Diversity, conservation, potential uses, and alien species of lowland plants of Batang Toru, Sumatra, Indonesia

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Abstract. Putra HF, Mustaqim WA. 2021. Diversity, conservation, potential uses, and alien species of lowland plants of Batang Toru, Sumatra, Indonesia. Biodiversitas 22: 1580-1591. A recent field inventory of lowland Sumatran plant diversity was carried out in two close sites of forest patches in the Batang Toru area. These are Muara Upu Swamp Forest and Simulak Anjing Hill Forest. This study aimed to investigate the species composition of two isolated lowland Sumatran forest patches on the west coast of the northern part of the island. The total number of species recorded was 181 species with 131 species known from Simulak Anjing Hill Forest, 54 from Muara Upu Swamp Forest, and only three species recorded from both sites. There are three species endemic to Sumatra, seven species listed as threatened according to the IUCN Red List, one species protected by the Indonesian government, and two are important records for Sumatra. Compared to the published literature, 88 species have been reported to have one or more uses, with 63 species have been used as the source of medicines, 19 as sources of fibers, 18 as the source of vegetables, and several other uses. Sixteen alien species were recorded including four species categorized as 100 world’s worst invasive species. It can be concluded that both areas are a home for important lowland plants of Sumatra as indicated by the presence of threatened, endemic, or poorly documented species. Besides that, there is also a need for concern about the presence of potential invasive alien species.

Keywords: alien plants, endemic, exploration, Sumatra, threatened plants

INTRODUCTION

Sumatra is the westernmost and the third largest island in Indonesia. This area is also a home for one of the most diverse places on Earth. The tropical rainforest of Sumatra has been included in the UNESCO World Heritage, namely the Gunung Leuser National Park, Kerinci Seblat National Park, and Bukit Barisan Selatan National Park (UNESCO 2020). The most prominent feature of this island is Bukit Barisan Mountains, formed by the collision between the Indian Ocean and Sundaland plate tectonics. This mountain complex stretches from the north to the south ends of the island with various types of vegetation including the Indonesian highest volcanic summit of Mount Kerinci at 3850 m above sea level. The lowland parts of Sumatra also consist of many vegetation types including the highly-threatened peat swamp forests that are mainly found in the coastal areas of the eastern side (Global Wetlands 2020).

The biodiversity of Sumatra is exceptional both for animals and plants. For plants, this island possibly inhabited by as many as 8391 species with around 1891 or 22.5 percent of them are endemic (Middleton et al. 2019). Many species are very flamboyant such as the giant parasite Rafflesia (Susatya 2011), the tallest flower titan arum Amorphophallus titanium (Yuzammi et al. 2017), and also home of many commercially important dipterocarp species such as Dipterocarpus, Hopea, and Shorea (Ashton 1982). Many other plant groups have high diversity in Sumatra, such as the beautiful forest floor dwellers Impatiens (Balsaminaceae) (Grey-Wilson 1989) and the pitcher plant genus Nepenthes (Nepenthaceae) (Cheek and Jebb 2001).

The lowland ecosystem of Sumatra is among the most threatened ecosystems in the world. Loucks and Whitten (2020) categorized the Sumatran Lowland Rain Forests as a critical or endangered ecoregion, and several important factors contribute to the damage of the ecosystems, such as fires, logging, and forest fires, that have become serious threats to the biodiversity in this area. Any remaining forest ecosystem in the lowland area of Sumatra becomes an important factor in its conservation as they may harbor species threatened with extinction. These often present in the form of fragmented and isolated landscapes within large plantations.

