<u>**Final Report**</u>

Project ID: 31132-1

Conservation of the Endangered Rosewoods *Dalbergia oliveri* and *D. cochinchinensis* in Cat Tien National Park, Vietnam

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Cover illustration: *Dalbergia oliveri* in Cat Tien National Park
Photo: La Quang Trung/CCD

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Acknowledgement

Abbreviation

Cat Tien National Park – CTNP

DBH – Diameter at Breast Height

EIA – Environmental Investigation Agency

Section 1:

1.1.   Executive summary

Dalbergia oliveri and *Dalbergia cochinensis* are two of the most threatened rosewood of *Dalbergia* group. According to preliminary review and report, Cat Tien National Park is one of very few protected areas are preserving these precious species. Our project therefore conducted field survey using transect and sampling plot methods to confirmed the vital populations and assess their natural regeneration status in this park. Collected data was used to develop a recovery and conservation plan that was presented at a technical workshop to take people attention on and encourage scientist to study this group. The plan was also agreed and provided to Cat Tien National Park to develop a long-term conservation programme. In short-term, we also provided recommendation in management and protection of rosewood in Cat Tien.

1.2.   Introduction

Rosewoods are among the most threatened group species which are commonly targets of the smuggling. Two of the most valuable of these woods, known as Siamese rosewood (*Dalbergia cochinchinensis*) and Burmese rosewood (*D. oliveri*), was listed on Appendix II of the Convention on International Trade in Endangered Species (CITES) (EIA, 2017). These rosewoods are hard, beautiful, durable and free from termites. Therefore, they have high value and being preference for construction and furniture making for century. Over the past two decades, demand in China for luxury furniture and cultural artworks has soared that led to the increasing trade in these precious timber to supply for traditional Hongmu market (EIA, 2014) (EIA, 2017).

Despite the fact that they are strictly protected by national and international laws, the logging and trade in illegal *D. cochinchinensis* and *D. oliveri* persist (EIA, 2015). Although rosewoods have been heavily harvested and traded, their current population status are undocumented and they are neglected from conservation efforts. The species are considered as locally extinct in most of it known ranges.

In Vietnam, a survey conducted in 2010 at five protected areas found a low density of Siamese rosewood of just one to 10 mature trees per hectare (EIA, 2014) while the status of Burmese rosewood is unknown. Currently they are confirmed to exist in six key provinces, including: Kon Tum, Gia Lai, Dak Lak, Lam Dong, Binh Phuoc, and Dong Nai. However, it is difficult to find any viable population in any non-protection forests due to heavy logging and deforestation. Based on our review and preliminary survey, Cat Tien National Park is one of the very few protected areas where are holding natural *D. oliveri* population with mature trees are productivity. Nevertheless, even in the best-known protected areas information on their population status was not clearly known and documented, and there is no conservation effort yet done for these two threatened species.

Our project therefore carried out field survey to identify the true population, natural regeneration and practical conservation actions of Burmese rosewood and possible

Siamese rosewood in Cat Tien National Park. From the survey findings, we worked with the park's management board to prepare a conservation plan of these species in Cat Tien and shared results to Government agencies and stakeholders to mobilize their attention and action for the conservation of threatened rosewoods.

1.3. The project site

Cat Tien National Park is one of two core zones of the Dong Nai Biosphere Reserve, situated in South-East of Vietnam. It is recognized as the Key Biodiversity Area (KBA, 2020). The park covers an area of 71,350 ha which includes three sub-areas. Those are:

- South Cat Tien belongs to Dong Nai province, 39,627 ha
- West Cat Tien belongs to Binh Phuoc province, 1,193 ha
- Cat Loc belongs to Lam Dong province, 27,530 ha

