NATURAL REGENERATION CHARACTERISTICS OF TROPICAL EVERGREEN MOIST CLOSE FOREST IN TAN PHU AREA OF DONG NAI PROVINCE

Le Van Long[1], Phung Thi Tuyen[2], Le Ba Toan[3], Pham Xuan Quy[4]

[1] *Vietnam National University of Forestry - Southern Campus*

[2] *Vietnam National University of Forestry*

[3] *Ho Chi Minh City Forestry Science Association*

[4] *College of Management for Agricultural and Rural II*

SUMMARY

This study was conducted from 2015 to 2017 to determine the natural regeneration characteristics of six plant communities of tropical evergreen moist close forest in Tan Phu area, Dong Nai province. Data were collected from 600 subplots (16 m^2) set up in thirty 0.25ha-plots (five 0.25-ha plots/each plant community). The results indicated that, regenerated tree density in study site ranged from 4,595 trees/ha in community Dipterocarpaceae-Elaeocarpaceae-Irvingiaceae (PC5) to 5,815 trees/ha in community Dipterocarpaceae-Myrtaceae-Rosaceae (PC3). The plant community Dipterocarpaceae-Fabaceae-Sapindaceae (PC2) was shown to have the highest number of species (55) among six communites. The similarity coefficient between regenerated trees and mother trees was very high which ranged from 58.3% in community Dipterocarpaceae-Myrtaceae-Rosaceae (PC3) to 96.4% in community Dipterocarpaceae-Rosaceae-Sapindaceae (PC4). Regeneration has been occurring continuously over time and more than 72.5% of regenerated trees had origin from seeds. Regenerated trees with the height > 100 cm were considered as promissing regenerated trees accounted for from 23.9% in community Fabaceae-Ebenaceae-Lythraceae (PC6) to 31.5% in community Dipterocarpaceae-Myrtaceae-Rosaceae (PC3). These regenerated trees can replace mother trees in the future. Base on the natural regeneration characteristics, this study confirm that the study forest will be a sustainable forest dominated by dipterocarpaceae species in the future.

Keywords: Dipterocarpaceae, Dong Nai province, natural regeneration characteristics, Tan Phu area, tropical evergreen moist close forest.

1. INTRODUCTION

Forest area is a central part of terrestrial ecosystems and plays important roles for biodiversity conservation, catchment protection, climate control, and the ecological services they provide (Abbas et al., 2016; Khuc et al., 2018). However, according to Abbas et al. (2016), 129 million hectare of forest areas decreased during the past quarter-century, and only 35% of remainder is primary forest. Forest regeneration is one of the topics that have been particular interest to the researchers for along time. The knowledge of forest regeneration allows the establishment of silvicultural and forest management practices (Smith, 1986; Whitmore, 1996; Kimmins, 1998). Forest regeneration was the reforestation of natural seed sources, shoots and seed banks available in the soil environment. Forest regeneration is divided into natural regeneration and artificial regeneration (Smith, 1986; Whitmore, 1996; Whitmore, 1998; Kimmins, 1998).

Natural regeneration is a biological process that can be assisted and managed to increase forest cover and achieve the recovery of the native ecosystem or some of its functions. Ecological restoration relies on natural regeneration processes for achieving forest ecosystem recovery. It was recognized that restoration strategies involving planting of tree seedlings are often costly and limited in large areas. However, natural regeneration significantly reduces the cost of restoration in areas that meet certain conditions. So that, forest restoration strategies based on natural regeneration also provide low-cost opportunities for conserving biodiversity and enhancing ecosystem services including carbon sequestration and watershed protection (Chokkalingam et al., 2018).

Tropical evergreen moist close forest in Tan

Phu area of Dong Nai province is a protected area contains a rich source of timber and non-timber forest products. This forest play crucial roles in preventing soil erosion, maintaining food chain, providing various useful materials, habitat to many plants and animals. Several studies have been conducted and reported about characteristics of tropical evergreen moist close forest in South East of Vietnam. However, so far, the knowledge about natural regeneration under forest canopy in Tan Phu area of Dong Nai province has been limited. Therefore, the research about natural regeneration of evergreen forest in study sites is necessary. The objectives of this study were to analyse and assess the natural regeneration status of six forest plant communities of tropical evergreen moist close forest in Tan Phu area of Dong Nai province from 2015 to 2017.

