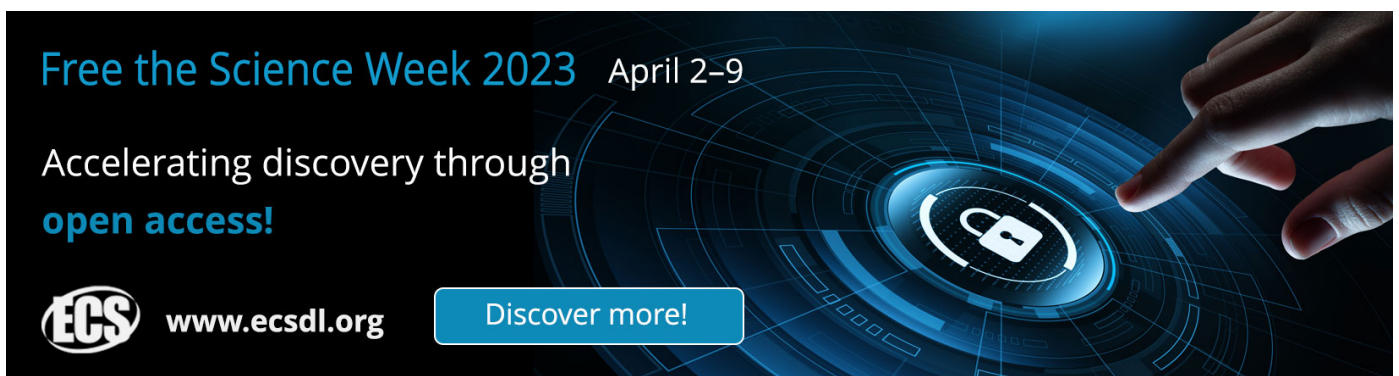


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# Plant diversity and useful plant species in Nam Dong Conservation Area, Thanh Hoa province, northern Vietnam

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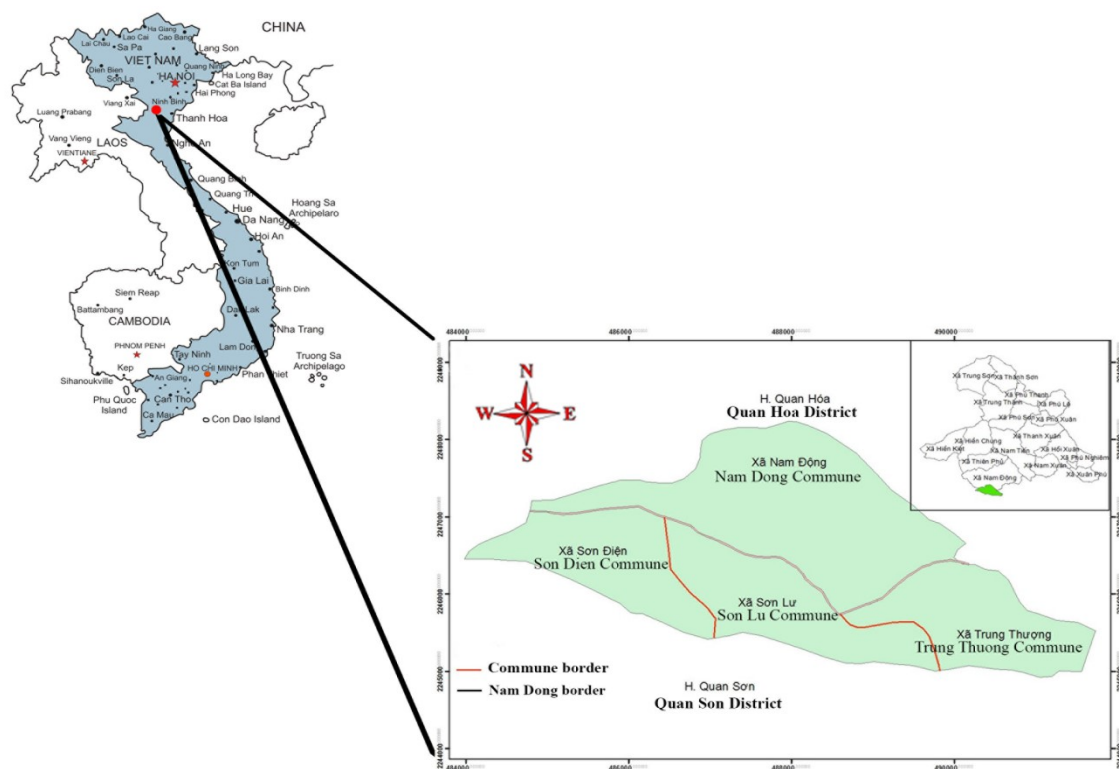
**Abstract.** The detailed floristic inventory of Nam Dong Conservation Area was undertaken during 2015-2021. For the survey, 11 plots were established and studied. Herbarium specimens for almost all observed plant species were collected in the studied area. They were used for identifications and documentation of plants cited in in this report. The study pays special attention to vascular plants notable for their high number of endemic and rare species in limestone karst ecosystems typical for Nam Dong Conservation Area. The results of our preliminary botanical survey, indicate that Nam Dong Conservation Area supports a rich and very diverse flora. The survey reports 1312 vascular plant species in 637 genera belonging to 180 families. May of recorded species are rare and narrowly endemic plants. Among them 2 taxa new for science, and 1 represents new record for the flora of Vietnam. Aside from the high plant diversity, the Nam Dong forests contain many economically important plants, widely used by local communities. Such species groups include numerous timber trees, medicinal, ornamental and edible plants.