As a starting point to the future conservation efforts of lowland biodiversity of Sumatra, biodiversity inventories are needed to be conducted in poorly explored areas. According to Launomier et al. (2010), Muara Upu Swamp Forest and Simulak Anjing Hill Forest are located in the vulnerable or endangered eco-floristic sectors. The Simulak Anjing Hill is also home to endemic Thottea tapalulensis (Mustaqim and Putra 2020a). In the study, we investigate the plant diversity in both areas that represent the isolated fragments of the lowland forest of Sumatra.
MATERIALS AND METHODS

Study area
The study was conducted in Muara Upu swamp forest (MUSF; 142.88 ha) and Simulak Anjing Hills forest (SAHF; 73.12 ha) in Batang Toru, Tapanuli Selatan Regency, North Sumatra Province (Figure 1). Both forests are located in the concession area of palm oil plantations named PT. Perkebunan Nusantara III (or PTPN III) and have been declared as High Conservation Value (HCV) areas. Each MUSF and SAHF represent a different type of vegetation (Figure 2). MUSF consists of degraded lowland peat swamp forest and riverine forest on alluvial at an elevation from 21 to 22 m above sea level. A part of them has been converted into road and agricultural fields. Some commonly observed plants include Gluta wallichii, Nauclea officinalis, shrubby Pandanus helicopus, and Licuala paludosa. Meanwhile, SAHF consists of lowland isolated hill forest, typically belonging to the lowland mixed dipterocarp forest at an elevation from 70 to 250 m above sea level. There are two major types of vegetation in SAHF, the less disturbed forest and the secondary vegetation. The less-disturbed forest areas have dense forest with large trees such as Dryobalanops sumatrensis, while in the secondary vegetation, shrub and small trees are the most important, like Macaranga heynei or Endospermum diadenum, which are quite common, in this area.

Data collection
The botanical survey was conducted using an exploratory method (Rugayah et al. 2004) in Muara Upu and Simulak Anjing Hills in January 2020 to all vascular plants. The identification was carried out in the field by the authors, and several species were also vouchered when the field identification was doubtful. The specimens were then identified in the Laboratory of Ecology and Plant Resources, Department of Biology, IPB University and later deposited to the Herbarium Bogoriense (BO), Research Center for Biology, Indonesian Institute of Sciences, and Herbarium Bandungense (FIPIA, Bandung Institute of Technology (FIPIA) (abbreviations follow Thiers 2020-continuously updated). The species name followed Plants of the World Online databases (POWO 2020). Conservation statuses of the species were acquired from the IUCN Red List (IUCN 2020).

RESULTS AND DISCUSSION
The total number of plant species recorded was 182, with 131 species recorded from SAHF and 54 from MUSF (Table 1). There is a high difference in the floristic composition, only three species were recorded from both areas, meaning that 51 species were restricted to MUSF and 128 in SAHF. The largest plant family in SAHF was Dipterocarpaceae (12 spp.), followed by Euphorbiaceae (10 spp.), Fabaceae, and Rubiaceae (each with 7 spp.), while in MUSF, the three largest plant families were Moraceae, Poaceae, and Rubiaceae (each with 7 spp.), followed by Arecaceae (3 spp.) (Figure 3). The striking difference may be in the presence of 12 dipterocarp species in SAHF, while there is none from MUSF (Table 1). Macaranga is the most diverse genus with six species and is the common genus in the secondary vegetation in SAHF.

Figure 1. Map of study area in Muara Upu Swamp Forest and Simulak Anjing Hill Forest, Batang Toru, Tapanuli Selatan Regency, North Sumatra Province
Figure 2. Vegetations in Muara Upu Swamp Forest (A-B) and Simulak Anjing Hill Forest (C-D), Batang Toru, Tapanuli Selatan Regency, North Sumatra Province

Plant life-form

In terms of plant life form, MUSF is largely composed of herbaceous plant species, while the SAHF is largely composed of trees. This situation has been expected since the plant species in less disturbed part of forest, like in SAHF, will have a higher percentage of trees compared to the degraded forest, like MUSF (Figure 4). The low percentage of herbaceous plants in SAHF is a characteristic of the lowland rain forest of Sumatra (Loucks and Whitten 2020) and could be an indication that past disturbance level in the forested landscape of SAHF was considered low.