2. RESEARCH METHODOLOGY

2.1. Study area

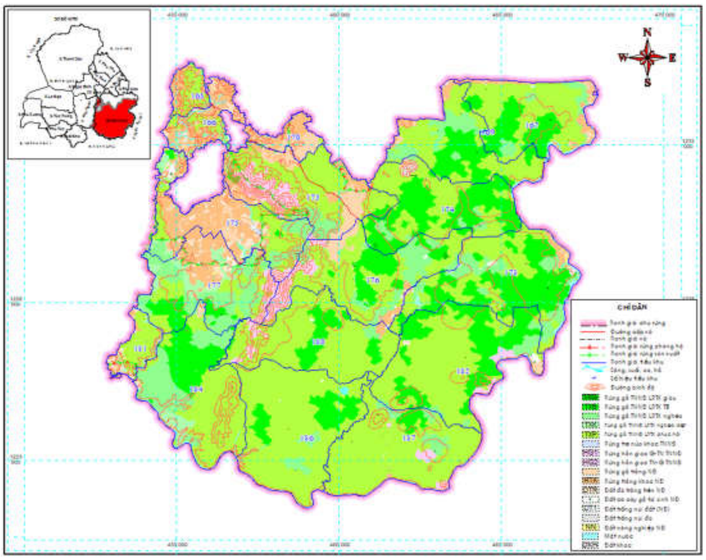

Figure 1. Study area

Study area was a Tan Phu protected area established in 1978. This protected area is tropical evergreen moist close forest belonging to Gia Canh commune, Dinh Quan district, Dong Nai province with total area of 13,594 ha according to Decision 4189/QD-UBND, 2016 of Dong Nai province. The forest located in 11º2’32’’ – 11º10’00’’N and 107º20’00’’ – 107º27’30’’E (Linh et al., 2018).

The study focused on six forest plant communities of tropical evergreen moist close forest. Six plant communities dominated by six species consisting of Dau song nang (*Dipterocarpus dyeri* Pierre), Dau con rai (*Dipterocarpus alatus* Roxb.), Sao den (*Hopea odorata* Roxb.), Sen mu (*Shorea roxburghii* G. Don), Ven ven (*Anisoptera costata* Korth.) and Cam xe (*Xylia xylocarpa* (Roxb.) Taubert.). The study communities were encoded in PC1 to PC6 (Table 1).

Table 1. Plant communities in the study

Plant communities	Dominant species	Codes
Dipterocarpaceae-Irvingiaceae-Verbenaceae	Dau song nang	PC1
Dipterocarpaceae-Fabaceae-Sapindaceae	Dau con rai	PC2
Dipterocarpaceae-Myrtaceae-Rosaceae	Sao den	PC3
Dipterocarpaceae-Rosaceae-Sapindaceae	Sen mu	PC4
Dipterocarpaceae-Elaeocarpaceae-Irvingiaceae	Ven ven	PC5
Fabaceae-Ebenaceae-Lythraceae	Cam xe	PC6

2.2. Sampling procedures

To determine compositions of woody plant, in each plant community we established five sample square plots (0.25 ha/each plot) species names and number of all individuals of woody trees with their diameter at breast height (DBH) larger than 8 cm (Hinh, 2012) were recorded. Total thirty 0.25-ha plots were conducted and measured for six communities.

