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Distribution and structural-functional attributions of *Erythrophleum fordii* Oliver in Bac Giang Province, Vietnam

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ABSTRACT

The research was conducted in 2022 in areas where *Erythrophleum fordii* Oliver naturally grows in Bac Giang Province, Vietnam. The objective was to determine the distribution and silvicultural attributes of *E. fordii*, including its structural features and regeneration. The study results identified that *E. fordii* is naturally distributed in five districts of Bac Giang Province: Luc Nam, Luc Ngan, Yen The, Son Dong, and Tan Yen. *E. fordii* is widely distributed at altitudes ranging from 50 to 500 m, with a prominent presence between 100 and 200 m above sea level. As the altitude increases, the occurrence of *E. fordii* decreases. The forest areas dominated by *E. fordii* exhibit rich biodiversity, particularly in primary evergreen broadleaved forests on mountain soils, with a total of 71 species. The number of species contributing to the forest structure ranges from 9 to 15, depending on the forest condition. The study also revealed that *E. fordii* has a high composition coefficient, followed by Burseraceae, Chestnut, *Jambolan*, *Elaeocarpus*, *Engelhardtia chrysolepis* Hance, among others. The natural regeneration of *E. fordii* is low, with an average density of 680 trees per ha and 8 trees per route. However, the regeneration quality is poor. The dominance of regenerated trees varies significantly with altitude, decreasing as the altitude elevates.

Keywords: Bac Giang Province, *E. fordii*, Distribution, Altitude, Regeneration, Species diversity.
Article type: Research Article.

INTRODUCTION

Erythrophleum fordii Oliver (Leguminosae) is a endangered evergreen broad-leaved plant species of Caesalpiniaceae, also known as “iron wood tree” with the great economic value with a distribution in Vietnam, Taiwan, Laos and Southern China (Nguyen et al. 2018; Yao *et al.* 2014; Tsao *et al.* 2008). It is classified as one of “four types of Vietnam timber” (Dinh, Lim, Sen, and Tau) and is a precious wood which is often a choice and has a greater value for high-quality crafts or furniture making as well as architecture constructions that require high durability, or even railway crosstie (Fang & Fang 2006; Vo *et al.* 2020; Zhao *et al.* 2021), thus more consideration is paid to its formation and evolution (Yang *et al.* 1991; Kerr & Harris1998; Woeste *et al.* 2002). There is also a significant medical value in *E. fordii*. Its seeds, bark, and leaves have been reported to contain alkaloids like diterpenoids (Tsao *et al.* 2008) and triterpenoids (Li *et al*. 2004; Yu *et al*. 2005). In recent years, due to extensive deforestation as well as land alteration for the large-scale production of cash crops or fast-growing tree species and other factors, natural distribution areas of *E. fordii* have severely decreased, and completely vanished in some cases (Huang *et al.* 1997; Trung 1998; Sala *et al.* 2000; Zhao *et al.* 2009). The remaining populations were smaller and there was more population fragmentation (Young *et al.* 1996; Fuchs *et al.* 2003; Farwig *et al.* 2008), which would have a detrimental effect on the species' ability to adapt and maintain stability. Hence, *E. fordii* became highly endangered (Huang 1997; Wang & Xie 2002), and as a result, it was added to the IUCN Red List of Threatened Species and designated as a national key protected plant in Vietnam. So, more focus

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should be placed on the biology of this species' conservation. In Vietnam, *E. fordii* is primarily distributed across Lang Son, Bac Giang, Quang Ninh, Thanh Hoa, Quang Nam, Lam Dong, etc., especially in the north and north-centre of Vietnam (Sein & Mitlöhner 2011). In the 1970s and 1980s, the districts of Luc Ngan, Luc Nam, and Son Dong in Bac Giang Province gained notoriety for its rare timber reserves, particularly *E. fordii*, which was given the nickname "Son Dong *E. fordii* treasure". Unfortunately, many local *E. fordii* populations have currently seen a reduction in size and quality due to the influence of numerous factors, and the majority of these populations only have regenerated populations left. Thus, it is imperative to conduct a study to determine distribution as well as silvicultural attributes of *E. fordii* such as features of structure and regeneration that are naturally dominated in Bac Giang province in order to give knowledge and data for efficient management and conservation.