Conservation status and protected species

The conservation status of more than a half number of the total species has not been evaluated by the IUCN (2020) with 97 species or 58.43%. This study will be an important component in the future assessment of all those species. MUSF and SAHF are very specific sites and any data could contribute to the distribution records. The records can be used to calculate the Extent of Occurrence (EOO) and Area of Occupancy (AOO), which are important components in conservation status evaluation (IUCN 2012; IUCNSPC 2019). The other 69 species which have been evaluated consist of 59 species or 85.51% Least Concern (LC), three Near Threatened (NT), and seven species belong to threatened categories. There are four species listed as Vulnerable (VU) named Aquilaria hirta (Thymelaeaceae) (Figure 5A), Cantleya corniculata (Stemonuraceae) (Figure 5B), and two from Dipterocarpaceae named Dipterocarpus crinitus (Figure 5C), and Dryobalanops sumatrensis (Figure 5D). One dipterocarp species named Vatica perakensis (Figure 5E) is the only species listed as Endangered (EN). The most threatened species are the commercial timber trees Shorea johorensis from the Dipterocarpaceae family (Figure 5F), and one pitcher plant species Nepenthes sumatrana (Nepenthaceae) (Figure 5G), which is also an endemic of Sumatra (Clarke 2001, 2014; Cheek and Jebb 2001). The presence of those threatened plant species indicates the importance of SAHF as a conservation site, and therefore, designation as a High Conservation Value site should be maintained as long as possible.

Nepenthes sumatrana or in Indonesian known as ‘kantung semar sayap alur’ is protected by the Indonesian Government under the Peraturan Pemerintah No. 106/2018. The species was recorded in SAHF on early regenerate vegetation. Only two pitcher plants were observed during the study, and are grown on the steep slope. Another species of pitcher plant, N. ampullaria, is also present near the population of N. sumatrana.
Noteworthy plant records

_Acrotrema in North Sumatra confirmed_

Acrotrema is a genus belonging to the Dilleniaceae family. This genus consists of around 10 species of mostly Asian mainland inhabitants and only one species extends to Malesia. The only _Acrotrema_ species in Malesia is _Acrotrema costatum_ Jack (Hoogland 1951) (Figs. 5H-I). Hoogland (1951) mentioned the distribution in North Sumatra as questionable as he wrote ‘N. Sumatra?’. Therefore, it can be concluded that the occurrence of this species in Sumatra needs to be confirmed. In Simulak Anjing, many individuals of plants belonging to this species have been found (specimen Mustaqim et al. 2335). They belong to _Acrotrema_ due to some characteristics: perennial herbs, amplexicaul petiole, numerous free stamens, and the flat receptacle. Further examinations of the literature have shown that morphological characteristics are matched to the _A. costatum_ (Hoogland 1951). Therefore, it can be concluded that the distribution of _A. costatum_ in Sumatra is now confirmed.

Figure 3. Number of species in largest plant families in both areas (A), Muara Upu Swamp Forest (B), and Simulak Anjing Hill Forest (C). Batang Toru, North Sumatra, Indonesia

Figure 4. Percentage of life-form of plant species in Muara Upu Swamp Forest and Simulak Anjing Hill Forest, Batang Toru, North Sumatra, Indonesia
Table 1. List of plant species from Muara Upu and Simulak Anjing Hills, Batang Toru, North Sumatra, Indonesia