To investigate natural regeneration characteristics of the forest, in each 0.25-ha plot, twenty 16 m^2 subplots were designed (Figure 2) and the positions of subplots were evenly arranged along two parallel transects and the distance between two transects was 20 m. Natural regeneration status for each plant community was investigated from one hundred 16 m^2 subplots (4 x 4 m). A total of 600 subplots (16 m^2) were measured in the whole forest. We recored species name, a number of individuals for regenerated trees of DBH smaller than 8 cm and height taller than 10 cm. We also identified origins of regenerated trees such as resprouted trees and seedlings. All regenerated trees in study subplots were classified based on the height of trees in different height levels including < 50 cm, 50 - 100 cm, 100 - 150 cm, 150 - 200 cm, 200 - 250 cm, and > 250 cm. Those regenerated trees were > 100 cm in height considered as promising trees.

For indentification of plant species, we also collected specimens and then identified species by working with taxonomists and comparing the collected specimens to known taxa from Ho (1999), Hop (2002), Hop and Quynh (2003), Ban et al. (2003).

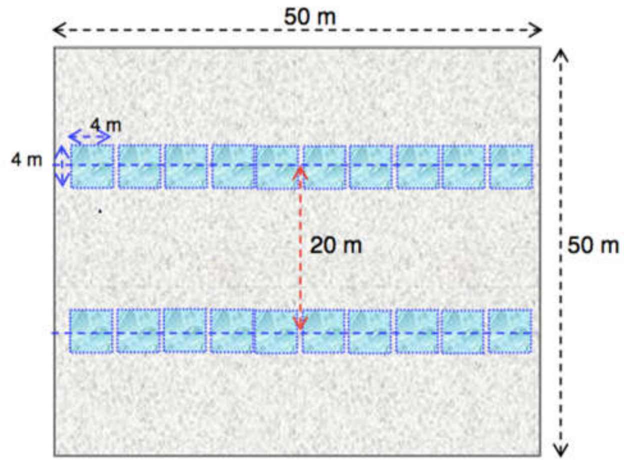

Figure 2. Sampling plot used in the study

(The solid border delineates the 0.25-ha (50 x 50 m) plots, the round dot border describes the 16 m^2 (4 x 4 m) subplots)

2.3. Statistical analysis

For each sample plot 0.25-ha, the following forest stand attributes were calculated: the numbers of woody trees per plot, regenerated tree density (n/ha), proportion of individuals in each species [(number of regenerated individuals of each species/total regenerated species density of community) x100].

The similarity coefficient between regenerated tree compositions (DBH ≤ 8 cm) and mature tree compositions (DBH > 8 cm) was determined by Sorensen's similarity coefficient (C_S %) as equation follow:

$$C_s = (2c/(a+b)) \times 100$$

where a and b are the number of regeneration and mature species found in each type of plant community, respectively; c is the number same species between regenerated trees and mature trees of each plant community (Sorensen, 1948).

3. RESULTS AND DISCUSSION

3.1. Structures of regenerated species in plant communities

Table 2. Composition fomulars of different plant communities

Plant communities	Regenerated densities (trees/ha)	Species numbers (Plants)	Composition fomular by proportion of individuals in each species
PC1	5,500	37	22.2 DSN + 8.9 DCR + 6.7 Ca + 6.3 TT + 5.5 Tru + 5.1 LM + 4.7 BL + 40.6 LK
PC2	5,588	55	11.1 DSN + 7.0 Ca + 6.4 DCR + 5.0 Cm + 4.7 Gie + 65.8 LK
PC3	5,815	41	15.9 DSN + 8.0 Cm + 7.5 Gie + 7.0 Ca + 5.5 SM + 4.7 DCR + 4.6 TT + 4.4 CDN + 4.3 CLO + 38.1 LK
PC4	4,688	41	26.8 SM + 15.2 TQN + 4.9 Ca + 4.9 VV + 4.4 DCR + 43.8 LK
PC5	4,594	41	17.0 DSN + 10.7 VV + 9.1 Cm + 7.5 DCR + 6.1 Ca + 5.4 CLN + 4.6 BLO + 4.4 BCN + 4.2 Gie + 31.1 LK
PC6	5,262	37	15.1 CX + 12.4 TT + 8.3 Gie + 7.2 Cm + 6.1 CLN + 5.1 Ca + 45.8 LK

DSN: Dau song nang; DCR: Dau con rai; Ca: Cay; TT: Tram trang; Tru: Truong nuoc; LM: Long mang; BL: Boi loi; Cm: Cam; Gie: Gien do; SM: Sen mu; CDN: Com dong nai; CLO: Chieu lieu oi, TQN: Truong qua nho; VV: Ven ven; CHN: Chieu lieu nuoc, BLO: Bang lang oi, BCN: Bo cap nuoc; CX: Cam xe; CLN: Chieu lieu nuoc; LK: other species.