## 1. Introduction

Nam Dong Conservation Area is situated in two districts: Quan Hoa and Quan Son, between 20°18'07"–20°19'38"N, and 104°52'08"–104°53'26"E (figure 1) in Thanh Hoa Province of northern Vietnam. It covers all territory of Nam Dong Commune and parts of territories in Son Dien, Son Lu, and Trung Thuong Communes with a total square of 646 hectares. Nam Dong Conservation Area is distant from Quan Hoa district capital on 25 km to the Nam Dong Commune and about 150 km from Thanh Hoa City as well. The mountain areas of Nam Dong are composed of granite, shale, sandstone and karstic limestone [1-2]. The lowest point of Nam Dong Reserve area is situated near the Lo hamlet in Nam Dong Commune at elevation 170 m a.s.l. This region represents a flat wide valley mostly used for rice paddies. People from ethnic minorities densely populate it. The highest point of the area reaches 1600 m a.s.l. The climate of the Nam Dong Reserve area is humid around the year with an average annual rainfall of 1600–1700 mm. The heaviest rains are observed in July–August. The average annual temperature is 15–20°C in winter and 27–34°C in summer. December and January are the coldest months when the temperature can drop to 4°C at night. The natural vegetation of Nam Dong is presented by the rich tropical forests largely logged by the ethnic people. Today, the largest



part of the reserve area is represented by the lands used for agriculture. Only 500 ha of primary aboriginal forest remains here but this area is presently damaged by human activity at different degrees. The total human population of the area is approximately 4333 including five ethnic groups: Thai (66.49%), Muong (24.11%), Kinh (7.48%), Mong (1.58%), and Hoa (0.34%). Their usual economic activity is slash-and-burn agriculture, the harvesting of the forest products (such as edible tubers, roots, fruits, leaf vegetables), and hunting for almost all kinds of animals [1-5].



**Figure 1.** Location of Nam Dong Conservation Area in Vietnam.

## 2. Materials and methods

The evaluation of useful plant resources in the Nam Dong Conservation Area is the main aim of the present botanical survey. The detailed documented inventory of plant diversity is the major part of this work. The study pays special attention and emphasis on vascular plants, which include many endemic and rare species in limestone karst ecosystems. During the survey 11 model plots (each  $20 \times 25$  m) were established and studied. All locations were identified by the Garmin navigation system (gpsmap 62s, 78s). During the study of each plot and associated transects, all plant species were recorded. Analytical photographs of the plants were made by Canon Power Shot SX60HS additionally to collecting of voucher herbarium specimens. Collected and studied voucher herbarium specimens were deposited at the Herbarium of Vietnam National University of Forestry (VNF) and the Herbarium of Komarov Botanical Institute of the Russian Academy of Sciences (LE). Plant species identification and their economic characters were based on available relevant literature reported by Averyanov et al. [6-8], Flora of China [9], Nguyen [10-11], Pham [12], Phung [13], Pierre [14], Pócs [15], Soejarto et al. [16], Suk et al. [17], Tran [18] and Vo [19].