MATERIALS AND METHODS

Study site

This study was carried out in Bac Giang Province, Vietnam（21° 20′ N 106° 20′ E in the natural distribution range of *E. fordii* and also its main plantation area in the northeast of Vietnam. The province primarily exhibits traits associated with the Northern Plain's tropical, temperate climate zone with the months and seasons, the temperature, humidity, and rainfall change. The hot and rainy season is from May to September, while the cold and dry season is from November to March. These two seasons are indicative of the province's climate. The maximum temperature recorded is 41°C (106 °F), while the lowest 13°C (55°F). The average temperature is between 22 and 23°C (72 and 73°F). The range of humidity values is from 73% to 87%. 1,953 mL of rain are recorded to fall on average each year (76.9 in). Tropical and subtropical trees grow with 1,500 to 1,700 hours of sunshine per year.

Fig. 1. Map of the study area.

Data collection

Methods of studying the distribution characteristics of *E. Fordii:* Interview

In order to collect preliminary data of *E. fordii* in Bac Giang Province such as the area characteristics, distribution area, forest status, etc., the interview method was used. The survey routes and quadrats were constructed according to these information for collecting research data. Also, the information from the interview were checked and verified from the field study, making it extremely valuable in the event that the field investigation had not been recorded the distribution of *E. fordii*. The interviewees were forestry managers in the province, including forest rangers, members of Management Boards for special-use and protection forests, Forest Protection Officers, local officials, and those who frequently visit the forest or have extensive knowledge of the forests where *E. fordii* dominated.

Setting up the investigation route

In Bac Giang Province, a survey was conducted to ascertain the status of the forest, high belts, and the distribution of *E. fordii* by geographic area. The findings of field surveys, interviews, topographic map data, forest status maps, etc. were used to produce a total of 18 survey routes. The survey of routes' length were typically between two and four km, and they should cross high-belt forests in any regions where *E. fordii* may be found. To determine the presence of *E. fordii*, the surveyor walked the road while carefully examining both sides. Important data were

gathered when recording *E. fordii*, such as the encounter location (coordinates), slope, altitude, forest condition and level of regeneration, etc.

Methods of studying silvicultural characteristics of *E. Fordii*

Quadrat method

In these areas that *E. fordii* have concentrated distribution, we conducted the establishment of quadrats. A total of 26 quadrats in areas with concentrated distribution of *E. fordii* from the survey results were established along the study site. The quadrats were guaranteed to represent different forest statuses as well as characteristics of the field study aiming to collect a plenty of silvicultural data of *E. fordii*. Quadrats were set up in rectangular shape, with an area of 2,000 m^2 (50 m × 40 m) to identity the silvicultural characteristics as well as the structure of higher tree layer that the distribution of *E. fordii* was existed along altitudes.

Investigation and measurement of regenerated trees

In each quadrat, 05 square-shaped plots (ODB) were arranged, each ODB had an area of 25 m^2 (5 m × 5 m) to investigate the regeneration characteristics with the distribution of *E. fordii*. The survey factors including regeneration, fresh vegetation and some other factors of tree species were measured according to typical survey methods in forestry to ensure the reliability of the collected data.

Data analyses

Data were analysed by mathematical statistical methods in forestry on Excel and SPSS software to calculate the composition formula (applying the formula to calculate the composition coefficient according to the number of trees, and according to the IV% index to determine dominant species in the stands), density, reserves, classification of regenerated trees, etc. using MapInfo software to build survey route maps, study site and geographical distribution.