The park is reputation for its biodiversity richness and diversity of natural habitats, with various type of habitats consisting of evergreen forest, deciduous forest, mixed bamboo forest, grassland and wetland. Cat Tien is home to several globally endangered species including the Critically endangered plant - *Camellia dongnaiensis* and several endangered plants species such as the rosewoods species (*Dalbergia* spp.), Cattien's Magnolia (*Magnolia cattienensis*), Cat Tien wild mango (*Mangifera dongnaiensis*),and several critically endangered and endangered animals such as the Asia elephant (*Elephas maximus*), large cats (*Felidae* spp.), bear (*Ursus* spp.), gaur (*Bos gaurus*), loris (*Nyctycebus* spp.), the endangered yellow-cheeked gibbon (*Nomascus gabriellae*), and endangered green peafowl (*Pavo munticus*).
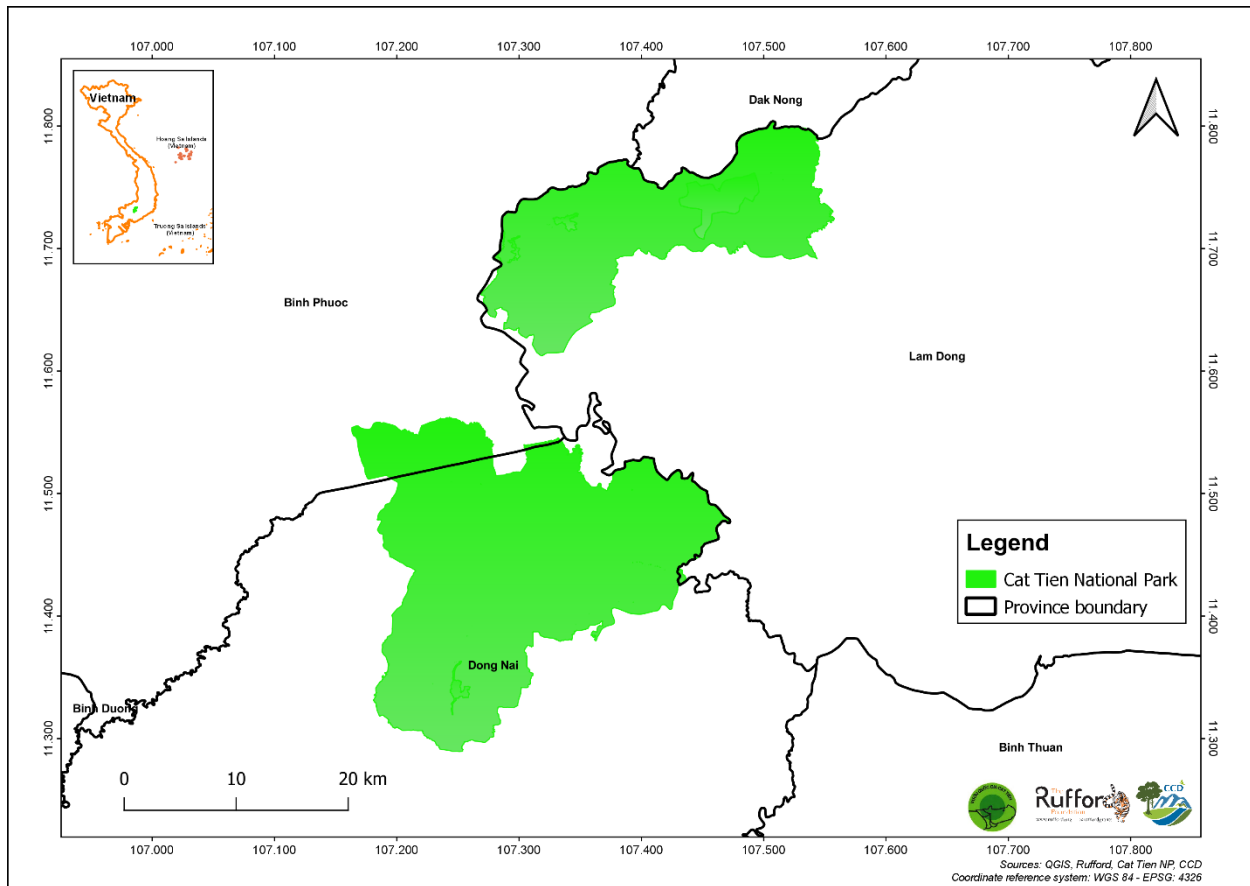
Figure 1. Map of Cat Tien National Park - the project site

Section 2:

2.1.   Aim and objectives

Our project goal is to ensure the sustainable conservation and management of threatened rosewood species in Vietnam. As this is the first rosewood conservation project in Cat Tien National Park, our project need to start by collecting baseline data on rosewood population including their distribution, natural regeneration, threats. Such baseline information allowed us to develop short-term and long-term conservation plan as well as provide recommendation on management for the government agency.

The project has following specific objectives:

- To implement study to document population and regeneration status for Siamese and Burmese rosewoods in CTNP;
- To identify threats and conservation opportunities to improve the protection and recovery of the rosewood's population in Cat Tien and its adjacent areas;
- To strengthen the park's research capacity and assist the park to prepare and implement a long-term rosewood conservation plan include replanting and facilitating natural regeneration.

2.2. Methodology

We interviewed the park's management board and technical staffs to identify the potential area for the presence of two threatened rosewoods to conduct field survey.

Transect survey and sample plot methods were used to conduct field survey. Transects were designed to identify distribution areas of Siamese and Burmese rosewood in CTNP. Surveyed transects were positioned within areas recommended by the park's staffs where the species possibly occur (Department of Planning, 2020). Based on the park's topography and vegetation, transect widths were 10 m from center to both sides. Target trees along each transect were recorded with following parameters: Diameter at Breast Height (DBH) of trees which DBH ≥ 6 cm; GPS coordinate; height; tree condition (good, bad, neutral); damage to target trees and their habitat and additional information on regeneration sources (shoot or seed regeneration) of seedlings (GTC, 2013).

Sample plots with an area of 1000 m^2 (20 m x 50 m) were set up to identify characteristics of forest where Siamese and Burmese rosewoods grow (Thin, 2007). Sample plots were placed randomly along surveyed transects. In each plot, we measured all trees that have diameter at breast height (DBH) from 6 cm using diameter measure tape of the Forestry Suppliers Inc. and their height using the Blume Leiss altimeter to calculate wood volume.

Collecting specimen or photo identification were applied if a species could not be identified right in the field.

Collected data was analyzed by Excel software includes following statistical indicators:

- Basal area:

$$G = \left(\frac{D_{1.3}}{2}\right)^2 \times \pi \div 10000$$

Of which: G: Basal area (m^2)
                 $D_{1.3}$: Diameter at Breast Height (DBH) (cm)

- Stem volume of each tree:

$$V = G \times H \times f$$

Of which: V: Stem volume (m^3)
                 G: Basal area (m^2)
                 H: Height (m)
                 f: Stem form factor, f = 0.5 for natural forest in Cat Tien

- Forest stand volume:

$$M = \sum_{n}^{1} V \times \frac{10000}{S}$$

Of which: M: Forest stand volume (m^3/ha)

$\sum_{n}^{1} V$: Total stem volume in sample plot (m^3)

S: Sample plot size (m^2)