## 3. Results and Discussion

Diversity of plant Resource.

On the basis of works published by Averyanov et al. (Preliminary Botanical Survey of Primary Vegetation in Pu Luong Nature Reserve, Thanh Hoa Province, 2003); Institute of Ecology and Works Protection (Preliminary Botanical Survey as the basis for establishing Nam Dong Nature Reserve in Nam Dong Commune, Quan Hoa District, Thanh Hoa, 2012) and Center for Environment and Sustainable Forestry Development (The result of the biodiversity survey in Nam Dong Conservation Area, Quan Hoa District, Thanh Hoa, 2016) and results from our investigations (2015–2019), the flora of Nam Dong area is reported and arranged according to the taxonomic Brummitt system (1992), including 1312 species from 673 genera, and 180 families of 6 highest divisions as presented in table 1.

**Table 1.** The highest taxa in the flora of Nam Dong Conservation Area.

| Taxa           | Species           |       | Genera           |       | Family             |       |
|----------------|-------------------|-------|------------------|-------|--------------------|-------|
|                | Number of species | %     | Number of genera | %     | Number of families | %     |
| Psilotophyta   | 1                 | 0.08  | 1                | 0.16  | 1                  | 0.56  |
| Lycopodiophyta | 10                | 0.76  | 4                | 0.63  | 2                  | 1.11  |
| Equisetophyta  | 1                 | 0.08  | 1                | 0.16  | 1                  | 0.56  |
| Polypodiophyta | 89                | 6.78  | 38               | 5.97  | 19                 | 10.56 |
| Pinophyta      | 11                | 0.84  | 8                | 1.26  | 6                  | 3.33  |
| Magnoliophyta  | 1200              | 91.46 | 585              | 91.84 | 151                | 83.89 |
| Total          | 1312              | 100   | 637              | 100   | 180                | 100   |

The diversity in the families in the each division is different. This is indicated by an average index of the number of species of every family. This index is the highest in Magnoliophyta – 7.95 and the following division: Lycopodiophyta – 5; Polypodiophyta – 4.68; Pinophyta – 1.83; together with Psilotophyta and Equisetophyta – 1.

**Table 2.** The list of largest plant families in the flora of Nam Dong Conservation Area.

| Family         | Genera |         | Species |         |
|----------------|--------|---------|---------|---------|
|                | Number | % total | Number  | % total |
| Fabaceae       | 39     | 6.12    | 88      | 6.71    |
| Orchidaceae    | 26     | 4.08    | 62      | 4.73    |
| Rubiaceae      | 27     | 4.24    | 56      | 4.27    |
| Lauraceae      | 17     | 2.67    | 45      | 3.43    |
| Euphorbiaceae  | 22     | 3.45    | 38      | 2.90    |
| Moraceae       | 8      | 1.26    | 38      | 2.90    |
| Lamiaceae      | 18     | 2.83    | 37      | 2.82    |
| Phyllanthaceae | 16     | 2.51    | 36      | 2.74    |
| Asteraceae     | 25     | 3.92    | 35      | 2.67    |
| Poaceae        | 23     | 3.61    | 27      | 2.06    |
| Total          | 221    | 34.69   | 462     | 35.21   |

The diversity of the families is indicated in table 2, in which there are only 10, representing about 5.6% of the 180 identified families in the area but the number of species goes up 462 species (35.21% of the total species). Several widespread and well-known families include relatively few species, however, but their representatives are abundant and well presented in flora. Such families are Fabaceae, Orchidaceae, Rubiaceae, and Lauraceae.

The diversity, in general, is presented by an average index of the number of species of every genus of the flora. The highest index is found in Lycopodiophyta (2.5) and the followings are Polypodiophyta (2.3), Magnoliophyta (2.05), Pinophyta (1.4) and the lowest is Psilotophyta and Equisetophyta.

Ten most diverse genera in the Nam Dong flora are also include largest number of species. These genera are listed in table 3.

