Diversity of Plant Species Composition and Forest Vegetation Cover of Dong Nai Culture and Nature Reserve, Vietnam

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Abstract. The obtained results from the study undertaken on the composition of plant species and forest vegetation in Dong Nai Reserve indicated a record of 864 species, 479 genera and 146 families that belongs to the four divisions of vascular plants. These includes: Lycophodiophyta, Polypodiophyta, Pinophyta and Magnoliophyta. Useful plants of 864 taxonomy species listed consists of 540 species of medicinal plants, 157 species of timber plants, 88 species of edible plants, 40 species of ornamental plants, 18 species of industrial plants, 15 species of fiber plants and 6 species of unknown use plants, respectively. During the duration of investigation, Cissus modeccoides Planch. and Goniothalamus vietnamensis Ban. were newly recorded in the forest vegetation of Dong Nai Reserve. One of the recorded species, named Goniothalamus vietnamensis is endangered medicinal plants in Vietnam. A variety of forest vegetations in the area under study is described. In this study, four major vegetation types of forest were identified in Dong Nai Reserve.

1. Introduction

Vietnam, support incredibly diverse vegetation types, rich plant communities and a wide variety of habitats. The incredible richness of the flora, the high level of biodiversity and diversity of vegetation types make general interpretations very difficult in the drawing of phytogeographic borders and the delimitation of basic phytogeographic regions [1].

Government policy in the years following the war favoured agricultural expansion and led to extensive forest loss. Instead of applying rehabilitation processes aimed at restoring the forest in affected areas, crop fields were created and in some cases forest areas were deforested to provide space for settlement. As a result of intense anthropogenic activity over millennia, most of the forest vegetation in Vietnam has been greatly reduced [2].

In southern Vietnam, Dong Nai Culture and Nature Reserve (hereafter Dong Nai Reserve) was officially mandated in December 2003 [3]. Dong Nai Reserve is the biggest reserve in the southern east region of Vietnam. With unique characteristics of geology and climate, it has abundant and diverse forest vegetation, including endemic, rare and protected species of plants. However, similar to any other special use of forests, Dong Nai Reserve is facing timber exploitation, animal poaching and land occupation due to low conservation awareness and hard living condition [2].
Our study is characterized by two broad aims. Firstly, the study intends to characterize the diversity and composition of vascular plants species in Dong Nai Reserve. Secondly, to assess the variability of vegetation in the forest area. This study deals with the diversity of plant families, genera, species, their conservation status, useful plants, and the vegetation types recorded during a three-year survey in Dong Nai Reserve from 2016 to 2018.

2. Materials and methods

2.1. Study area and site description

The study was conducted in Dong Nai Reserve, Dong Nai Province, in Southern Vietnam. Dong Nai Reserve is one of Vietnam’s largest reserves. The Reserve is situated 40 km north-east of Bien Hoa City, and covers an area of approximately 100303.3 ha, and 66038.6 ha is covered with forest, and non-forested portion of the reserve covers an area of about 1865.2 ha and the remaining 32440 ha represent the area of Tri An lake [5]. Based on the data of a socio-economic survey conducted in 2017, the total population of 5413 households which constituted 24518 persons, located in 3 communes was recorded: Ma Da, Hieu Liem and Phu Ly in Vinh Cuu District. The majorities of the people who are living in the Reserve belongs to the Cho Ro, Kinh, Hoa, Kho Me and Tay ethnic groups [6].

Figure 1. Study area and the map of 25 plots across Dong Nai Reserve.

The climate of Dong Nai Reserve is tropical monsoon region with two main seasons: the rainy season from May to October, and the dry season from November to April. The mean annual rainfall is 2572 mm, mean annual temperature is 26.4°C and the mean relative humidity is 80%. Rain falls on an average of 2000-2800 mm per year, mainly from July to October and during the rainy seasons, rainfall is about 85–95% per year [7].

Dong Nai Reserve has been shown to have a high diversity of fauna and flora, especially for a relatively small area with a limited altitudinal range. The high biodiversity of the reserve stems from its location in the last part of Truong Son Ridge and south-eastern region [1].

