IMPACTS OF RUBBER PLANTATION ON DIVERSITY OF UNDERSTORY VEGETATION AND SOIL ANIMALS IN BAO LAM RUBBER ENTERPRISE, BAO LAM DISTRICT, LAM DONG PROVINCE

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SUMMARY

This study was conducted in Bao Lam rubber enterprise, Bao Lam district, Lam Dong province and concentrated in impacts of rubber plantation on diversity of understory vegetation and soil animals. Based on data collected from the rubber tree plantations, number of species and number of individuals of understory vegetation, and soil animals in five plots of rubber trees, five plots of adjacent vegetation, the characteristics of distribution were figured out and diversity indices of understory vegetation and soil animal were determined. With understory vegetation, there are 56 species of 35 vegetation families in study site, mainly belonging to Araceae, Asteraceae, Euphobiaceae, Moraceae, Myrsinaceae, Rubiaceae and Poaceae. Species composition of understory vegetation in rubber plantation is different from the adjacent vegetation. All diversity indices in rubber plantation are lower than that of adjacent vegetation. With soil animals, there are 15 species of 10 families in study site, mainly belonging to Megasoclecidae, Glossoscolecidae, Fomicidae, Termitoidae, and Noctuidae. Species composition of soil animals in rubber plantation is similar with adjacent vegetation. Diversity indices of soil animals between rubber plantation and adjacent vegetation are not significantly differentas well.

Keywords: Diversity, impacts, rubber plantation, soil animals, understory vegetation.

I. INTRODUCTION

Rubber *(Heveabrasillensis)* belongs to Euphobiaceae family; it is one of trees that have high economic value, besides taping for latex itstrunk can be used for furniture processing industry. It was developed rapidly since the first rubber tree appeared in Vietnam in 1877, the total area of rubber plantation reached 981,000 hectares in 2015 (The Vietnam Rubber Association, 2015).

However, there are some opposite opinions about the impacts of rubber on environment. Though it was popularly thought that rubber has positive impacts on environment, it was considered to have negative impacts to local people health and biodiversity. This study was conducted to check the hypothesis that there is any differencein biodiversityof understory vegetation and soil animals between rubber plantation and other adjacent vegetation, and then some suggestions for sustainable development of rubber plantation in Vietnam will be suggested.

II. RESEARCH METHODOLOGY

2.1 Study objects

Understory vegetation and soil animals in rubber plantation and adjacent vegetation which belong to Bao Lam Enterprise in Bao Lam district, Lam Dong province.

2.2 Methodology

Data collection

Based on the data collected in five plots of rubber plantation and five plots of adjacent vegetation (area of each plot is 1,000 m^2 (25 m x 40 m)) toinvestigate the growth indicators of rubber plantation stands and adjacent vegetationsuch as: height, diameter at breast height (DBH) and canopy coverage. Characteristics of understory vegetation and soil animals were also investigated by collecting data of number of species, number of individuals, species composition and distribution (Magurran, A.E., 1988). Species diversity indiceswere determined by using Simpson's diversity index, Shannon-Weaver diversity index for the understory vegetation

and soil animals in plots (James A. Danoff-Burg, 2003).

Data analysis

Calculate Simpson's diversity index:

$$D' = 1 - \sum_i^m \frac{ni \ (ni \ 1)}{N \ (N \ 1)}$$

Where D': Simpson's diversity index;

m: Total of number species in a plot;

$P_i = ni/N$: The ratio of each species in a plot;

ni: Number of individual of species i;

N: Total number of individuals of all species in a plot;

$0 \leq D' \leq 1$; If a community has high D' value it has high biodiversity

(Simpson, E. H., 1949*).*

Calculate Shannon-Weaver diversity index:

$$H' = -\sum_{i=1}^m (Pi.\lg(Pi))$$

Where H': Shannon – Weaver diversity index;

m: Total number of species in a plot;

$P_i = ni/N$;

ni: Number of individual of species i;

N: Total number of individuals of all species in a plot;

H' focuses on number of species and the evenness of species. The higher the H' the more species richness or more special species (Shannon, C. E. And W. Wiener, 1963).