**Table 3.** Largest genera in the flora of the Nam Dong Conservation Area.

| No. | Genera             | Family        | Species | % total |
|-----|--------------------|---------------|---------|---------|
| 1   | <i>Ficus</i>       | Moraceae      | 22      | 1.68    |
| 2   | <i>Begonia</i>     | Begoniaceae   | 13      | 0.99    |
| 3   | <i>Ardisia</i>     | Primulaceae   | 12      | 0.91    |
| 4   | <i>Castanopsis</i> | Fagaceae      | 12      | 0.91    |
| 5   | <i>Dendrobium</i>  | Orchidaceae   | 11      | 0.84    |
| 6   | <i>Litsea</i>      | Lauraceae     | 10      | 0.76    |
| 7   | <i>Callicarpa</i>  | Lamiaceae     | 9       | 0.69    |
| 8   | <i>Piper</i>       | Piperaceae    | 9       | 0.69    |
| 9   | <i>Dioscorea</i>   | Dioscoreaceae | 8       | 0.61    |
| 10  | <i>Diospyros</i>   | Ebenaceae     | 8       | 0.61    |
|     | Total              |               | 114     | 8.69    |

Table 3 indicates that 10 genera, representing 5.5% of 180 genera known in the region, include 114 species comprising 8.69% of the total number of species in the flora. This fact suggests that the local conditions in Nam Dong region encourage diversification in several genera.

New records for the flora in Nam Dong Conservation Area.

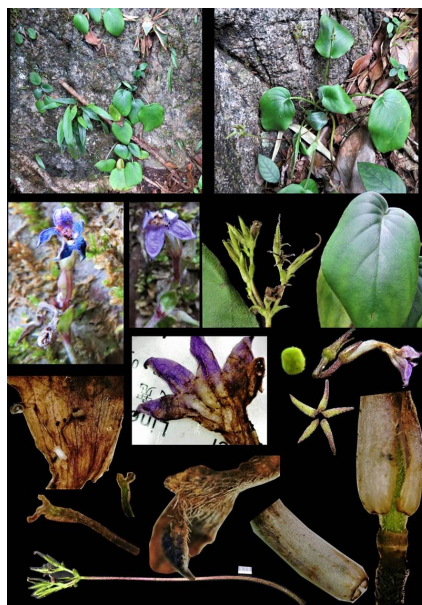
Present survey documents 44 families newly recorded for the flora of Nam Dong Conservation Area. They are: Equisetaceae, Cyatheaceae, Lindsaeaceae, Hymenophyllaceae, Lomariopsidaceae, Nephrolepidaceae, Cycadaceae, Balanophoraceae, Basellaceae, Bombacaceae, Boraginaceae, Brassicaceae, Buddlejaceae, Buxaceae, Campanulaceae, Capparaceae, Cardiopteridaceae, Cactemanniaceae, Cecropiaceae, Crassulaceae, Gentianaceae, Hippocastanaceae, Hydrangeaceae, Linaceae, Meliosmaceae, Muntingiaceae, Nyctaginaceae, Onagraceae, Pentaphragmataceae, Portulacaceae, Punicaceae, Ranunculaceae, Sabiaceae, Saururaceae, Simaroubaceae, Staphyleaceae, Thymelaeaceae, Alliaceae, Bromeliaceae, Cannaceae, Colchicaceae, Musaceae, Pandanaceae and Phormiaceae. Our study also reports 172 genera and 639 species firstly found in the flora of Nam Dong Conservation Area. One discovered species from Gesneriaceae family is described as a new for science (figure 2). It is *Hemiboea thankhoensis* C.H. Nguyen, Aver. et F. Wen (Nguyen, 2019). Additionally, the study found one variety new for science, *Cymbidium lancifolium* Hook.f. var. *albiflorum* Aver. et C.H. Nguyen (Orchidaceae) and species, *Petrocodon ainsliifolius* W.H. Chen et Y.M. Shui (Gesneriaceae) new for the flora of Vietnam (figures 3 and 4).