There are some typical characteristics of forest in Dong Nai Reserve: 1) the ecosystem with dominated dipterocarpus typical to Dong Nai watershed forest and south-eastern region; 2) high biodiversity value for conservation; 3) high value for environmental and historical education; 4) contiguous with Cat Tien National Park and better support for animals specially such as elephant, gaur [2].

In natural forests ecosystems there are more diverse species composition and high density of population. The forest vegetation of Dong Nai Reserve characterized by tropically evergreen broad-leaved forest and semi-deciduous forest. The flora of this area was reported containing 1401 species, belonging to 623 genera, 156 families; 30 species are listed in the Vietnam Red Data Book and 18 are endemic [7].

2.2. Methods

The objects for research were forest ecosystems on the territory of Dong Nai Reserve. Ecological and geographical analysis of the species composition of forests in the reserve indicates certain links between regions and environmental conditions reveals their environmental specificity.

Geobotanical and floristic study was carried out on the 25 plots (20×20 m) [8, 9] (Figure 1). We established 7 transects, which covered the whole surface area of the Dong Nai Reserve. Transect 1 from the Ba Hao forest ranger station to Suoi Mop forest ranger station (about 5 km), transect 2 from Cay Gui to Cay Sung (3.5 km), transect 3 from Ma Da commune to Khu Uy (about 8.5 km), transect 4 from Chien Khu D to Cu Dinh (about 6.5 km), transect 5 from Da Dung to Cong Vien Da (about 5 km), transect 6 from Suoi Koop to Suoi Giang (about 4 km) and transect 7 from Ba Hao to Trung uong Cuc Mien Nam (about 12 km). The total length of these transects combined is 45.5 km. In each transect we marked all species and collected specimens of plants which could not be identified in the field. We also collected many plants outside the plots and traverses, to make sure that our inventory was as representative of the entire area with species of the local flora.

Voucher species were sent to the Herbarium of the Vietnam National University of Forestry–Southern campus and other specialists for identification. Plant species were identified with reference to An Illustrated of Flora of Vietnam [10].

The vegetation types of Dong Nai Reserve were classified according to Thai Van Trung [11]. Additionally, the human disturbance levels of the vegetation were determined by noting the number of tree stumps and number of foot paths in the plots [12].

From 2016-2018, the research team conducted many surveys in Ma Da, Hieu Liem and Phu Ly villages in Dong Nai Reserve. Field research was conducted to gain intensive understanding of people through discussions and interactions. Primary data was gathered initially through household interviews based on questionnaires, Rapid Rural Appraisal (RRA), and the “walk in the woods” method [2].

3. Results and discussion

3.1. Vegetation types in Dong Nai Reserve

The vegetation of the Dong Nai Reserve is dominantly lowland forest type with the highest peak level of about 368 m [11]. Among the natural vegetation of Dong Nai Reserve there is a major dichotomy between the evergreen forests on lowland types and other types of formations. The composition of the vegetation in Dong Nai Reserve is identified by 4 major types: tropical evergreen broad-leaved, tropical evergreen broad-leaved semi-deciduous, tropical broad-leaved deciduous and plantation forest (Figure 2):