- Important value of species in each sample plot:

$$IV\% = \frac{N\% + G\%}{2}$$

Of which: IV%: The important value of a species in plot

N%: Percentage according to number of trees of each species

G%: Percentage according to basal area of each species

- Important value index of species for whole forest stand:

$$IVI\% = N\% + G\% + F\%$$

Of which: IVI%: The important value index of a species in stand

N%: Percentage according to the number of trees of each species

G%: Percentage according to basal area of each species

F%: Relative frequency of a species

- Density:

$$N/ha = \frac{10\,000 \times N}{S}$$

Of which: N/ha: Number of tree in one hectare

N: Number of recorded trees

S: Total surveyed area (m^2)

- Regeneration density:

$$n/ha = \frac{10\,000 \times n}{S}$$

Of which: n/ha: Number of seedling in one hectare

n: Number of recorded seedings

S: Total surveyed area (m^2)

- Seedling rate:

$$N\% = \frac{n \times 100}{N}$$

Of which: N%: Percentage of shoot regeneration/seed regeneration/ potential seedlings/non-potential seedlings

n: Number of shoot regeneration/seed regeneration/ potential

seedlings/non-potential seedlings
N: Total recorded seedlings in transects

Cat Tien National Park is strictly protected and forest fire rarely occurs. Thence we would consider a seedling as a potential one if it met all following three criteria:

- The height is from 1 m;
- Seedling has straight stem without infected with pests;
- Low level of competition with other species: growing in open areas, not completely shaded by taller trees or suppressed by shrubs and liana.

To improve research capacity of the park's forest ranger, we trained forest rangers with survey techniques and they directly applied those techniques to support our field survey. Forest rangers were equipped with plant identification knowledge, using GPS device, survey equipment for field work and designing survey plan. Total 15 forest rangers and technical staffs were trained with relevant techniques and twelve of them participated in our field research.

We organized a consultation workshop to share our findings on field survey as well as to consult with stakeholders on draft conservation plan. Participants included conservation and botanical experts from NGOs, Government agencies, research institutes and university.

2.3.   Outputs and results

According to interview with Cat Tien management board, the Burmese rosewood mostly distributes in South Cat Tien whilst there is no evidence of Siamese rosewood in project area. Therefore, our survey efforts focused in South Cat Tien.

Total 18 transects were set up with total length of 62.792 km (approximately average is 3.5 km per transect). Those transects went through three different forest types include evergreen forest, semi-deciduous forest and evergreen forest mixed bamboo. There were three sample plots positioned in study area. The location of surveyed transects and sample plots are presented on the following map.
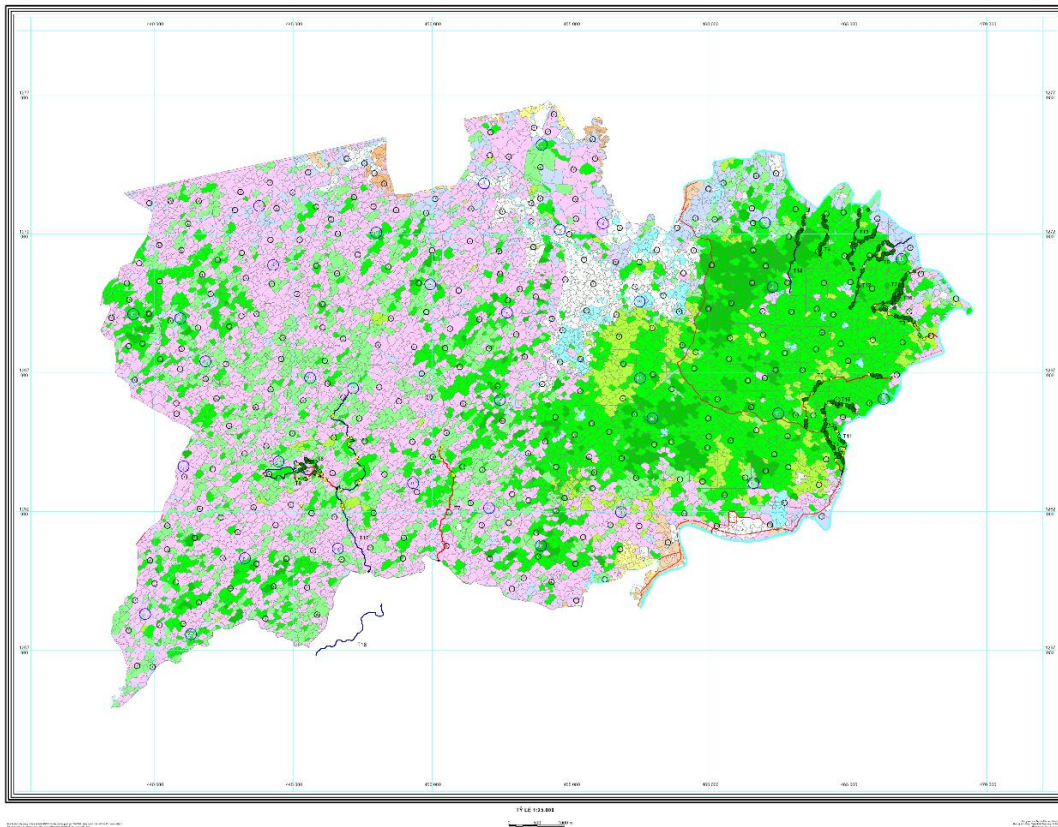
Figure 2: Map includes surveyed transects, sample plots and recorded locations of rosewood

Burmese rosewood was recorded on 17 of 18 surveyed transects with the relative density of trees whose DBH from 6 cm and above is approximately 6.8 trees/ha and relative density of seedlings is 12.3 seedlings/ha.