Composition of woody plants and regeneration are the assemblage of plant species that characterize the vegetation (Isango, 2007), therefore, determination of the plant compositon is necessary. Results of regenerated densities and number of species for each plant community were showed in Table 2. There was a high density of regenerated individuals in all plant communities. Of which, the community PC2 had the highest regenerated density and it also had more diverse species (55 tree species) than other communites. Community PC5 had the lowest regenerated density with 41 species. PC6 was the least species diversity with 37 species.

Regarding regenerated tree composition, Diterocarp species in PC1, PC2, PC3, PC4 and PC5 and Fabaceous species in PC6 were the dominant species in their plant communities. The dominant regenerated species were similar with the dominant mother species in plant comminities (Table 1, 2) except PC3. Long et al. (2018) found that Sao den (*Hopea odorata* Roxb.) is the dominant species in PC3, but in this report Sao den was not available in composition fomular of regenerated trees. From the survey, it was explained that seeds of Sao den had good germinated ability in the first 1 - 2 years after germination. In this periods, seedlings required a low light intensity, however, when seedlings grew up (especially 2 m in height), they needed a high light intensity than before. If light intensity was not supplied enough for tree growth, trees had died gradually. This reason might lead to the numbers of seedlings of Sao den has been reduced gradually, they did not appear in composition fomular. In the previous reports from Trung (1985) and Minh (1986) stated that the density of regenerated tree of Sao den under the forest canopy was very low.

In contrast, Dau song nang (*Dipterocarpus dyeri* Pierre) had strong natural regeneration ability under forest canopy of PC1, PC2, PC3 and PC5. Them (1992) determined that *Dipterocarpus dyeri* Pierre strongly regenerated under forest canopy cover from 0.6–0.8 or in gap places with square areas from 200–300m^2. It is predicted that mother tree of Sao den (*Hopea odorata* Roxb.) in PC3 will be replated by regenerated tree of Dau song nang (*Dipterocarpus dyeri* Pierre) in the future and the forest in the study site still become a forest dominated by Dipterocarp species (PC1, PC2, PC3, PC4 and PC5) and Fabaceous species (PC6) in the future.

Table 3. Similarity coefficient values (Cs%) between regeneration and mature species compositions in plant communities

Compositions	Number of mature species (DBH > 8 cm) and regeneration species (DBH < 8 cm) in plant communities					
	PC1	PC2	PC3	PC4	PC5	PC6
Mature species	53	63	60	42	55	54
Regererated species	37	55	43	41	41	37
Species overlap*	37	55	30	40	34	37
Similarity coefficient (Cs %)	82.2	93.2	58.3	96.4	70.8	81.3

Species overlap* was defined by the number of same species between regenerated trees and mature trees.

Stability of tree species is determined by the similarity between mature tree composition and regenerated tree composition. When similiraly coefficient values (Cs%) between mature plants and regenerated tree compositions is high (Cs% > 50%), plant communities have developed to be stable status with the environmental conditions. In contrast, when Cs% is low (< 50%), plant communities are in the process of development to achieve a stable status (Ashton and Hall, 1992; Whitmore, 1998; Kimmins, 1998; Trung, 1999). In this study, the similiraly coefficient values (Cs%) between regenerated and mature species compositions range from 58.3 - 93.2% with the highest value recorded in PC1 and the lowest value in PC3 (Table 3). Based on Cs values, it is concluded that six plant communities are in stable status.