RESULTS

Distribution characteristics of *E. fordii* in Bac Giang

Geographical distribution characteristics

E. fordii has been identified and distributed naturally in 5 districts of Bac Giang Province including Tan Yen, Yen The, Luc Nam, Luc Ngan, Son Dong, of those, mainly concentrated in 3 districts of Luc Nam, Luc Ngan and Son Dong. In Tan Yen district, *E. fordii* exhibited a relatively large concentration in the area of Den Ha, Tan Trung commune with about 60 trees, with an average diameter of 1.3 m ($\bar{D}1.3$) reaching 33 cm and height reaching 1.3 m. The average height ($\bar{H}vn$) was 14 m. This is a population of *E. fordii* with natural origin associated with the culture and beliefs of local people. In Yen The district, *E. fordii* was determined to be scattered distribution in 5 communes namely Tam Tien, Dong Vuong, Dong Tien, Canh Nau and Xuan Luong, most concentrated in Tam Tien commune with $\bar{D}1.3$ reached 26.6 cm and $\bar{H}vn$ reached approximately 16 m. Especially in Xuan Lung village, Xuan Luong commune, there was an "ancient *E. fordii*", which has been recognized as a Vietnamese heritage tree and is considered as one of the oldest trees in the northern mountainous region of Vietnam remaining (diameter at 1.3 m position is 179.0 cm, height is about 45m). In Luc Nam district, *E. fordii* was distributed in 4 communes including Huyen Son, Nghia Phuong, Binh Son and Luc Son, in which mainly concentrated in Luc Son commune. Here, *E. fordii* was distributed in areas associated with the culture and beliefs of local people and special-use as well as the protection of forests under the management of the Forest Management Boards and the Forestry Companies. Especially in the sacred forest of Nghe Man village, Binh Son commune, there is a population of *E. fordii* with quite large size with $\bar{D}1.3$ of 32.4 cm and $\bar{H}vn$ of 18 m. This is also one of the areas with the largest growing *E. fordii* in the area of Luc Nam district in particular and in Bac Giang Province in general. In Luc Ngan district, *E. fordii* was recorded naturally distributed in 6 communes, including 2 communes in the north, Cam Son and Son Hai, while 4 in the south, Tan Moc, Tan Lap, Phu Nhan and Deo Gia. *E. fordii* populations here were also quite large, $\bar{D}1.3$ was 37cm, and $\bar{H}vn$ was higher than 20 m. Among the areas recorded with the distribution of *E. fordii*, Son Dong was the locality with the largest distribution of *E. fordii*, determined to be distributed in 9 communes: Cam Dan, Yen Dinh, Tuan Dao, Tay Yen Tu, Bong Am, Thanh Luan, Long Son, Duong Huu, An Lac. *E. fordii* populations in these areas were diverse in size. There was a large number of

trees with large sizes: $\bar{D}_{1.3}$ was 39 cm, $\bar{H}_{vn}$ reached higher than 20 m. These are also extremely valuable *E. fordii* populations today in Bac Giang Province.

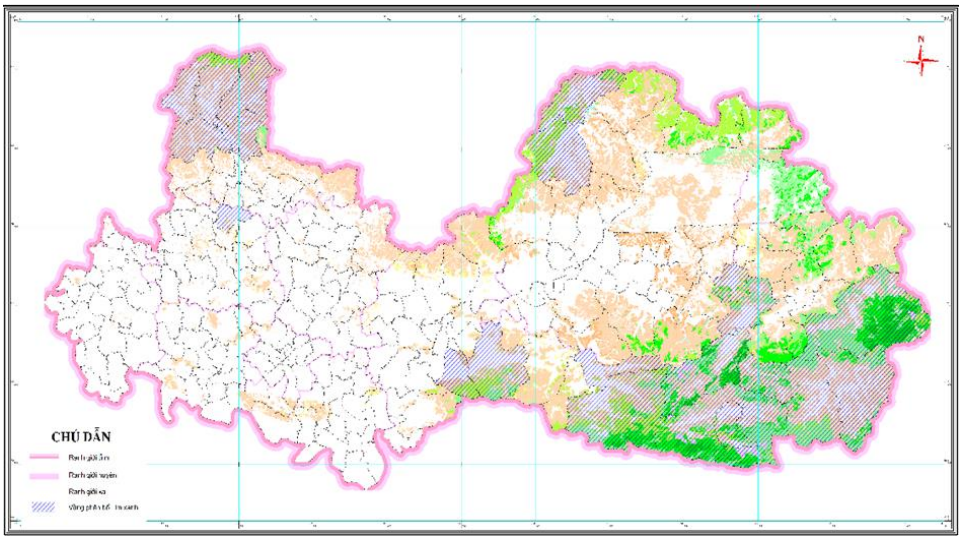

Fig. 2. Distribution of *E. fordii* in Bac Giang Province.