There was no recorded of Siamese rosewood individual during survey time even our efforts were focused to find it at the West South Cat Tien where was supposed to be its suitable habitat.

2.3.1. Distribution of Burmese rosewood

Distribution of Burmese rosewood in different forest types

Transects were designed to survey three different forest types which include:

The broadleaf evergreen forest: This forest type is mostly located in the South East Cat Tien, where is dominated by Fagaceae sp., *Aglaia* sp., *Pterocarpus macrocarpus*, *Afzelia xylocarpa* and *Dalbergia oliveri*. Six transects were designed to survey this area. The Burmese rosewood is distributed in this forest type in study area with density of trees is 11.1 trees/ha that is higher than average density of the entire surveyed area. Trees whose DBH from 20 cm and above is accounting for 55%. The density of seedlings is 12.3 seedlings/ha.

The semi-deciduous forest: Total four transects surveyed this forest type. This forest type is characterized by deciduous trees in dry season include *Lagerstroemia calyculata* and *Tetrameles nudiflora*. The density of *D. oliveri* trees (DBH ≥ 6 cm) is relatively high

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compared to average density of entire surveyed area, 9.9 trees/ha and the density of seedling is 7.5 seedlings/ha. Recorded trees mainly have DBH from 20 cm and above, accounting for 67.5% of total recorded trees whose DBH from 6 cm.

The evergreen forest or semi-deciduous forest mixed bamboo: Total seven transects surveyed this forest type. The Burmese rosewood is scatteredly distributed in surveyed area with the density or trees and seedlings are correspondingly 4 trees/ha and 16.1 seedling/ha. The Burmese rosewood seedlings prefer light at an early age therefore mixed bamboo forest has low canopy cover about 20 – 40% are priority condition to the growth of seedlings that led to the high density of seedlings in this forest type. However, bamboo trees have tendency to branch and spread at the lower, it suppresses *D. oliveri* seedlings that led seedlings to be topless or not straight stem as well as prevent seedlings growing to be mature trees. Moreover, annual forest fire in some parts of the park in mixed bamboo forest also affect to *D. oliveri* seedlings.
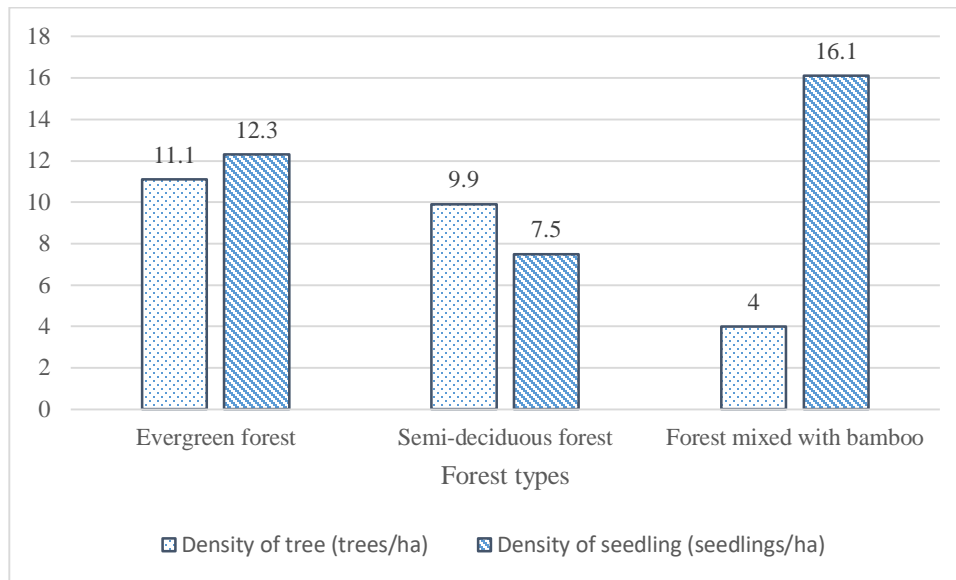
Chart 1. Density of D. oliveri in different forest types

Elevation distribution:

The South East of the park is characterized by low and flat hills with the elevation from 120 m – 160 m, rarely reach to 190 m above sea level. The slope is approximately between 5 – 7 degrees. *Dalbergia oliveri* was commonly recorded at the elevation of 120 m – 175 m in the South East Cat Tien.

The topography of the South West Cat Tien is medium high mountain with slope side. The average elevation is from 200 m – 300 m or sometime reach to 350 m above sea level. The mountain has slope side of 15 – 20 degrees. In this area, *Dalbergia oliveri* is generally growing at the elevation of 210 m – 320 m.

Distribution of Burmese rosewood in different forest ranger's management areas:

Dalbergia oliveri was found in forest stands where belong to management areas of Da Mi, Ben Cu, Da Lak, Da Co, Dat Do and Sa Mach forest ranger stations. Of which, it is distributed in forest stands of Ben Cu, Da Mi and Da Lak with the highest density 11.7 trees/ha, 11.6 trees/ha and 10.4 trees/ha correspondingly. Ben Cu forest ranger station is also managing areas contain dense seedling which is 32 seedlings/ha, higher than the rest of the park. *D. oliveri* seedlings were recorded along the tourist routes or bicycle roads. Meanwhile, Da Mi and Da Lak, where are dominated by broadleaf evergreen forest with the canopy cover estimated 60% – 70%, have lower density of seedling which are 10.0 seedlings/ha and 11.4 seedlings/ha.