3.1.1. Tropical evergreen broad-leaved forest. The tropical evergreen broad-leaved forest type is the most common in the lowland forest. This is the most extensive forest type in Dong Nai Reserve (about 4200 ha, and it takes 85% of the total area of the Reserve). This type can be found in Ma Da, Hieu Liem and Phu Ly in Dong Nai Reserve. The structure of this forest type includes four layers: The canopy layer is formed by trees about 15-25 m tall. Dominant species of family Dipterocarpaceae are Dipterocarpus alatus, Dipterocarpus dyeri, Dipterocarpus turbinatus, Hopea recpeoi, Hopea odorata, Shorea guiso, Antisoptera costata, etc... The subcanopy layer is composed of small timber trees below 15 m in height. Dominant species are Artocarpus melinoxyloa, Aglaia hootensis, Afzelia xylcarpa, Dalbergia cochinchinensis, Pterocarpus macrocarpus, Dillenia ovata, Cratoxylon formosum,
Barringtonia racemosa, Xerospermum microcarpum, and Kibatalia laurifolia. The shrub layer includes only few species, such as Euodia lepta, Croton dongnaiensis, Bridelia balansae, Morinda cochinchinensis, Eurycoma longifolia, Brucea javanica, Aporusa dioica, Leea rubra, Cleistanthus indochinensis, Melastoma saigonense, ... The herb layer is composed of a few species are Gongiethalamus vietnensis, Cyclea barbata, Dracaena cochinchinensis, Ardisia silvestris, Nervilia aragoana, Homalomena pierreana, Peliosanthes teta, Thotthea tomentosa, Coscinium fenestratum, Fibraurea tinctoria, Tectedodium dongnaiense, Tacca integrifolia, Drynaria bonii, Ancistrocladus cochinchinensis, Uncaria macrophylla and some other species.

Figure 2. Vegetation types of Dong Nai Reserve.

3.1.2. Tropical evergreen broad-leaved semi-deciduous forest. This forest type covers about 750 ha. Dominant families are Lythraceae, Sapindaceae, Myrtaceae, Sterculiaceae, Anacardiaceae, etc. The forest structure is simple with three layers: The canopy layer is composed mainly of Dipterocarpus alatus, Dipterocarpus turbinatus, Swintonia floribunda, Lagerstroemia calyculata, Tetrameles nudiflora, Anogeissus acuminata, Irvingia malayana, Garicinia oblongifolia, Scaphium macropodium, Syzygium chanlos, Knema globularia, Cinnamomum iners, Sandoricum koetjape, etc. The shrub layer is composed of many species, with as dominant ones Lasianthus hoaensis, Dracaena cochinensis, Gongiethalamus dongnaiensis, Grewia asiatica, Polyalthia suberosa, Colona auriculata, Adenanthera pavonica, Tabernaemontana pallida, Fagerlindia depauperata, Dracaena angustifolia, etc... The herb layer is composed mainly of species are Ampelopsis cantoniensis, Tacca palmata, Ardisia crenata, Tetracera indica, Salacia verrucosa, Fibraurea tinctoria, Peliosanthes teta, Homalomena occulta, Homalomena pierreana, Pothos scandens and some other species.

3.1.3. Tropical broad-leaved deciduous forest. This forest type occupies about 500 ha, located in the south-western part of Dong Nai Reserve. This type can be found in the forest of Hieu Liem. The canopy layer is characterized by timber trees over 20 m tall: Dipterocarpus intricatus, the diameter of the trunks is 24-28 cm and the number of species is more than 90% dominated by the forest type layer. The subcanopy layer is composed of small timber trees below 15 m in height. Dominant species are Xylia xylocarpa, Afxelia xylocarpa, Lagerstroemia floribunda, Canthium dicoccum, Sandoricum koetjape, Kibatalia laurifolia, Wrightia kongtumensis, Fagraea racemosa, Trevesia palmata, Canarium tramdenum, etc... The shrub layer is composed of many species, with as dominant ones Dracaena cochinensis, Eurycoma longifolia, Clerodendrum cochinensis, Zicyphus oenoplia,
Mussaenda frondosa, Saprosma cochinchinensis, Psychotria adenophylla, Ixora nigricans, Rubur alceaefolius, Micromelum minutum, Indigofera zollingeriana, etc. The herb layer is composed mainly of species are Kaempferia galanga, Nervilia aragoana, Stemona pierrei, Dracaena angustifolia, Costus speciosus, Homalomena occulta, Tetracera indica, Globba pendula, Hedychium coronarium, Drynaria quercifolia, Clerodendrum paniculatum and some other species.

3.1.4. Plantation forest. This forest type covers about 6200 ha. The following species, such as: Afzelia xylocarpa, Dipterocarpus alatus, Dipterocarpus dyeri, Hopea odorata, Pterocarpus macrocarpus, Melaleuca cajuputi, etc… are planted in plantation forest of Dong Nai Reserve. The structure of this forest type is simple; it includes the tree layer and a ground layer with mainly weedy species belonging to families Poaceae, Asteraceae, Rubiaceae, Euphorbiaceae, Acanthaceae.