Species composition:

$$K_i = (n_i/N)*10$$

Where K_i: Composition coefficient of species i;

n_i: The number of individual of species i;

N: Total number of individuals in the plot.

Compare differences between biodiversity indices:

We used Mann-Whitney U Test using SPSS. The U statistics will be compared to 1.96. If U statistics is higher than 1.96 two indices are significantly different. Otherwise they are not significantly different (Nguyen Hai Tuat, Nguyen Trong Binh, 2005).

III. RESULTS AND DISCUSSION

3.1. Structural characteristics of rubber plantation

Table 1. Descriptive statistics for variablesin plots

Plot	Vegetation type	Height (m)			DBH (cm)			Canopy coverage (%)		
		Mean	S	V%	Mean	S	V%	Mean	S	V%
1	AV	13.17	2.31	17.54	13.14	6.16	46.88	85.60	2.36	2.76
2	AV	15.78	5.24	33.21	14.57	7.27	49.90	86.40	2.76	3.16
3	AV	10.76	3.68	34.20	12.38	5.11	41.28	79.40	1.90	2.39
4	AV	16.95	4.96	29.26	14.87	5.63	37.86	89.10	1.83	2.05
5	AV	10.30	2.74	26.60	10.35	3.72	35.94	85.10	1.85	2.17
6	RB	16.31	1.15	7.05	18.47	1.56	8.45	90.20	1.89	2.10
7	RB	15.24	1.04	6.82	16.42	1.98	12.06	86.70	2.04	2.35
8	RB	14.81	0.98	6.62	13.46	1.64	12.18	81.20	1.67	2.06
9	RB	11.63	1.39	11.95	12.23	1.69	13.82	76.70	1.91	2.49
10	RB	12.43	1.16	9.33	11.69	1.76	15.06	79.90	1.67	2.09

*RB: Rubber plantations   *AV: Adjacent vegetation

The mean height of rubber plantations range from 11.63 m to 16.31 m and adjacent vegetations are from 10.30 m to 16.95 m. The average coefficient of variation ($V_H\%$) on the height in rubber plots is 8.35%, lower than that in the adjacent vegetation (28.16%). The mean of DBH of rubber plantations are from 11.69 cm to 18.47 cm and mean DBH of adjacent vegetation are form 10.35 cm to 14.87 cm. Average coefficient of variation on the tree diameter in rubber plot is 12.31%, much lower than that in the adjacent vegetation ($V_D\% = 85.12\%$). So the average height and diameter of trees in rubber plots aremore uniform than those in the adjacent vegetation plots, because rubber plantations are even-age and they have been applied similar tending activities meanwhile adjacent vegetations are secondary tropical forest.

About canopy coverage: Based on the data in Table 1, the means canopy coverage of rubber plantation range from 76.70% to 90.20%; those values are from 79.40% to 89.10%. Vegetation coverage in both rubber plantation and adjacent vegetationare quite high. This is good for protecting soil from erosion. The average coefficient of variation on the canopy coverage in rubber plot ($V_C\%$) is 2.22%, slightly lower than that in the adjacent vegetation ($V_C\% = 2.51$).

Species composition of understory vegetation

Table 2. Species composition of understory vegetation in plots

Plot	Vegetation type	Sl (Number of species)	N (number of individuals)	X_i (Average number)	Species composition
1	AV	26	42	1.62	1.14 Ch + 0.86 Bo + 0.86 Cn + 0.86 Dm + 0.57 Bg + 0.57 Ct + 0.57 Cx + 0.57 Gt + 0.57 La + 0.57 Ru + 0.57 Rn + 0.57 Tk
2	AV	22	39	1.77	1.60 Ho + 1.60 Ld + 1.20 Ba + 1.20 Dr
3	AV	28	55	1.96	1.35 Bb + 1.35 Ct + 1.08 Dx + 1.08 La + 0.81 Be + 0.81 Cn + 0.81 Ms
4	AV	21	35	1.67	0.71 Bg + 0.71 Ct + 0.71 Cx + 0.71 Ho + 0.71 Ms + 0.71 Qd + 0.71 St + 0.71 Tp + 0.71 Tk
5	AV	27	43	1.59	1.18 Ct + 1.18 Ho + 0.88 Bc + 0.88 Cg + 0.88 La + 0.88 Xu
6	RB	11	19	1.73	3.33 Ct + 2.50 Bb + 1.67 Dx
7	RB	15	30	2.00	1.43 Ct + 1.43 Dx + 1.43 La + 1.43 Qb + 0.95 Cm + 0.95 Ho
8	RB	18	24	1.33	2.61 Ct + 1.74 Du + 1.30 Bo + 1.30 Ck
9	RB	16	26	1.63	1.48 Bb + 1.48 Ct + 1.48 Ho +1.11 Co + 1.11 Dm + 1.11 Tp
10	RB	11	21	1.91	1.60 Bo + 1.60 La + 1.20 Cm + 1.20 Dr + 1.20 Dx