3.2. Regenerated densities and regeneration sources of plant communities

Table 4. Regenerated densties of plant communities, number of individuals (*n*) and proportion of each group (PN) for two regenerated sources in plant communities

Plant communities	Regenerated density (trees/ha)		Origins of regenerated individuals			
			Seedlings		respouted trees	
	N	PN	*n*	PN	*n*	PN
PC1	5,500	100.0	4,631	84.2	869	15.8
PC2	5,588	100.0	4,050	72.5	1,538	27.5
PC3	5,815	100.0	4,781	82.2	1,034	17.8
PC4	4,688	100.0	3,821	81.5	867	18.5
PC5	4,595	100.0	3,660	79.6	935	20.4
PC6	5,262	100.0	3,869	73.5	1,393	26.5

Regenerated densities and origin of tree regenerations (seedlings and respouted trees) of six plant communities were presented in Table 4. Among six plant communities, it can be seen that more than 72.5% of regenerated trees had origin from seeds. The percentage of regenerated trees from seeds reached maximum value in plant community PC1 while the lowest number was indicated in community PC2. In contrast, community PC1 had the smallest number of regenerated trees from sprout with 15.8% and community PC2 had the highest percentage of respouted trees with 27.5%. Results from survey indicated that, seedlings were appeared in all height levels but respouted trees only occurred in height levels less than 200 cm (data were not showed).

3.3. Phân bố số cây theo cấp chiều cao

Table 5 illustrates the regenerated individuals appeared in all tree height levels. It was recognized that forest regeneration occurred continuously over time. Most of regenerated trees (> 80% of individuals) in six communities were lower than 150 cm. The number of regenerated trees of the height level < 50 cm had the highest number which was varied from 1,938 - 2,450 individuals and account for 38.5 - 46.6% of total regenerated trees in their communities.

Tree height is a parameter to assess the survival and development of regenerated trees (Them, 2002). The healthy regenerated trees had height level > 100 cm were considered as promising trees in the reforestation because their height almost exceeds the height levels of shrubs in the forest. According to this state, the communities PC3 had the maximum number of promissing trees (1839 individuals/ha, 31.5%) followed by community PC2 (1614 individuals/ha, 28.9%), community PC6 showed the lowest number of promissing trees (1262 individuals/ha, 23.9%) (Table 5). PC6 dominated by Fabaceous species Cam xe (*Xylia xylocarpa* (Roxb.) Taubert.), thus, in comparison with other communities dominated by Dipterocarp species, the growth of regenerated trees of Fabaceous species was weaker than Dipterocarp species.

Table 5. Number of individuals/ha (*N*), proportion of individuals (PNH) of regenerated trees in each tree height levels (cm)

Plant communities		Tree height levels (cm)						Regenerated density (trees/ha)
		< 50	50 - 100	100 - 150	150 - 200	200 - 250	> 250	
PC1	*N*	2,119	1,800	863	488	150	81	5,500
	PNH	38.5	32.7	15.7	8.9	2.7	1.5	100
PC2	*N*	2,531	1,444	769	544	188	113	5,588
	PNH	45.3	25.8	13.8	9.7	3.4	2.0	100
PC3	*N*	2,288	1,688	1,088	450	188	113	5,815
	PNH	39.3	29.0	18.7	7.7	3.2	1.9	100
PC4	*N*	1,975	1,344	750	344	175	100	4,688
	PNH	42.1	28.7	16.0	7.3	3.7	2.1	100
PC5	*N*	1,938	1,275	750	375	163	94	4,595
	PNH	42.2	27.7	16.3	8.2	3.5	2.0	100
PC6	*N*	2,450	1,55	675	374	138	75	5,262
	PNH	46.6	29.5	12.8	7.1	2.6	1.4	100

PNH = (*N* /regenerated density of each community) x100.

3.4. Quality of regenerated trees in plant communities

The rate of good quality regenerated trees ranged from 65.0 - 76.5%

The highest percentage of good regenerated trees were observed in community PC1 with 76.5% trees followed by PC3 with 75.8. Community PC6 had lesser percentage of good regenerated trees than other communities. In constract, the biggest number of midium and bad regenerated trees was shown in community PC6 (Table 6).