**Figure 2.** *Hemiboea thanhhoensis* C.H. Nguyen, Aver. et F. Wen (Gesneriaceae).



**Figure 3.** *Cymbidium lancifolium* Hook.f. var. *albiflorum* Aver. et C.H. Nguyen (Orchidaceae).



**Figure 4.** *Petrocodon ainsliifolius* W.H. Chen et Y.M. Shui (Gesneriaceae).

**Useful plant groups.**

The conservation of forests and the protection of economically significant natural genetic resources is an urgent matter in development strategies for Vietnam. The investigation and inventory of plant diversity, particularly the evaluation of useful plant resources is very important for nature conservation, as well as for the rational economic development of the country. Our investigation in the studied area reports 842 useful plant species (table 4). They represent 64% of the total number of

species known up to date in the studied area. Below is a description of the main groups of useful plants.

**Table 4.** Useful tree species identified in Nam Dong Conservation Area.

| No. | Kind of use    | Proposed symbol | Number of species | % from all species of the flora |
|-----|----------------|-----------------|-------------------|---------------------------------|
| 1   | Medicine       | M               | 624               | 47.56                           |
| 2   | Food           | F               | 242               | 18.45                           |
| 3   | Timber         | T               | 220               | 16.77                           |
| 4   | Ornamental     | Or              | 136               | 10.37                           |
| 5   | Fat oil        | Oil             | 32                | 2.44                            |
| 6   | Poison         | Mp              | 25                | 1.91                            |
| 7   | Essential oils | E               | 23                | 1.75                            |
| 8   | Fiber          | Fb              | 18                | 1.37                            |

Medicinal plant group: Traditional oriental medicine is said to be based on more than 3500 years of medical practice that includes various forms of herbal therapy. Forests in Vietnam contain 10386 woody plant species including 4700 species of vascular plants with reported medicinal qualities [19]. There is a long tradition of using plants as medicines, particularly among local ethnic people who use a great variety of the plants distributed in the forested mountainous area. Nam Dong Conservation Area can be considered as a center of medicinal plants of Thanh Hoa Province in northern Vietnam with 624 species representing 47.56% of the total Nam Dong flora. The medicinal species of Nam Dong listed in national and international publications are *Cibotium barometz*, *Drynaria fortunei*, *Eleutherococcus trifoliatus*, *Artemisia vulgaris*, *Pluchea indica*, *Gynostemma pentaphyllum*, *Senna tora*, *Stephania rotunda*, *Aglaonema modestum*, *Homalomena occulta*, *Pandanus tonkinensis*, *Tacca chantrieri* u *Paris polyphylla*.

Edible plant group: Edible plants are very important food for the local people in Nam Dong area, especially for the ethnic minorities in mountainous regions. Many farmers consume wild vegetables as usual food easily available from the nearest forest. For a long time, they traditionally accumulated essential knowledge, which they passed from generation to generation. This many-aged knowledge is based on their traditional needs, observations, trial, and error of a very long experience. Traditional wild edible plant products are used mostly as soup, boiled, spice, and jelly or eaten as a fresh vegetable [4;18]. Among 842 useful species of the Nam Dong Conservation Area flora, 242 species are widely used as the food by the local people, representing 18.45% of the total species. A comparative analysis of the diversity of edible plants of Nam Dong Area showed that their traditional food customs are unique. Most of the food plants are trees, shrubs, and herbs, those are represented approximately equally, a smaller part are lianas. Popular species of edible wild plants are followings:

- Tree group: *Antidesma montanum*, *Arenga pinnata*, *Baccaurea rauliflora*, *Bischofia javanica*, *Canarium bengalense*, *Caryota mitis*, *Choerospondias axillaris*, *Dillenia ovata*, *Elaeocarpus griffithii*, *Ficus auriculata*, *Ficus racemosa*, *Mangifera longipes*, *Melientha suavis*, *Microcos tomentosa*, *Oroxylum indicum*, *Phyllanthus emblica*, *Rhus chinensis*, *Saraca dives*, *Schefflera heptaphylla*, *Spondias lakonensis*, *Sterculia lanceolata*.
- Shrub group: *Aralia armata*, *Clausena excavata*, *Clerodendrum cyrtophyllum*, *Garcinia oblongifolia*, *Maesa perlaria*, *Melastoma cadidum*, *Morus alba*, *Saurauja roxburghii*, *Sauropus racemosus*, *Solanum nigrum*, *Solanum torvum*, *Streblus asper*.
- Herb group: *Amaranthus viridis*, *Artemisia vulgaris*, *Begonia aptera*, *Blumea lanceolata*, *Centella asiatica*, *Colocasia gigantea*, *Diplazium esculentum*, *Eryngium foetidum*, *Musa acuminata*, *Oxalis corymbosa*, *Peperomia pellucida*, *Physalis angulata*, *Plantago asiatica*, *Polygonum chinensis*, *Solanum nigrum*, *Tacca plantaginea*.