*RB: Rubber plantations　　　**AV: Adjacent vegetation*

In which:

Ba: *Euodia lepta*; Bb: *Chromolaena odorata*; Bc: *Breynia fruticosa*; Be: *Mallotus floribundus*;

Bg: *Hibiscus sabdariffa*; Bo: *Lygodium flexuosum*; Cg: *Cynodon dactylon*; Ch: *Phyltanth usurinaria*;

Ck: *Grewia asiatica*; Cm: *Chrysopogon aciculatus*; Cn: *Embeli aribes*; Co: *Cyperus rotundus*;

Ct: *Lophantherum gracile*; Cx: *Achyranthes aspera*; Dm: *Colocasia gigantean*; Dr: *Canna edulis*;

Du: *Streblus indica;* Dx: *Dryopteris filix-mas*; Gt: *Catunaregam tomentosa*; Ho: *Ageratum conyzoides*;

La: *Psychotria montana*; Ld: *Vernonia amygdalina*; Ms: *Rubus alcaefolicus*; Qb: *Selaginella frondosa*;

Qd: *Blechnum oriantale*; Rn: *Sauropus androgynous*; Ru: *Mallotus philippinensis*;

St: *Strophanthus caudatus*; Tk: *Helicteres hirsuta*; Tp: *Smilax glabra*; Xu: *Lasianthuswallichii*

The number of species of understory vegetation in rubber plantation is from 11 to 18. Meanwhile in adjacent vegetation this number is from 21 to 28, much higher than that in rubber plantation. Adjacent vegetation plots have more and different dominant species than that in theplots of rubber plantation. Species composition of understory vegetation in plots of rubber plantation isdifferent from adjacent vegetation. It might prove that rubber plantation has impacts on composition of understory species.

Diversity of understory vegetation

Two diversity indices used to compare are: Simpson's diversity index and Shannon-Weaver diversity index. All data are showed in the Table 3.

Table 3. Diversity indicesof understory vegetation in plots

Plot	Vegetation type	Sl (number of species)	N (number of individual)	D'	H'
1	AV	18	35	0.96	2.80
2	AV	12	25	0.93	2.35
3	AV	14	37	0.93	2.50
4	AV	18	42	0.96	2.83
5	AV	15	34	0.95	2.61
6	RB	6	12	0.85	1.63
7	RB	11	21	0.93	2.29
8	RB	9	23	0.87	2.06
9	RB	10	27	0.92	2.21
10	RB	11	25	0.92	2.27
Max (10 plots)		18	42	0.96	2.83
Max (Rubber)		11	27	0.93	2.29
Max (Adjacent vegetation)		18	42	0.96	2.83
Min (10 plots)		6	12	0.85	1.63
Min (Rubber)		6	12	0.85	1.63
Min (Adjacent vegetation)		12	25	0.93	2.35