Table 6. Quality of regenerated trees, number of individuals (*N*)/ha and proportion of individuals (PNQ) of regenerated trees in each quality type

Plant communities	Quality						Regenerated density (Trees/ha)
	Good		Medium		Bad		
	N	PNQ	*N*	PNQ	*N*	PNQ	
PC1	4,206	76.5	881	16.0	413	7.5	5,500
PC2	4,201	75.2	1,013	18.1	375	6.7	5,588
PC3	4,406	75.8	938	16.1	471	8.1	5,815
PC4	3,483	74.3	814	17.4	391	8.3	4,688
PC5	3,438	74.8	713	15.5	444	9.7	4,595
PC6	3,419	65.0	1,238	23.5	605	11.5	5,262

PNQ = (*N* /regenerated density of quality type) x100.

Regeneration in this study site was occurring consecutively under mother trees and good regenerated trees were accouted for 58.7 - 100% depended on each tree height level (Table 7). The healthy regenerated trees which will contribute to forest composition fomular in the future with tree height > 100 cm had the highest number in communities PC 3 with total 1595 individuals/ha and the lowest number in community PC6 with 1013 individuals/ha. In particular, at the tree height levels of 200 - 250 cm and > 250 cm, 100% of regenerated trees had good quality (213 - 301 individuals/ha in six plant communities) (Table 7).

Table 7. Number of individuals (*N*), proportion of individuals (PNG) of good regenerated trees in plant communities in different tree height levels

Plant communities		Tree height levels (cm)						Good regenerated density (Trees/ha)
		< 50	50 - 100	100 - 150	150 - 200	200 - 250	> 250	
PC1	*N*	1,425	1,388	731	431	150	81	4,206
	PNG	67.3	77.1	84.7	88.4	100	100	76.5
PC2	*N*	1,725	1,106	600	469	188	113	4,201
	PNG	68.2	76.6	78.0	86.2	100	100	75.2
PC3	*N*	1,538	1,275	900	394	188	113	4,406
	PNG	67.2	75.5	82.7	87.5	100	100	75.8
PC4	*N*	1,294	989	613	313	175	100	3,483
	PNG	65.5	73.6	81.7	90.8	100	100	74.3
PC5	*N*	1,294	950	613	325	163	94	3,438
	PNG	66.8	74.5	81.7	86.7	100	100	74.8
PC6	*N*	1,438	969	500	300	138	75	3,419
	PNG	58.7	62.5	74.1	80.2	100	100	65.0

PNG = (*N* /good regenerated tree density of each community) x 100.

Those healthy regenerated trees together with the mother trees will build a sustainable forest in study site. Trung (1985) suggested that Dipterocarp species had very good regeneration capacity under forest canopy, however, most of regenerated trees were lower than 50 cm. Them (1992) verified that most of regenerated trees of Diterocarp species were lower than 100 cm. Another previous work of Them and Manh (2017) reported that the regenerated trees in plant communities dominated by Dipterocarp species in Nam Cat Tien indicated that those species had high regeneration capacity and regenerated density varied from 7,076 - 7,745 trees/ha. Most of trees were originated from seeds and tree height varied from 50 - 250 cm (Them and Manh, 2017). Results in this research agreed with report of Them and Manh (2017).

In general, the plant communities in Tan Phu area had high regeneration capacity. The composions of regenerated trees are similar with mother trees. Regeneration had been consecutively occurring in time with regeneated source from seeds. The density of regenerated trees are high and most of trees are heathly. The number of promissing regenerated trees will replace some mother trees in future and they will contribute to composition fomular of the forest. This is the most important characteristic suggests that those plant communities will sustainable development over time. Once the forest has reached a stable stage, the timber species composition is also stable. Stability is manifested in the fact that older and dead trees will be replaced by young trees of the same species (Whitmore, 1998; Kimmins, 1998; Trung, 1999).