3.2. Floristic diversity in Dong Nai Reserve
During our investigations, 864 vascular plant species belong to 479 genera and 146 families were identified in Dong Nai Reserve can be seen in Table 1. At the period time, three species of plants were newly recorded in literature devoted to the flora of Vietnam, named: Lithocarpus dahuoaiensis Ngoc & L. V. Dung [13], Typhonium dongnaiense Luu, Nguyen-Phi & H.T. Van [14] and Castanopsis dongnaiensis T.S. Hoang & V.N. Nguyen [15]. The present study recorded 2 new species in Dong Nai Reserve: Goniothalamus vietnamensis in Annonaceae and Cissus modeccoides in Vitaceae.

Table 1. Summary on the floristics of Dong Nai Reserve.

| No. | Taxa              | Family | Genus | Species |
|-----|------------------|--------|-------|---------|
| 1.  | Lycopodiophyta   | 2      | 2     | 4       |
| 2.  | Polypodiophyta   | 8      | 12    | 16      |
| 3.  | Pinophyta        | 6      | 6     | 14      |
| 4.  | Magnoliophyta    | 130    | 459   | 830     |
|     | Magnoliopsisida  |        |       |         |
|     | Liliopsisida     | 106    | 377   | 685     |
|     | Total            | 146    | 479   | 864     |

Among the investigated 864 species, 10 endemic species in Vietnam were also included. Many plant species are endemic to Vietnam (the species were first records in Vietnam and scientific names take the places of Vietnam) such as Goniothalamus vietnamensis, Lithocarpus dahuoaiensis and endemic plants of local (the first records of species in Dong Nai province) as 9 species (Table 2).

Table 2. List of endemic plants in Dong Nai Reserve.

| No. | Family name         | Scientific name               | Vietnamese name |
|-----|---------------------|--------------------------------|-----------------|
| 1.  | Anacardiaceae       | Mangifera dongnaiensis Pierre. | Xoài Đồ ng Nai |
| 2.  | Annonaceae          | Goniothalamus vietnamensis Ban.| Bò béo đen | |
| 3.  | Annonaceae          | Goniothalamus dongnaiensis Fin. & Gagn.. | Giác đế Đồ Nai |
| 4.  | Araceae             | Typhonium dongnaiense Luu, Nguyen-Phi & H T Van | Bán hạ Đồ Nai |
| 5.  | Areccaceae          | Calamus dongnaiensis Pierre ex Conrad. | Máy Đồ Nai |
| 6.  | Euphorbiaceae       | Croton dongnaiensis Pierre ex Gagn.. | Cù đên Đồ Nai |
| 7.  | Fabaceae            | Cynometra dongnaiensis Pierre. | Mót Đồ Nai |
| 8.  | Fagaceae            | Castanopsis dongnaiensis T S Hoang & | Đè Đồ Nai |


In Dong Nai Reserve there are endangered and rare plants (Table 3).

In Dong Nai Reserve, useful plants of 864 species listed consists of 540 species (62.5%) of medicinal plants (Me), 157 species (18.2%) of timber plants (Ti), 88 species (10.2%) of edible plants (Ed), 40 species (4.6%) of ornamental plants (Or), 18 species (2.1%) of industrial plants (In), 15 species (1.7%) of fiber (Fi) and 6 species (0.7%) of unknown use plants (Un), respectively in Table 4.