RB: Rubber plantations   *AV: Adjacent vegetation*

The table 3 shows that the Simpson's diversity indices of understory vegetation of rubber plantation are from 0.85 to 0.93, lower than that of adjacent vegetation which range from 0.93 to 0.96. It means understory vegetation in rubber plantation has low biodiversity than that in adjacent vegetation. The Shannon-Weaver diversity indices of understory vegetation in rubber plantation are from 1.63 to 2.29. Those values of adjacent vegetation are from 2.35 to 2.83. Understory vegetation in adjacent vegetation has higher species richness than that in rubber plantation. The highest diversity indices valuesisbelonging to plot 4 (plot of adjacent vegetation) and thelowest diversity indexisbelongingto plot 6 (plot of rubber plantation).
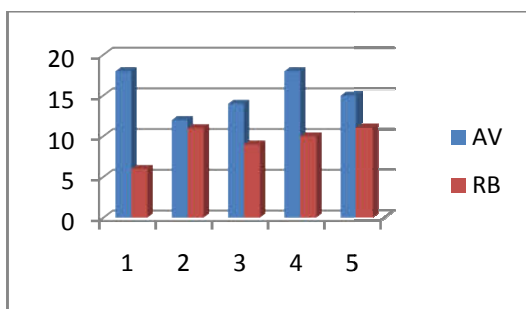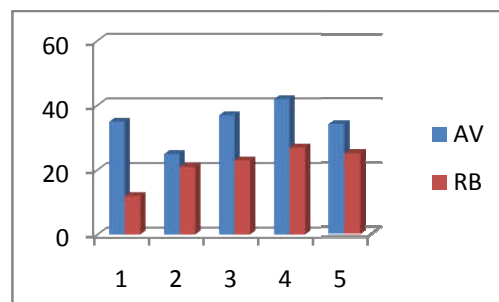
Figure 1. Number of species in plot comparison

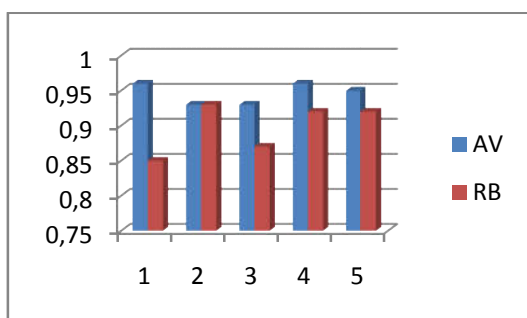**Figure 2. Number of individuals in plot comparison**

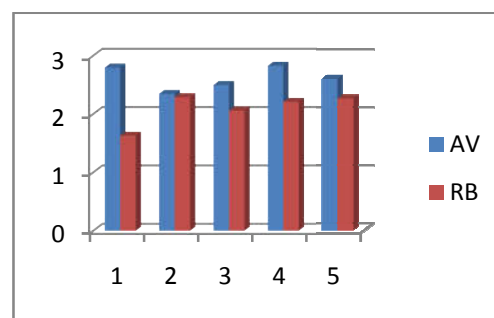**Figure 3. Simpson's diversity index in plot comparison**

Figure 4. Shannon-Weaver diversity index in plot comparison

The differencein diversity of understory vegetation between rubber plantation and adjacent vegetationis identified by Mann-Whitney U test and the resultsare showed in the following table 4.

Table 4. Biodiversity indices comparison

	Rubber plantation	Adjacent vegetation	|U Stat|	Conclusion
Number of species (Sl)	9.40	15.40	3.63	Significantly different (Sig. Diff.)
Number of individuals (N)	21.60	34.60	2.10	Sig. Diff.
Simpson (D')	0.90	0.95	2.31	Sig. Diff.
Shannon - Weaver (H')	2.09	2.62	2.10	Sig. Diff.

It isshowed that |U Stat| of all valuesare higher than 1.96. It means the biodiversity of understory vegetation between 2 types of vegetationare significantly different. Besides that, the mean values of all diversity indices of adjacent vegetation are higher than that of rubber plantation. So rubber plantation decreases diversity of understory vegetation.