The forest stands of Da Co and Sa Mach also have high seedling density, approximately 31.6 seedlings/ha and 16.1 seedlings/ha.

Table 1: Distribution of Dalbergia oliveri in South Cat Tien

No.	Management ranger station	Sub-area	Compartment	Elevation (m)
1.	Da Mi situated in South East Cat Tien	10	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13	120 - 170
		30	1,3	
2.	Da Co situated in South East Cat Tien	30	5, 6, 7, 8, 10	120 - 175
		31	7, 10	
3.	Da Lak situated in South East Cat Tien	14	1	130 - 190
		6	5, 6, 11	
4.	Ben Cu situated in South East Cat Tien	30	11	120 - 160
5.	Dat Do situated in South West Cat Tien	27	5, 3	220 - 325
		41	1, 4, 3, 7	
		43	3	
		48	2	
6.	Sa Mach situated in South West Cat Tien	35	3, 4	210 - 280
		48	1	

Correlation between the number of trees and the diameter:

Dalbergia oliveri trees in studied area largely have small diameter in the range between 6 cm – 20 cm, the bigger in diameter the fewer in number of trees. The recorded biggest one is DBH = 89.1 cm.
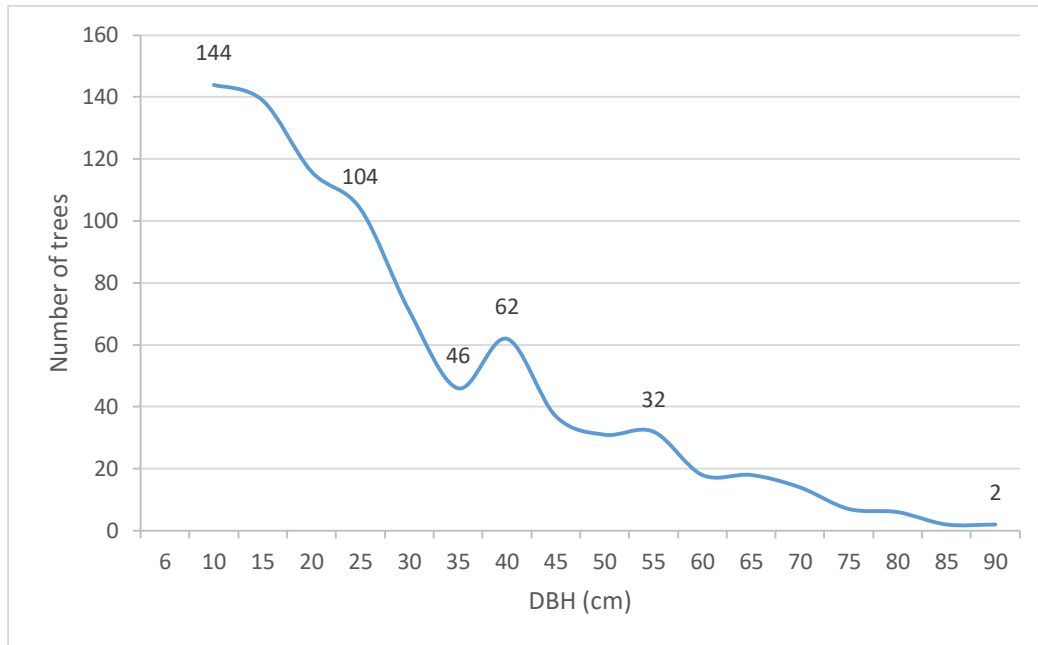
Chart 2. Correlation between the number of trees and the diameter

2.3.2. Natural regeneration status of Burmese rosewood

Findings of the survey revealed that the density of *Dalbergia oliveri* seedlings was 12.3 seedlings/ha and it was mostly sprouted from seeds. Total 1,544 seedlings and saplings were recorded. Of which 1,364 seedlings sprouted from seeds, accounting for 88.34% and shoot regeneration rate is about 11.66%. The high regeneration rate from seeds indicated Cat Tien National Park has potential for genetic diversity in the Burmese rosewood population that facilitate to conservation and recovery of the species. The park is maintaining a good source of mother trees which produce numerous quality seeds every year.

At the time of surveying the potential seedlings were approximated 39.3%. The low rate of potential seedlings could be attributed to the following reasons:

Recorded seedlings were just generated from seed of fruiting season in 2019 hence its height is about 20 cm – 50 cm. It was appraised as non-potential seedlings.

The mixed bamboo forests maintained high density of seedlings. However, it was suppressed by bamboo trees that led to topless and crooked seedlings.

It must be noted that this indicator was just used to assess potential seedlings at the time of surveying. More studies and monitoring plans are needed to get the accurate assessment and understanding on natural regeneration of Burmese rosewood in CTNP.

2.3.3. Species composition of stand

Three sample plots of 20 m x 50 m (1000 m²) each were set up to survey forest stands. The results show that *Dalbergia oliveri* was mainly distributed in forests which stand volumes were relatively high. These areas are located in the South East Cat Tien under the management of Da Mi and Da Lak ranger stations.

Table 2. Stand volume where Dalbergia oliveri is distributed

Plot ID	Stand volume (m³/ha)
Plot 1	600,6
Plot 2	970,1
Plot 3	510,8

Cat Tien national park is diverse in plant species with average number of species found at each sample plots was 18 species.