| No. | Scientific name                  | VRDB | IUCN |
|-----|----------------------------------|------|------|
| 1.  | Aegina indica L.                | VU   |      |
| 2.  | Afzelia xylocarpa (Kurz) Craib. | ENd  | ENd  |
| 3.  | Alstonia scholaris (L.) R. Br.  |      | LCf  |
| 4.  | Aquilaria crassna Pierre ex Lec.| ENd  |      |
| 5.  | Ardisia silvestris Pit.          | VU   |      |
| 6.  | Caesalpinia sappan L.            |      | LCf  |
| 7.  | Canarium tramdenum Đa & Yakol.   | VU   |      |
| 8.  | Canthium dicoccum Gaertn. var. rostratum Thw. ex Pit. | VU |      |
| 9.  | Chukrasia tabularis A. Juss. var dongnaiensis Pierre. | VU | LCf |
| 10. | Coscinium fenestratum (Gaertn.) Colebr. |      | DDe |
| 11. | Cycas inermis Lour.              | VU   | VU   |
| 12. | Dalbergia oliveri Gamble ex Prain | ENd | ENd  |
| 13. | Dioscorea colletii Hook. f.      | ENd  |      |
| 14. | Dipterocarpus dyeri Pierre.      | VU   | ENd  |
| 15. | Drynaria bonii Christ.           | VU   |      |
| 16. | Drynaria fortunei (Mett.) J. Sm. | ENd  |      |
| 17. | Dysoxylum loureirii Pierre.      | VU   |      |
| 18. | Fagerlindia depauperata (Drake) Tirv. | VU |      |
| 19. | Goniothalamus vietnamensis Ban.  | VU   |      |
| 20. | Helixanthera annamica Dans..     | VU   |      |
| 21. | Homalomena pierreana Engler.     | VU   |      |
| 22. | Kibatalia laurefolia (Ridl.) Woods. | VU |      |
| 23. | Peliosanthes teta André. subsp. teta. | VU |      |
| 24. | Pterocarpus macrocarpus Kurz.    | ENd  |      |
| 25. | Sindora siamensis Teysm. ex Miq. | ENd | LCf  |
| 26. | Stemona pierrei Gagnep.          | VU   |      |
| 27. | Tacca integrifolia Ker.-Gawl.    | VU   |      |
| 28. | Telectadium dongnaïense Pierre ex Cost. | CR |      |
| 29. | Wrightia kongtumensis Lý         | ENd  |      |

Table 3. List of endangered and rare plants in Dong Nai Reserve.
30. *Xylopia pierrei* Hance.  

| Uses | Me | Ti | Ed | Or | In | Fi | Un |
|------|----|----|----|----|----|----|----|
| Species | 540 | 157 | 88 | 40 | 18 | 15 | 6 |
| %    | 62.5 | 18.2 | 10.2 | 4.6 | 2.1 | 1.7 | 0.7 |

**4. Conclusion**

Dong Nai Reserve is characterized by four major vegetation types of forest: tropical evergreen broad-leaved, tropical evergreen broad-leaved semi-deciduous, tropical broad-leaved deciduous and plantation forest.

The diversity of plant species in Dong Nai Reserve was studied to provide baseline information for conservation and sustainable management processes that will prolong the life of the reserve. A total of 864 species of vascular plants are recorded in Dong Nai Reserve belonging to 479 genera and 146 families. From the indicated two species: *Cissus modeccoides* and *Goniothalamus vietnamensis* are new species for the flora in Dong Nai Reserve.

The useful plant resources were divided into seven groups as follows: medicinal plants with 540 species, timber plants with 157 species, edible plants with 88 species, ornamental plants with 40 species, industrial plants with 18 species, fiber plants with 15 species and unknown use plants with 6 species.

Besides this survey, the forest areas were explored, concentrating on the useful plants and it was recorded that Dong Nai Reserve has 10 endemic species, 30 species subject to global-level and national-level conservation.