- Lianas group: *Calamus flagellum*, *Cissampelos andromorpha*, *Erythralium scandens*, *Gnetum montanum*, *Gynostemma pentaphyllum*, *Hodgsonia macrocarpa*, *Passiflora foetida*, *Rubus alceaefolius*.

Timber plant group: The timber trees of Nam Dong include 220 species (16.77% of the total species) and represent a valuable resource not only for the local community but also for the national economy. This resource is becoming increasingly important as the forest is being destroyed and degraded. It is necessary to stop illegal logging and protect all mature timber trees in Nam Dong area. The most valuable timber species here are *Amesiodendron chinense*, *Burretiodendron hsienmu*, *Cephalotaxus mannii*, *Garcinia fagraeoides*, *Erythrophleum fordii*, *Markhamia stipulata*, *Madhuca pasquieri*, *Nageia fleuryi*, and *Vatica odorata*.

Ornamental plant group: The group of ornamental plants includes 136 species representing 10.37% of the total species of the Nam Dong flora. Many wild aboriginal plants found in the Nam Dong Mountain area have great potentials for cultivation as spectacular ornamental plants. Many coniferous and broad-leaved trees with beautiful foliage and perfect crown shape can be cultivated as individual trees, or in groups in parks and gardens, used in urban landscaping, a forest plantation, and reforestation. Additionally, numerous wild shrubs, palms, giant herbs, climbers, and herbs found in the studied area are also may be successively cultivated as spectacular ornamental plants to decorate gardens and parks, and as a beautiful natural element in modern "green" architecture. Some suitable species of Nam Dong may be listed as follows: *Amentotaxus argotaenia*, *A. yunnanensis*, *Cephalotaxus mannii*, *Pinus kwangtungensis*, *Podocarpus neriifolius*, *Podocarpus pilgeri*, *Taxus chinensis*, *Acer tonkinense*, *Magnolia albosericea*, *Michelia balansae*, *Saraca dives*, *Sterculia lanceolata*, *Streblus asper*, *Jasminum sambac*, *Ardisia crenata*, *Caryota mitis*, *Pinanga baviensis*, *Aeschynanthus bracteatus*, *A. micranthu*, *Begonia cucphuongensis*, *B. handelii*, *Paphiopedilum hirsutissimum*, *Aerides odorata*, *Anoectochilus roxburghii*, *Bulbophyllum andersonii*, *Calanthe alismifolia*, *C. triplicata*, *Dendrobium anosmum*, *D. gibsonii*, and *D. lindleyi*.

The remained groups 5, 6, and 7 are represented by an approximately equal number of species, namely, Fat oil plants (32 species), Poison plants (25 species), and Essential oils plants (23 species). Group 8, Fibre-bearing plants, is the smallest group. It includes in the Nam Dong area 18 species.

#### 4. Conclusion

In total 172 genera and 639 species of vascular plants were recorded for the flora of Nam Dong Conservation Area before our research. During the period of our research in 2015-2021, the flora of Nam Dong Conservation Area was significantly expanded and now there are 1312 species from 673 genera and 180 families from 6 higher divisions. The useful plants identified in the flora of Nam Dong are divided into eight groups as follows: 1 Medicinal plants with 624 species, 2 Edible plants with 242 species, 3 Timber plants with 202 species, 4 Ornamental plants with 136 species, 5 Fat oil plants with 32 species, 6 Poison plants with 25 species, 7 Essential oils with 23 species, and Fiber-bearing plants with 18 species. Additionally, two taxa are discovered as new for science, and one species is found and recorded for the flora of Vietnam at first.

#### Acknowledgments

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