Table 3. The Important Value Index (IVI%) of tree species

No	Tree species	Relative density (%)	Relative dominant (%)	Relative frequency (%)	Important Value Index (%)
1.	*Lagerstroemia calyculata*	16.7	58.2	5.36	80.26
2.	*Diospyros* sp.	20.8	4	5.36	30.16
3.	*Dalbergia oliveri*	9.8	10.7	5.36	25.86
4.	*Streblus ilicifolius*	8.6	0.5	1.79	10.89
5.	*Polyathia* sp.	4.5	0.5	5.36	10.36
6.	*Syzygium* sp.	2.9	1.7	5.36	9.96
7.	*Syzygium wightianum*	2.9	1	5.36	9.26
8.	*Xerospermum noronhianum*	3.7	1.9	3.57	9.17
9.	*Hopea odorata*	0.4	6.9	1.79	9.09
10.	Ochrocarpos siamensis	4.1	1.2	3.57	8.87
11.	*Cleistanthus indochinensis*	4.1	0.7	3.57	8.37
12.	26 others	21.9	19.6	55.36	87.77
	Total	**100**	**100**	**100**	**300**

The results presented in Table 3 show tree species with their Important Value Index (IVI) of the highest one. *Lagerstroemia calyculata* was the most dominant species in study site with the highest IVI of 80.26% of density, frequency and dominant. *Dalbergia oliveri* was also among the most dominant species and play an important ecological role. It was consistent with ecology and distribution of *Dalbergia oliveri* as it is mostly found in semi-deciduous forest in which *Lagerstroemia calyculata* is dominant species.

2.3.4. Threats and conservation efforts

Cat Tien National Park is among few protected areas where strictly protect wild population of Burmese rosewood with many individuals whose have large diameter at breast height (DBH from 20 cm). However, this population is still under threats of declining

due to illicit exploitation. One of illegal logging cases was documented in 2020, three poachers illegally entered CTNP to collect 0.121 cubic meter of *Dalbergia oliveri* who thence detected by forest ranger.

Besides, the population is also affected by annual clearing of flammable materials in early dry season. The unintentional clearing activity has affected the natural regeneration of *Dalbergia oliveri*. During conducting field survey within Ben Cu forest survey team recorded many regenerated saplings that were cut off, broken or removed.

The natural elements also hamper the growth of rosewood population. Forest fire in the South West Cat Tien prevents seedlings to be mature trees. Many seedlings under 1 meter sprouted from shoot were recorded in this area. Moreover, seedlings germinated in mixed bamboo forests were suppressed by bamboo branches that led to their topless and crooked stem.

Cat Tien National Park has paid attention to protecting and conserving threatened tree species in general and rosewood in particular. In 2019, the park management board carried out a program to tag and figure out all individuals of some endangered species and *Dalbergia oliveri* was one of them. To continue the work, they are planning to implement experiment on germination of *D. oliveri* in nursery that support for further planting program.

2.3.5. Sharing workshop

The workshop on sharing research findings and consulting on conservation plan of rosewood in Vietnam was organized on 11 March 2021. The workshop convened experts from Government agency (Vietnam Administration of Forestry), NGOs (Save Vietnam's Wildlife, TRAFFIC-Vietnam), research institutes (Institute of Ecology and Biological Resources, Vietnam National Museum of Nature, Institute of Silviculture) and university (Hanoi University of Science).

At the workshop, participants highlighted the important of the information shared and urge for more discussion on rosewood management and conservation issue as this workshop was the only meeting on rosewood in Vietnam. Participant also recommended that findings should be published in conservation journal for broader audience; information should also be prepared as a policy brief then send to Government Agencies to raise concern about the important of rosewoods conservation and urge for government program on rosewood conservation and replanting.

2.3.6. Rosewood conservation plan

Conservation plan was agreed by workshop's participant and Cat Tien National Park management board.

Table 4. Rosewood conservation plan

Overall goal: *Burmese rosewood populations thrive in all their original habitat*			
Goal: *Burmese rosewood population in Vietnam recovered and protected with the engagement of stakeholders* **Duration**: 2022 - 2040			
Objective	**Result**	**Activity**	**Indicator**
Objective 1: Protect and maintain current populations in priority sites for Burmese rosewood conservation	R1.1. *Dalbergia oliveri* population identified and protected effectively in their home habitat	A1.1. Conduct further field surveys on *Dalbergia oliveri* to confirm its distribution areas and identify population size A1.2. Develop management plan for *Dalbergia* ssp. in priority sites and ensure that requirements of in-situ management and protection are taken into account. A1.3. Enforce relevant laws and regulations to protect rosewood A1.4. Enhance applying technical intervention to patrolling and monitoring of rosewood population	Location of population; Number of mature trees; Natural regeneration status; Number of violations on logging over time.
Objective 2: Identify mature/mother trees to provide good source for propagation and population recovery	R2.1. Mother trees tagged and their ecology understood R2.2. Germination and planting process developed based upon actual experiment	A2.1. Conduct further field surveys to identify mature/mother trees A2.2. Conduct research on ecology such as phenology, germination, growth rate to support population recovery A2.3. Conduct germination and replanting experiment at protected areas which are their historical habitat	Number of mother trees and their status; Number of seed produced every year; Seed quality: germination rate, growth rate; Number of replanted seedling and number of survival one