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**References**

[1] Averyanov L V, Phan Ke Loc, Nguyen Tien Hiep and Harder D K 2003 Phytogeographic review of Vietnam and adjacent areas of Eastern Indochina [in Russian – Fitogeograficheskij obzor Vietnam i prilegayushchih rajonov Vostochnogo Indokitaya] Konarovia. vol 3 pp 1–83

[2] Le M H, Robbins M B, Rice N H, Garcia-Trejo E A, Roels S M and Bodbyl-Roels S A 2011 Preliminary survey of the avifauna at Dong Nai Culture and Nature Reserves, Vietnam Forktail 27 pp 114-117
[3] Tordoff A W, Tran Quoc Bao, Nguyen Duc Tu and Le Manh Hung 2004 *Sourcebook of existing and proposed protected areas in Vietnam* Second edition. (Hanoi: BirdLife International in Indochina and the Ministry of Agriculture and Rural Development) pp 261–268

[4] Dinh T S, Hyakumura K and Ogata K (March 14th 2012). Livelihoods and Local Ecological Knowledge in Cat Tien Biosphere Reserve, Vietnam: Opportunities and Challenges for Biodiversity Conservation. The Biosphere, Natarajan Ishwaran, IntechOpen. [in Russian – Istochniki sredstv k suschestvovaniyu i mestnye ekologicheskie znaniya v Biosfernom zapovednik Kat Tien, Vietnam: vozmozhnosti i problemy sohraneniya bioraznoobraziya]. Available from: https://www.intechopen.com/books/the-biosphere/livelihoods-and-local-ecological-knowledge-in-cat-tien-biosphere-reserve-vietnam-opportunities-and-challenges

[5] Do H T T, Grant J C, Trinh N B, Zimmer H C, Tran L D and Nichols J D 2018 Recovery of tropical moist deciduous dipterocarp forest in Southern Vietnam *Forest Ecology and Management, 433* pp 184–204

[6] Pilgrim J D *et al.* 2007 *Biological assessment of the Dong Nai River basin conservation landscape, Vietnam*. Final report, 19 October 2007. Hanoi, pp 50–54

[7] Nguyen Van Thinh and Okolelova A A 2014 *Protected Natural Areas of South Vietnam – Dong Nai Biosphere Reserve* [In Russian – Ohranyaemye prirodnuye territori yuzhnoho Vietnama - Biosfernyj zapovednik Dong Naj] Published in the Russian Federation Biogeosystem Technique. Vol. 2, pp 191–200

[8] Nguyen T T and Baker P J 2016 Structure and composition of deciduous dipterocarp forest in Central Vietnam: patterns of species dominance and regeneration failure *Plant Ecology & Diversity* 9(5-6), 1210261 pp 589–601

[9] Thanh Do H T, Grant J C, Trinh B N, Zimmer H C and Nichols J D 2017 Diversity depends on scale in the forests of the Central Highlands of Vietnam *Journal of Asia-Pacific Biodiversity.*

[10] Pham H H 1999 Cây Cỏ Việt Nam [In Vietnamese - An Illustrated Flora of Vietnam] (Ho Chi Minh City: The Youth Publishing House) Vol. 1–3, pp 202–208 & 295–296

[11] Thai V T 1999 *Những hệ sinh thái rừng nhiệt đới Việt Nam* [In Vietnamese - The forest ecosystems of tropical Vietnam] (Hồ Chí Minh: NXB Khoa học và Kỹ Thuật) p 298

[12] Hoang Van Sam, Baas P and Keßler P J A 2008b The use and conservation of plant species in a National Park - A case study of Ben En, Vietnam *Economic Botany* 62: pp 574 – 593

[13] Ngoc N V, Dung L V, Tagane S, Binh H T, Son H T, Trung V Q and Yahara T 2016 *Lithocarpus dahuoaensis* (Fagaceae), a new species from Lam Dong Province, Vietnam *PhytoKeys* 69, pp 23–30

[14] Van H T, Nguyen-Phi N, Vu N L, Galloway A and Luu H T 2017 Typhonium dongnaiense (Araceae), a New Species from Vietnam *Annales Botanici Fennici* 54(4-6) pp 405–408

[15] Hoang T S, Nguyen V N, Tran L D, Vo Q T, Trinh N B, Nguyen H T and Li B 2018 *Castanopsis dongnaiensis* (Fagaceae), a new species from Vietnam *Ann. Bot. Fennici* 55 pp 227–231

[16] Ministry of science and technology of Vietnam. Red book. Part 2: plants. Hanoi: science and technology publishing House, 2007. p 612