Distribution characteristics along altitudes

The distribution characteristics along altitudes of *E. fordii* in Bac Giang Province are synthesized from the results of the survey route and the standard on quadrats. The results of the general distribution of *E. fordii* individuals are summarized in Table 1:

Table 1. Distribution characteristics of E. fordii along altitudes.

No.	Altitude (m)	Species quantity	Rate (%)
1	≤100m	46	19.31
2	101 - 200m	148	62.17
3	201-300m	38	16.0
4	301-400	3	1.26
5	>400	3	1.26

Research results show that in Bac Giang Province, the *E. fordii* species is naturally distributed along altitudes of 50 – 500 m, mainly concentrated in the high belt from 100 – 200 m. The higher altitudes are, the less *E. fordii* have distributed. Specifically, at the altitude of under 100 m, 46 individuals of *E. fordii* were recorded (accounting for 19.31% of the recorded individuals); at 101 - 200, 148 individuals (62.17%); and at 201 – 300 m, only 38 individuals (16%), while only 3 individuals at 301- 400 m and 3 individuals above 400 m. Different topographical areas exhibited different rates of occurrence of *E. fordii*. Its appearance was closely related to environmental conditions, altitude, slope, soil, direction, etc. The altitude from 100 - 200m asl was the most suitable height for *E. fordii* to grow and develop. Through the trend chart, we can see that *E. fordii* in Bac Giang Province displayed s a fairly wide distribution range. The growing trend was most concentrated at the high belt from 101 to 200 m, the higher the altitude, the less the distribution of *E. fordii*. From the altitude of 400 m, the quantity of *E. fordii* individuals was recorded less and almost not encountered. This showed that the distribution characteristics of *E. fordii* in Bac Giang Province were consistent with those in Vietnam.

Some features of composition formula in these areas that *E. fordii* is distributed

Composition formula of high tree layer

The composition of forest tree species is an ecological indicator showing the level of participation of forest tree species in the forest plant community. In this study, the formula for forest composition was analysed by the number of trees (N) and the forest structure by the important index (IV%).

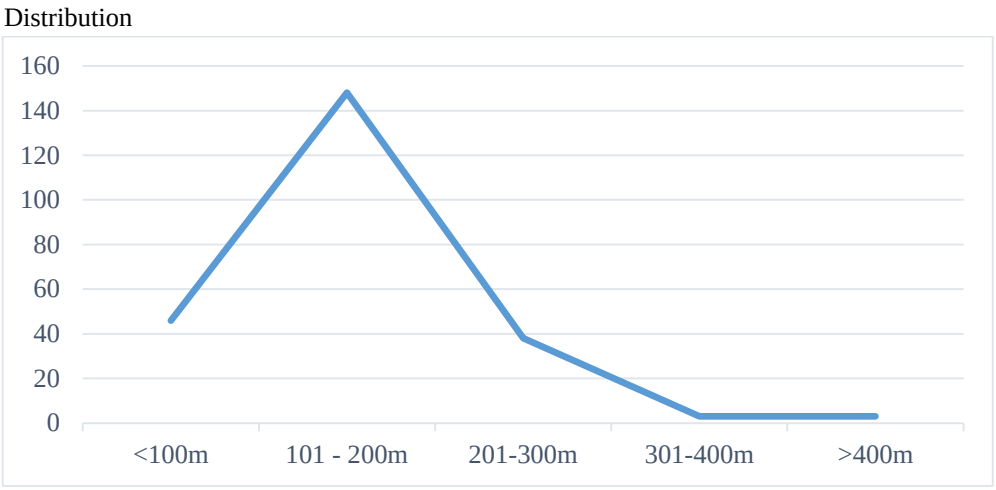

Fig. 3. Distribution trend chart of *E. fordii* along altitudes.

Forest composition formula according to the number of trees

Research results on forest composition by the number of trees in the study area are depicted in Table 2.