Objective 3: All provinces where *D. oliveri* distributed aware of important role and the urgent need of conserving this species therefore it will be included in annual afforestation as a native species	R3.1. *Dalbergia oliveri* and others *Dalbergia* species included in annual reforestation programme	A3.1. Inform provincial stakeholders information of *Dalbergia oliveri* population status to mobilize them to take action A3.2. In collaboration with local stakeholders to organize afforestation activity in which *D. oliveri* is one of planted trees	*Dalbergia* along the list of species in reforestation programme; Number of planted *Dalbergia*; Number of provinces implemented and included *Dalbergia* in their reforestation
Objective 4: Replant rosewood in at least 500 ha in their distribution area	R4.1. Seedling available for replanting programme in their historical habitat R4.2. New population of rosewood established or their current population extend	A4.1. Conduct survey to understand ecological condition and identify priority sites for replanting A4.2. Establish nursery to produce seedling for replanting program A4.3. In conjunction with local stakeholders to implement replanting program	Number of seedling produced every year in nursery; Name of area where are ready for replanting programme; Location of planting site; Number of seedling replanted at each site.
Objective 5: Enhance social involvement in rosewood conservation	R5.1. Social involved in project by donating to the project or being volunteer for planting programme and reducing the using of rosewood product in particular and other natural wood in general	A5.1. Raise awareness of the public on rosewood conservation by using media such as radio, online social media, television and newspapers	Public; NGOs

2.4. Achievements and impacts

Our project carried out the first survey to study the distribution and natural regeneration of *Dalbergia oliveri* and *Dalbergia cochinchinensis* in Cat Tien National Park. Although *Dalbergia cochinchinensis* has not been recorded in CTNP, our results provided a clear picture of distribution characteristics and natural regeneration status as well as priority for conservation of *D. oliveri* at the park. Our findings allowed CTNP technical staffs using to develop a conservation and recovery strategy of rosewood. Our baseline data on distribution supported the park to identify mother trees for propagation programme and initiate recovery plan by assisting natural regeneration. The conservation and recovery plan of rose wood was in place, our conservation recommendation initiated a long-term conservation programme developed and managed by the park. By participating in our project, the park staff now understand applying survey techniques and using equipment for flora survey that allowed them to conduct survey of other threatened species independently.

Before our project, botanist or even conservationist were not aware of the urgent status of *Dalbergia* species and there were very few study conducted upon this threatened group. At the workshop, participant all highlighted the important of immediate conservation and recovery actions focusing on rosewood with the participation of all relevant organization. Besides, the necessary of networking and sharing between individuals or organization was also discussed.

Section 3:

3.1. Conclusion

Dalbergia cochinchinensis was not recorded in the study area. *Dalbergia oliveris* naturally distributes in the South Cat Tien with an average density of trees whose diameter at breast height (DBH) from 6cm and above is approximately 6,8 trees/ha, average density of seedlings is 12,3 individuals/ha, at the elevation of 120 m – 175 m in the South east and 210 m – 321 m in the South west.

Cat Tien National Park is maintaining good mother trees that produce good seeds every year. It demonstrated that the park has potential and facilities to develop and implement a recovery plan of Burmese rosewood. At the park, each *D. oliveri* trees whose has DBH from 20 cm were tagged for long-term monitoring; all forest rangers were trained on applying Spatial Monitoring and Reporting Tool (SMART) on forest patrolling that effectively improved forest protection.

However, the *Dalbergia oliveri* population there is still under illegal logging pressure and other threats comprising natural forest fires, competition in plants or unintentional clearance of flammable materials.

3.2. Recommendation

Proposed recommendation for conservation and sustainable development of this species in Cat Tien National Park.

- Strictly enforce the relevant laws and regulation to improve the management and protection of forest;
- Integrate communication campaign on Rosewood conservation in dissemination programme on forest protection legislation of the park and other annual environmental programme that focus on local community and tourists;
- Implement rosewood population recovery programme at its historical distribution areas using available mother trees;
- In collaboration with scientists and conservationists to comprehensively study on its biology and utilization.

Section 4:

4.1.   Appendices

Appendix 1. Total number of recorded D. oliveri trees

#No	Transect	Transect length (m)	Recorded trees according to DBH			Recorded trees
			6cm ≤ D1.3 < 15 cm	15cm ≤ D1.3 < 20 cm	20cm ≤ D1.3	
1.	T1	1,853	6	8	31	45
2.	T2	2,073	34	5	27	66
3.	T3	3,925	17	4	28	49
4.	T4	1,832	17	8	46	71
5.	T5	5,063	27	10	30	67
6.	T6	1,211	12	8	35	55
7.	T7	5,071	0	0	0	0
8.	T8	2,416	38	10	9	57
9.	T9	2,525	31	5	6	42
10.	T11	2,496	36	12	9	57
11.	T12	4,258	10	5	42	57
12.	T13	4,104	28	17	60	105

#No	Transect	Transect length (m)	Recorded trees according to DBH			Recorded trees
			6cm ≤ D1.3 < 15 cm	15cm ≤ D1.3 < 20 cm	20cm ≤ D1.3	
13.	T14	3,514	3	1	36	40
14.	T15	2,475	9	12	58	79
15.	T16	1,017	9	10	34	53
16.	T17	10,320	1	0	0	1
17.	T18	4,084	0	0	0	0
18.	T19	4,555	1	1	3	5
Total		**126**	**279**	**116**	**454**	**849**