4. CONCLUSIONS

Among six studied plant communities, PC1 observed the highest regenerated tree density and it was the most species diversity community. Community PC6 had the lowest species number with 37 species. Six plant communities in study area had very good regeneration capacity. The similarity coefficient between regenerated tree composion and mother tree composition was high and varied from 58.3 - 96.4%. Most of regenerated trees had good quality and the densities of regenerated trees in six plant communities ranged from 4,595 - 5,815 trees/ha. Among all species in plant communities, seeds of dominant species belongs to Dipterocarpaceae and Fabaceae can regenerate well under forest canopy excepted Sao den (*Hopea odorata* Roxb.). The number of promissing regenerated trees was the highest in PC3 and lowest in PC6. Results of this study confirm that the forest in Tan Phu area will be a sustainable forest dominated by Dipterocarp and Fabaceous species in the future. This study also provides scientific basic to apply silvicultural methods for forest management in study area.

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ĐẶC ĐIỂM TÁI SINH TỰ NHIÊN CỦA RỪNG KÍN THƯỜNG XANH ẨM NHIỆT ĐỚI TẠI KHU VỰC TÂN PHÚ TỈNH ĐỒNG NAI

Lê Văn Long[1], Phùng Thị Tuyến[2], Lê Bá Toàn[3], Phạm Xuân Quý[4]

[1]Phân hiệu Trường Đại học Lâm nghiệp

[2]Trường Đại học Lâm nghiệp

[3]Hội Khoa học Lâm nghiệp Thành phố Hồ Chí Minh

[4]Trường Cán bộ quản lý Nông nghiệp và Phát triển nông thôn II

TÓM TẮT

Nghiên cứu được thực hiện trong thời gian từ năm 2015 đến 2017 với mục tiêu nhằm xác định đặc điểm tái sinh tự nhiên của sáu kiểu quần xã thực vật tại rừng kín thường xanh ẩm nhiệt đới thuộc khu vực Tân Phú, Đồng Nai. Số liệu về đặc điểm tái sinh rừng được thu thập từ 600 ô dạng bản 16 m^2/ô thuộc 30 ô tiêu chuẩn diện tích 0,25 ha/ô tiêu chuẩn (5 ô tiêu chuẩn 0.25 ha/quần xã thực vật rừng). Kết quả nghiên cho thấy những kiểu quần xã thực vật tại khu vực nghiên cứu đều có khả năng tái sinh tự nhiên rất tốt dưới tán rừng. Mật độ cây tái sinh dao động từ 4.595 cây/ha ở kiểu quần xã họ Sao Dầu-họ Côm-họ Cầy đến 5.815 cây/ha ở kiểu quần xã họ Sao Dầu-họ Sim-họ Hoa hồng. Hệ số tương đồng giữa thành phần cây tái sinh với thành phần cây mẹ nhận giá trị rất cao; dao động từ 58,3% ở kiểu quần xã họ Sao Dầu-họ Sim-họ Hoa hồng đến 96,4% ở kiểu quần xã họ Sao Dầu-họ Hoa hồng-họ Bồ hòn. Tái sinh rừng diễn ra liên tục theo thời gian và phần lớn (> 72%) cây tái sinh có nguồn gốc từ hạt. Cây tái sinh có chiều cao lớn hơn 100 cm được xem là cây tái sinh có triển vọng dao động từ 23,9% ở quần xã thực vật họ Đậu-họ Hồng-họ Tử vi đến 31,6% ở quần xã thực vật họ Dầu-họ Sim-họ Hoa hồng. Kết quả về đặc điểm tái sinh tự nhiên đã khẳng định rừng tại khu vực nghiên cứu sẽ phát triển bền vững trong tương lai, cây họ Dầu và cây họ Đậu vẫn sẽ là các loài chiếm ưu thế.

Từ khóa: Họ Dầu, rừng kín thường xanh ẩm nhiệt đới, tái sinh tự nhiên, Tân Phú - Đồng Nai.

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