Table 2. Composition by N in the forest status where *E. fordii* distributed

No.	Forest status	Quadrat quantity	Composition formula of high tree layer by N
1	HG1	2	1.61 Elaeaocarpaceae + 1.46 Fagaceae + **0.88 *E. fordii*** + 0.88 *Embelia pulchella* Mez + 0.83 SP + 0.78 *Syzygium cumini* + 0.73 *Gironniera subaequalis* + 0.67 *Diospyros decandra* + 2.16 other species
2	HG2	4	**1.92 *E. fordii*** + 1.57 *Embelia pulchella* Mez + 0.59 *Engelhardtia chrysolepis* Hance + 0.59 Elaeaocarpaceae + 0.56 *Canarium* + 0.53 Fagaceae - 0.43 *Cinnamomum bejolghota* Sweet - 0.40 SP - 0.32 *Syzygium cumini* - 0.32 *Prunus arborea* - 0.27 *Syplocos racemosa* Roxb - 0.27 *Aphanamixis grandifolia* Blume - 0.21 *Wedelia chinensis* + 2.02 other species
3	TXG	4	**4.98 *E. fordii*** + 1.45 *Canarium* + 0.51 Fagaceae - 0.37 *Gironniera subaequalis* - 0.30 *Syzygium cumini* - 0.24 Elaeaocarpaceae - 0.24 *Hopea mollissima* - 0.20 Amaranthus - 0.20 *Sáng nhung* + 1.51 other species
4	TXB	12	**3.84 E. *fordii*** + 0.81 *Syzygium cumini* + 0.68 Fagaceae + 0.56 *Embelia pulchella* Mez - 0.49 *Canarium* - 0.42 Elaeaocarpaceae - 0.34 *Engelhardtia chrysolepis* Hance - 0.34 *Gironniera subaequalis* - 0.34 SP - 0.25 *Endospermum chinense* + 1.93 other species
5	TXN	4	2.61 Fagaceae + **1.67 *E. fordii*** + 0.77 *Canarium* + 0.52 *Engelhardtia chrysolepis* Hance + 0.52 *Syzygium cumini* - 0.45 SP1 - 0.36 *Prunus arborea* - 0.32 SP - 0.29 Elaeaocarpaceae - 0.29 *Cratoxylum maingayi* - 0.23 *Gironniera subaequalis* - 0.23 *Embelia pulchella* Mez - 0.22 *Madhuca pasquieri* + 1.52 other species

According to Table 2, all 5 forest status of *E. fordii* were the main components participating in the composition formula with a high coefficient and it is the species that play an important role, dominating the forest. In the investigated status, the TXG status of *E. fordii* was the species with the highest composition coefficient, accounting for 4.98, while the lowest in the HG1 status of the composition coefficient of *E. fordii* was 0.88, the number of species participating in the composition formula varied from 9-15 species depending on the forest status. The most diverse was the TXG forest status with 71 species. The HG1 status exhibited 8 species of 31 species participating in the composition formula, while the HG2 status displayed 14 of 44 species and the TXN status 14 of 38. In general, the composition formula in the forest status where the *E. fordii* was distributed is quite diverse, it was the dominant species in the TXG and TXB status, which tended to decrease gradually in the HG1, HG2 and TXN status. This is also consistent with the rules of ecology.

Composition formula by key index IV%

The formula for composition by importance index IV% is an index indicating the importance of a species to the forest in which it is distributed. The index IV% depends not only on the number of trees but also on the total cross-section of species in the ecosystem. The higher the species index IV%, the greater its influence on the forest. Species with index IV% ≥ 5% are the species that create the forest environment and the habitat of the forest. The results of the calculation of the composition formula according to the key index IV% are summarized in Table 3.

Table 3. Composition by IV% on forest status where E. fordii is distributed.