Species composition of soil animals

Table 5. Species composition of soil animals in plots

Plot	Vegetation type	Sl (Number of species)	N (number of individuals)	X_i (Average number)	Soil animal species composition
1	AV	12	136	11.33	3.38 Mc + 1.76 Kl + 1.47 Kv + 1.25 Gi + 0.88 Kb
2	AV	8	89	11.33	6.29 Mc + 1.35 Gi
3	AV	8	92	11.50	3.37 Mc + 2.17 Kl + 1.63 Gi + 1.30 Bh
4	AV	8	70	8.75	3.86 Mc + 2.00 Kv + 1.71 Gi + 1.57 Kb
5	AV	9	81	9.00	3.09 Mc + 2.59 Kv + 1.60 + 1.11 Dm
6	RB	10	75	7.50	3.2 Mc + 2.53 Gi + 1.33 Kv
7	RB	7	73	10.43	4.66 Mc + 2.19 Kv + 2.05 Gi
8	RB	7	130	18.57	4.77 Mc + 1.46 Kl + 1.38 Kb
9	RB	11	82	7.45	3.90 Mc + 1.46 Kv + 1.34 Gi + 1.10 Kl
10	RB	8	96	12.00	4.17 Mv + 2.40 Gi + 1.46 Kl

*RB: Rubber plantations   **AV: Adjacent vegetation*

Where:

Bh: *Canthon vigilans*; Gi: *Pontoscolex corethrurus*; Kb: *Leptogeny spp*; Kl: *Solenopsis spp*;

Kv: *Oecophylla smaragdina*; Mc: *Macrotermes annandalei*

The numbers of species of soil animal in rubber plantation are from 7 to 10 species. These values in adjacent vegetation arefrom 8 to 12 species. Individuals of soil animal in rubber plantation range from 73 to 130. While in adjacent vegetation they range from 70 to 136. The average numbers between rubber plantation plots and adjacent plots aresimilar.

The species composition of soil animals in rubber is similar to that of adjacent vegetation. So the impact of rubber on species component of soil animals is negligible.

Diversity of soil animals

Two diversity indices used to compare are: Simpson's diversity index and Shannon-Weaver diversity index. All data are showed in the following table:

Table 6. Biodiversity resultsin plots

Plot	Vegetation type	Sl (number of species)	N (number of individuals)	D'	H'
1	AV	12	136	0.81	1.86
2	AV	8	89	0.58	1.31
3	AV	8	92	0.80	1.73
4	AV	8	70	0.68	1.87
5	AV	9	81	0.80	1.77
6	RB	10	75	0.81	1.88
7	RB	7	73	0.70	1.39
8	RB	6	130	0.70	1.41
9	RB	11	82	0.80	1.91
10	RB	8	96	0.75	1.59
Max (10 plots)		12	136	0.81	1.91
Max (Rubber)		11	130	0.81	1.91
Max (Adjacent vegetation)		12	136	0.81	1.87
Min (10 plots)		6	70	0.58	1.31
Min (Rubber)		6	73	0.70	1.39
Min (Adjacent vegetation)		8	70	0.58	1.31

*RB: Rubber plantations   **AV: Adjacent vegetation*

The maximum number of species and number of individuals are in plot of the adjacent vegetation. Besides that, nearly all of the minimum diversity indices are belonging to plots of the adjacent vegetation, except only the number of species. The max and min values between rubber area and adjacent vegetation are close together.

Simpson diversity values of soil animal in rubber plantation range from 0.70 to 0.81. These values of that of adjacent vegetation are from 0.58 to 0.81. The maximum value of Simpson's diversity index and Shannon-Weaver diversity index are in plot of rubber plantation. Based on the maximum and minimum value of diversity indices we can realize that diversity of soil animals in rubber plantation plots are similar tothat of adjacent vegetation.

The different about diversity of understory vegetation between rubber plantation and adjacent vegetation is identified by using Mann-Whitney U test function and the results are showed in the table 7.

Table 7. Biodiversity index comparison

	Rubber	Adjacent vegetation	|U Stat|	Conclusion
Number of species (Sl)	8.40	9.00	0,65	Not Sig. Diff.
Number of individuals (N)	91.20	93.60	0,10	Not Sig. Diff.
Simpson (D')	0.75	0.73	0,31	Not Sig. Diff.
Shannon - Weaver (H')	1.64	1.70	0,10	Not Sig. Diff.

After analysis we have the result: |U Stat| of all value are lower than 1.96, so all diversity indices of soil animals in rubber plots are nearly similar with diversity indices of soil animals in adjacent vegetation plots. So we can conclude that rubber plantation has negligible impacts on diversity of soil animals.