Appendix 2. Recorded seedlings in survey transect

#No	Transect	Total seedling	No. of seedlings according to regeneration source				No. of seedlings according to potential of growth			
			Seed	%	Shoot	%	Potential	%	Non-potential	%
1.	T1	45	30	66.67	15	33.33	24	53.33	21	46.67
2.	T2	72	42	58.33	30	41.67	41	56.94	31	43.06
3.	T3	67	63	94.03	4	5.97	43	64.18	24	35.82
4.	T4	94	75	79.79	19	20.21	58	61.70	36	38.30
5.	T5	84	65	77.38	19	22.62	46	54.76	38	45.24
6.	T6	29	27	93.10	2	6.90	7	24.14	22	75.86
7.	T7	8	5	62.50	3	37.50	2	25.00	6	75.00
8.	T8	117	84	71.79	33	28.21	43	36.75	74	63.25
9.	T9	74	51	68.92	23	31.08	29	39.19	45	60.81
10.	T11	233	230	98.71	3	1.29	133	57.08	100	42.92

#No	Transect	Total seedling	No. of seedlings according to regeneration source				No. of seedlings according to potential of growth			
			Seed	%	Shoot	%	Potential	%	Non-potential	%
11.	T12	7	5	71.43	2	28.57	4	57.14	3	42.86
12.	T13	60	52	86.67	8	13.33	38	63.33	22	36.67
13.	T14	28	25	89.29	3	10.71	9	32.14	19	67.86
14.	T15	392	388	98.98	4	1.02	77	19.64	315	80.36
15.	T16	98	96	97.96	2	2.04	15	15.31	83	84.69
16.	T17	21	18	85.71	3	14.29	11	52.38	10	47.62
17.	T18	0	0	0	0	0	0	0	0	0
18.	T19	115	108	93.91	7	6.09	27	23.48	88	76.52
Total		1.544	1.364	88,34	180	11,65	607	39,31	937	60,69

Appendix 3. Tree species recorded within sample plots

#No	Species name	F	F%	N	N%	G	G%	IVI%
1	*Lagerstroemia calyculata*	3	5.36	41	16.7	10.7	58.2	80.26
2	*Dyospyros sp.*	3	5.36	51	20.8	0.7	4	30.16
3	*Dalbergia oliveri*	3	5.36	24	9.8	2	10.7	25.86
4	*Polyathia sp.*	3	5.36	11	4.5	0.1	0.5	10.36
5	*Syzygium sp.*	3	5.36	7	2.9	0.3	1.7	9.96
6	*Syzygium wightianum*	3	5.36	7	2.9	0.2	1	9.26
7	*Xerospermum noronhianum*	2	3.57	9	3.7	0.4	1.9	9.17
8	*Ochrocarpos siamensis*	2	3.57	10	4.2	0.2	1.2	8.97
9	*Cleistanthus indochinensis*	2	3.57	10	4.2	0.1	0.7	8.47
10	*Afzelia xylocarpa*	2	3.57	3	1.2	0.6	3.2	7.97
11	*Orophea sp.*	2	3.57	6	2.4	0.1	0.7	6.67
12	*Pterospermum sp.*	2	3.57	3	1.2	0.1	0.5	5.27
13	*Randia wallichii*	2	3.57	3	1.2	0	0.1	4.87
14	*Albizia lucidior*	2	3.57	2	0.8	0.1	0.3	4.67

#No	Species name	F	F%	N	N%	G	G%	IVI%
15	Streblus ilicifolius	1	1.79	21	8.6	0.1	0.5	10.89
16	Hopea odorata	1	1.79	1	0.4	1.3	6.9	9.09
17	Terminalia nigrovenulosa	1	1.79	7	2.9	0.1	0.5	5.19
18	Garcinia basacensis	1	1.79	1	0.4	0.3	1.7	3.89
19	Vitex trifolia	1	1.79	4	1.6	0.1	0.4	3.79
20	Barringtonia sp.	1	1.79	1	0.4	0.3	1.6	3.79
21	Tetrameles nudiflora	1	1.79	3	1.2	0.1	0.7	3.69
22	Flacourtia jangomas	1	1.79	2	0.8	0.1	0.4	2.99
23	Aglaia sp1.	1	1.79	2	0.8	0.1	0.4	2.99
24	Aglaia sp2.	1	1.79	2	0.8	0.1	0.3	2.89
25	Stereospermum neuranthum	1	1.79	2	0.8	0	0.2	2.79
26	Vitex glabrata	1	1.79	1	0.4	0.1	0.5	2.69
27	Dalbergia sp.	1	1.79	2	0.8	0	0.1	2.69
28	Albizia sp.	1	1.79	1	0.4	0.1	0.4	2.59
29	Endospermum chinense	1	1.79	1	0.4	0.1	0.4	2.59
30	Knema globularia	1	1.79	1	0.4	0	0.1	2.29
31	Cryptocarya sp.	1	1.79	1	0.4	0	0.1	2.29
32	Garcinia delpyana	1	1.79	1	0.4	0	0.1	2.29
33	Xantolis dongnaiensis	1	1.79	1	0.4	0	0	2.19
34	Antidesma sp.	1	1.79	1	0.4	0	0	2.19
35	Polyalthia luensis	1	1.79	1	0.4	0	0	2.19
36	Syzygium zeylanicum	1	1.79	1	0.4	0	0	2.19
	Total		**100**		**100**		**100**	**300**

Appendix 4. Some photos of survey team

Figure 3, 4. Working with the park's forest ranger to identify survey areas

Figure 5. Measuring D. oliveri tree's DBH

Figure 6. Taking pictures of D. oliveri

Figure 7. Taking note field data

Figure 8. Establishing sample plot

Figure 9. D. oliveri fruit

Figure 10. D. oliveri seedling

Figure 11. Presenting survey findings at the workshop

Figure 12. Survey team in Da Mi ranger station

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