No.	Forest status	Quadrat quantity	Composition structure of high tree layer by IV%
1	HG1	2	19.09 Fagaceae + 15.06 Elaeaocarpaceae + **8.52 *E. fordii*** + 7.85 *Gironniera subaequalis* + 7.58 SP + 7.26 *Embelia pulchella* Mez + 6.54 *Syzygium cumini* + 5.92 *Diospyros decandra* + 22.18 other species
2	HG2	4	**29.58 *E. fordii*** + 11.69 *Embelia pulchella* Mez + 5.62 Fagaceae + 5.13 Elaeaocarpaceae + 5.02 *Engelhardtia chrysolepis* Hance + 4.85 *Canarium* + 3.45 *Prunus arborea* + 3.18 *Cinnamomum bejolghota* Sweet + 2.81 SP + 2.47 *Syzygium cumini* + 2.18 *Aphanamixis grandifolia* Blume + 24.02 other species.
3	TXG	4	**62.29 *E. fordii*** + 12.38 *Canarium* + 3.70 Fagaceae + 2.36 *Gironniera subaequalis* + 19.27 other species
4	TXB	12	**49.36 *E. fordii*** + 7.48 Fagaceae + 6.14 *Syzygium cumini* + 4.14 Trám + 4.02 *Embelia pulchella* Mez + 3.50 Elaeaocarpaceae + 3.13 *Engelhardtia chrysolepis* Hance + 2.75 *Gironniera subaequalis* + 2.61 SP + 2.04 *Endospermum chinense* + 14.83 other species
5	TXN	4	29.21 Fagaceae + **21.83 *E. fordii*** + 5.93 Canarium + 4.68 Prunus Arborea + 4.40 SP1 + 4.10 *Syzygium cumini* + 3.81 *Engelhardtia chrysolepis* Hance + 3.21 SP + 2.59 Elaeaocarpaceae + 2.48 *Gironniera subaequalis* + 2.29 *Cratoxylum maingayi* + 15.47 other species

In the composition structure according to IV%, species with index IV% ≥ 5% are creation species and dominant to the forest. From the results from Table 3, we saw that in the status TXG, TXB and HG2, *E. fordii* has the composition coefficient of respectively 62.29, 49.36 and 29.58 respectively, ranking 1st in composition structure by index IV%. In TXN and HG1 status, *E. fordii* exhibited a composition coefficient of 21.83 and 8.52 respectively, ranking 2nd and 3rd in the composition structure. This proved that in all status, *E. fordii* plays an important role, having a dominant influence on the development of the forest and the characteristics of the forest structure where they are distributed.

Density and volume structure characteristics

Forest density and volume are important indicators for assessing forest quality as well as predicting the nature of status. From the results of calculating and synthesizing data on the density and volume of forest by the forest status, the results are summarized in Table 4:

Table 4. Statistical results of some indicators of some survey factors of the E. fordii.

No.	Forest status	Quadrat quantity	N (tree/ha)	$\overline{D}_{1.3}$ (cm)	$\overline{H}$vn (m)	$\overline{G}$ (m²/ha)	$\overline{M}$ (m³/ha)
1	HG1	2	483	19.96	15.69	17.51	139.90
2	HG2	4	470	18.64	15.76	16.53	148.57
3	TXG	4	371	29.02	18.51	34.99	394.96
4	TXB	12	423	20.91	15.18	17.78	140.30
5	TXN	4	388	15.96	12.65	9.76	66.45

The density of trees on quadrats and in different forest status ranged from 371 trees/ha to 483 trees/ha. The highest density was in HG1 and HG2 status - mixed wood and bamboo forest. The average diameter ranged from 15.96 cm to 29.02 cm; the average height ranged from 12.65 m to 18.5 m; the total cross-section of the status was from 9.76 m2/ha to 34. 99 m2/ha; The volume of forest status ranged from 66.45 m3 to 394.96 m3, which is suitable

according to the criteria for classifying forest status according to Circular No. 33/2018/TTBNNPTNT in 2018 by the Ministry of Agriculture and Rural Development providing regulations on forest survey, inventory and monitoring. In forest status there are many different diameter sizes.

Characteristics of the distribution of *E. fordii* quantity by diameter

The results of distribution of N/D1.3 on the forest status with the distribution of *E. fordii* are illustrated in Fig. 4.