IV. CONCLUSION

The structural characteristics of rubber plantationare not much different from characteristics of adjacent vegetation, only DBH of trees in rubber plantation different from that of adjacent vegetation.

Diversity of understory vegetation in rubber plantationsis lower than that of understory vegetation in adjacent vegetation, it means rubber plantation has negative impacts on understory vegetation, leading to theless diversity of understory vegetation, that mainly explained by human activities in rubber plantation area.

Diversity of soil animals in rubber plantation isnot significantly different from the diversity of soil animals in adjacent vegetation; it meansthe practices that applied in rubber plantation did not have significant effects to soil animal diversity so far.

When implementing tending activity in rubber plantation such as weeding and using herbicide people need to consider about understory vegetation to maintain its biodiversity for future economic and environmental uses.

There should be more studies on the effect of rubber plantation on biodiversity and environment for the better vision to harmonize economic and environmental purposes, leading to the better strategy for conservation and management of natural resource in the area.

REFERENCES

1. James A. Danoff-Burg (2003). *Choosing between diversity indices*. Department of Ecology, Evolution & Environmental Biology, Columbia University.

2. Magurran, A.E. (1988). *Ecological Diversity and its Measurement*. Princeton University Press, Princeton, NJ.

3. Nguyen Hai Tuat, Nguyen Trong Binh (2005).

Exploitation and use of SPSS to process research data in forestry. Agricultural Publishing House, Hanoi.

4. Shannon, C. E. And W. Wiener (1963). *The mathematical theory of communities*. University of Illinoisat Urbana, Illinois Press.

5. Simpson, E. H. (1949*). Measurement of diversity*. London: Nature.

6. http://www.vra.com.vn/thong-tin/dien-tich-san-luong-va-nang-suat-cay-cao-su-tai-viet-nam.7964.html

ẢNH HƯỞNG CỦA VIỆC TRỒNG CÂY CAO SU
TỚI ĐA DẠNG THỰC VẬT DƯỚI TÁN RỪNG VÀ ĐỘNG VẬT ĐẤT
TẠI NÔNG TRƯỜNG CAO SU BẢO LÂM, HUYỆN BẢO LÂM, TỈNH LÂM ĐỒNG

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TÓM TẮT

Nghiên cứu tiến hành tại Nông trường Cao su Bảo Lâm, huyện Bảo Lâm, tỉnh Lâm Đồng, tập trung vào tác động của rừng trồng Cao su tới đa dạng của thực vật dưới tán rừng và động vật đất. Dựa trên số liệu thu được về tầng cây cao, số loài và số cá thể của lớp thực vật dưới tán rừng và động vật đất trong 5 ô tiêu chuẩn lập dưới tán rừng Cao su, 5 ô tiêu chuẩn lập ở các thảm thực vật xung quanh khu vực đã chỉ ra đặc điểm phân bố và tính toán chỉ số đa dạng của thực vật dưới tán rừng và động vật đất. Đối với thực vật dưới tán rừng khu vực nghiên cứu có 56 loài cây thuộc 35 họ, chủ yếu tập trung vào các họ Ráy, họ Cúc, họ Thầu dầu, họ Dâu tằm, họ Đơn nem, họ Cà phê và họ Lúa. Tổ thành loài của lớp thực vật dưới tán rừng khác so với khu vực xung quanh. Tất cả các chỉ số đa dạng ở rừng trồng Cao su đều thấp hơn thực vật ở khu vực xung quanh. Đối với động vật đất khu vực nghiên cứu phát hiện 15 loài thuộc 10 họ tập trung vào các họ Giun to, họ Giun trung bình, họ Kiến, họ Mối và họ Bướm đêm. Tổ thành loài của động vật đất dưới tán rừng Cao su tương đồng với tổ thành động vật đất dưới tán thảm thực vật xung quanh. Chỉ số đa dạng sinh học của động vật đất ở hai khu vực này cũng tương tự nhau.

Từ khóa: Đa dạng, động vật đất, rừng trồng cao su, tác động, thực vật dưới tán rừng.