| 18 | Tree             | Salagundi   | Haudolok | 0.12 | Very low|
| 19 | Tree             | Salagundi   | Pine     | 0.32 | Low     |
| 20 | Tree             | Salagundi   | Situlan  | 0.12 | Very low|
| 21 | Tree             | Salagundi   | Tinggiran| 0.04 | Very low|

This result showed that association pairs have very low associate degrees. This means that there is a tendency for Salagundi not to have a dependency or reciprocal relationship spatially with Haudolok and Pine despite showing tolerance for living together in the same area, especially in the distribution of living space. Other abiotic and biotic factors (insects, microorganisms, etc.) may provide a greater reciprocal relationship, but further studies are still needed. This suspicion is supported by the fact that until now the regeneration of Salagundi still relies on natural seedlings, and not many studies have been explored to understand its regeneration. Understanding of phenology, the need for light, nutrients need to be studied immediately, so that it can better explain the degree of association between species that still tend to be low.

**4. Conclusion**

The main constituent species in the Salib Kasih Tourism Area are Boji-boji (*Stachytarpheta indica*), Haudolok (*Syzygium racemosum*), Pine (*Pinus merkusii*), Salagundi (*Roudholia teysmanii*), Situlan (*Weinmannia fraxinea*), Tinggiran (*Caralia bradiata*), Hapas-hapas (*Exbucklandra popunea*), Nongkar-nangkir (*Parastemon urophyllum*) and Atarasa (*Castanopsis itermis*). A positive association was found at the sapling and tree level between Salagundi and Haudolok and Salagundi with Pinus at the sapling level. The Association Index Value ranges from very low to low (0.12-0.28).

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