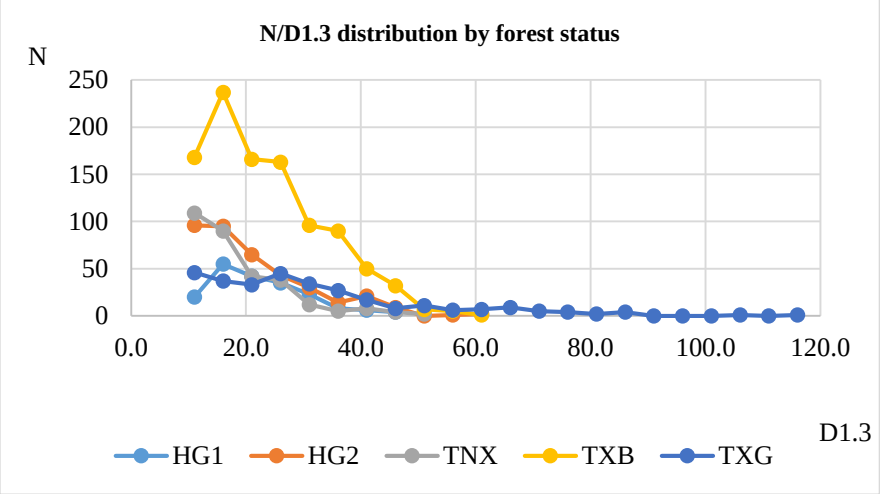

Fig. 4. N/D1.3 distribution of high tree layer and *E. fordii* by forest status.

According to the experimental results of the N/D1.3 distribution, most of the status exhibited a left skewed distribution, in which, the HG1 status displayed a distribution of a peak, with a left deviation, and the number of trees was concentrated at 11cm in diameter. The HG2 status indicated a reduced distribution; the trees were concentrated in diameter sizes from 11-16 cm. In addition, there were some secondary peaks at 41 cm in diameters. The TXN status revealed a reduced distribution; the number of trees was concentrated at 11 cm in diameter. The TXB status displayed a distribution of a peak, with a left deviation; the number of trees was concentrated at 16 cm in diameter. The TXG status displayed a reduced distribution of trees with a large concentration in the diameter from 11-26 cm. This was completely consistent with the characteristics of the investigated areas. The recovery time was short; the forest situation was newly formed; and the number of trees was concentrated in small diameters and tended to decrease in the large diameter. In the case of the species of *E. fordii* in the investigated stands, the number of *E. fordii* accounted for higher than 30% of the tree species in the surveyed forest. However, in all status, at the large diameter from 41-116 cm, the percentage of *E. fordii* was quite high (higher than 70%), exhibiting that, although the number of *E. fordii* as a tree species, accounted for low rate compared to the investigated tree species, however, structurally, *E. fordii* was an important tree species participating in the main tree layer of the investigated forest.

Regeneration characteristics of *E. fordii* species

Distribution of regenerated trees by height

The distribution of the number of regenerated trees by height reflects the growth and development rules of the regenerated tree, thereby assessing the maturity and development situation of the forest in the future. From the results of calculating data on the origin, the distribution characteristics of the number of regenerated trees by height are summarized in Table 5. From Table 5, we can see that 100% of the regenerating trees of *E. fordii* have the origin of regeneration by seeds. This feature is favourable for the formation of the main forest layer in the future, since the seed-regenerating trees were resistant to adverse environment are better than bud-regenerating trees. The number of regenerated trees was unevenly distributed at different height, mainly at the height level < 0.5 m (57.9%); followed by the height from 0.5 m - 1.0 m (26.7%); 1.1 m - 1.5 m (7.24%); 1.6 m to 5 m, (accounting for a low rate ranging from 2.26 to 2, 71%); height above 5 m, only 1 tree was detected (0.45%). In all 5 forest status, the number of regenerated trees decreased as the height increases. This is also the general development trend for forest regeneration trees. In the young stage, there was a big number of generated trees. In

the process of growth and development due to the elimination of nature, the number of generated trees decreased, until a certain stage is stable and developing.

Table 5. Characteristics of the distribution of regenerated trees by height.

Forest status	ODB quantity	Tree quantity in ODB	Regeneration form		Height (m)						
			Seed	Bud	<0.5	0.5-1.0	1.1.-1.5	1.6-2.0	2.1-3	3.1-5	>5.0
HG1	10	27	27		22	5					
HG2	20	22	22		14	8					
TXB	60	86	86		65	13	2	4	2		
TXG	20	19	19		5	12	2				
TXN	20	67	67		22	21	12	2	4	5	1
Total		221	221		128	59	16	6	6	5	1
Rate (%)			100		57.9	26.7	7.24	2.71	2.71	2.26	0.45

Density and quality of regenerated trees

The results of the survey on the density and quality of regenerated *E. fordii* in different forest conditions are summarized in Table 6:

Table 6. Density and quality of regenerated *E. fordii.*

Forest status	ODB quantity	Density of regenerated tree (tree/ha)	High quality		Medium quality	
			Quantity (tree/ha)	Rate (%)	Quantity (tree)	Rate (%)
HG1	10	1080	800	74.07	280	25.93
HG2	20	440	400	90.91	40	9.09
TXB	60	573	506	88.31	67	11.69
TXG	20	380	360	94.74	20	5.26
TXN	20	1340	1080	80.60	260	19.40

According to Table 6, the density of regenerated trees in the TXN status was the highest at 1340 trees/ha, followed by the HG1 status with 1080 trees/ha, while the lowest was the TXG status, the average density of regenerated trees was 380 trees/ha. According to the assessment of regeneration by the Forest Inventory and Planning Institute, the density of regenerating trees in all investigated forest status was at level 5 - poor regeneration, unevenly distributed among forest status. The reason may be that in the past years in the investigation area, the large trees have been exploited, only small trees remained, have not yet produced fruit, or the time of investigation was not the time of seed, so it has not been detected yet. Some areas are community forests where people worship, there has been the impact of people's vegetation clearing into shrubs, fresh carpets, etc. which has indirectly affected the regeneration process of *E. fordii*. The quality of good regenerated trees in all 5 status accounted for a high percentage ranging from 74.07% to 94.74%; the highest in TXG status accounted for 94.74% and HG2 status was 90.91%. All five status did not exhibit low quality regeneration trees, mainly displayed good quality. It can be affirmed that the climatic conditions, soil, and forest habitat are very suitable for the growth and development of the *E. fordii*, or the factors of light, nutrition, and water meet the needs of the regenerated plants at a small stage, so most of the regenerated plants are of good quality. According to the results, it was shown that in order for this regenerated tree layer to contribute to the high tree layer, it is necessary to have appropriate measures to promote forest regeneration and at the same time ensure the normal process of forest restoration.

CONCLUSION

Distribution characteristics: *E. fordii* is a precious tree species with both economic value and high conservation value. In Bac Giang Province, *E. fordii* displayed scattered distribution in districts: Tan Yen, Luc Ngan, Luc Nam, Yen The and is most concentrated in Son Dong district. *E. fordii* is distributed naturally along the altitude of 50 - 500 m, mainly concentrated in the high belt from 100 - 200 m asl. The higher the altitude is, the less *E. fordii* is distributed.

Characteristics of the composition formula

The species composition in the forest status where *E. fordii* is distributed, was quite diverse. The number of species participating in the composition formula ranged from 9 - 15 species depending on the forest status; the most diverse was TXG forest status with 71 species. In all 5 survey status, *E. fordii* was a species with a high coefficient of composition and was the main component participating in the composition formula, exhibiting a great influence on the situation of the forest. The density of high tree layers in the forest status ranged from 371 trees/ha to 483 trees/ha. In status of HG1 and HG2 (mixed wood and bamboo forest) there was the highest density compared to other status. The average diameter ($\bar{D}$1.3) of the tall trees ranged from 15.96 cm to 29.02 cm; $\bar{H}$vn from 12.65 m to 18.5 m; the total cross-section of the forest from 9.76 m^2/ha to 34.99 m^2/ha. The forest volume ranged from 66.45 m^3 to 394.96 m^3.

Distribution of *E. fordii* by diameter

In all forest status, the distribution was left skewed in accordance with the characteristics of the investigated areas; The number of trees was concentrated in small diameters and tended to decrease at large diameters. The percentage of *E. fordii* trees accounted for over 30% of the tree species in the surveyed forests, however structurally, the *E. fordii* was an important tree species participating in the main canopy layer of the surveyed forests.

Regeneration characteristics

100% of *E. fordii* were regenerated from seeds, the number of regenerated trees was unevenly distributed among heights, mainly at the heights of below 0.5 m. According to the assessment of regeneration by the Forest Inventory and Planning Institute, the density of regenerating trees in all forest status was at level 5 - poor regeneration, unevenly distributed among forest status. Good quality regenerating trees accounted for a high percentage, and there were no low quality regenerating trees. In all 5 forest status the number of regenerated trees decreased as the height level upraised.

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