| Family/species          | MU | SA | LF | IUCN | IDN |
|-------------------------|----|----|----|------|-----|
| Acrostichaceae          |    |    |    |      |     |
| *Acrostichum aureum* L. | √  |    | H  | LC   |     |
| Anacardiaceae           |    |    |    |      |     |
| *Gluta wallichii* (Hook.f.) Ding Hou | √  | T  | NE |     |     |
| *Mangifera griffithii* Hook.f. | √  | T  | NE |     |     |
| Anisophyllaceae         |    |    |    |      |     |
| *Anisophylya disticha* (Jack) Baill. | √  | S  | LC |     |     |
| Annonaceae              |    |    |    |      |     |
| *Cananga odorata* (Lam.) Hook.f. & Thomson | √  | T  | LC |     |     |
| *Dasydaschalan dasydacshanum* (Blume) I.M.Turner | √  | S  | NE |     |     |
| *Goniothalamus macrophyllus* (Blume) Zoll. | √  | S  | NE |     |     |
| *Maasia gela* (Hassk.) Mols, Kessler & Rogstad | √  | T  | NE |     |     |
| *Popowia pisocarpa* (Blume) Endl. ex Walp. | √  | S  | NE |     |     |
| *Xylopia cf. oxyantha* (Hook.f. & Thomson) Hook.f. & Thomson | √  | T  | NE |     |     |
| Apocynaceae             |    |    |    |      |     |
| *Alstonia spatulata* Blume | √  | T  | LC |     |     |
| *Dyera costulate* (Miq.) Hook.f. | √  | T  | LC |     |     |
| *Vincetoxicum flexuosum* (R.Br.) Kuntze | √  | C  | NE |     |     |
| Araceae                 |    |    |    |      |     |
| *Colocasia esculenta* (L.) Schott | √  | H  | LC |     |     |
| *Homalomena humilis* (Jack) Hook.f. | √  | H  | NE |     |     |
| *Pothos scandens* L.    | √  | C  | NE |     |     |
| *Raphidophora korthalsii* Schott | √  | C  | NE |     |     |
| *Schismatoglottis cyphatra* (Roxb.) Zoll. & Moritzi | √  | H  | NE |     |     |
| *Scindapsus pictus* Hassk. | √  | C  | NE |     |     |
| *Syngonium podophyllum* Schott | √  | C  | NE |     |     |
| Arecaceae               |    |    |    |      |     |
| *Calamus diepenhorstii* Miq. | √  | C  | NE |     |     |
| *Calamus melanochaetes* (Blume) Miq. | √  | C  | NE |     |     |
| *Licuala paludosa* Griff. | √  | SL | NE |     |     |
| *Oncoesperma horridum* (Griff.) Scheff. | √  | TL | NE |     |     |
| *Oncoesperma tigillarium* (Jack) Ridl. | √  | TL | NE |     |     |
| Aristolochiaceae        |    |    |    |      |     |
| *Thottea tapanuliensis* Mustaquin | √  | H  | NE |     |     |
| Aspleniaceae            |    |    |    |      |     |
| *Asplenium nidus* L.    | √  | H  | NE |     |     |
| *Blechnum orientale* L. | √  | H  | NE |     |     |
| *Stenochlusa palustris* (Burm.f.) Bedd. | √  | H  | NE |     |     |
| Asteraceae              |    |    |    |      |     |
| *Aristolochia*          |    |    |    |      |     |
| *Asplenium nidus* L.    | √  | H  | NE |     |     |
| *Blechnum orientale* L. | √  | H  | NE |     |     |
| *Stenochlusa palustris* (Burm.f.) Bedd. | √  | H  | NE |     |     |
| Asterae                 |    |    |    |      |     |
| *Mikania micrantha* Kunth. | √  | H  | -  |     |     |
| Begoniaceae             |    |    |    |      |     |
| *Begonia isoptera* Dryand. ex Sm. | √  | H  | NE |     |     |
| Burseraceae             |    |    |    |      |     |
| *Dacyodes rugosa* (Blume) H.J.Lam | √  | T  | LC |     |     |
| Cannabaceae             |    |    |    |      |     |
| *Gironniera nervosa* Planch. | √  | T  | NE |     |     |
| *Trema cannabimnum* Lour. | √  | T  | LC |     |     |
| Celastraceae            |    |    |    |      |     |
| *Lophopetalum javanicum* (Zoll.) Turcz. | √  | T  | LC |     |     |
| Chusiaeae               |    |    |    |      |     |
| *Garcinia nervosa* (Miq.) Miq. | √  | T  | NE |     |     |
| Commelinaceae           |    |    |    |      |     |
| *Commelina diffusa* Zoll. ex C.B.Clarke | √  | H  | LC |     |     |
| Conneraceae             |    |    |    |      |     |
| *Cnestis palala* (Lour.) Merr. | √  | C  | NE |     |     |
| Costaceae               |    |    |    |      |     |
| *Cheilocostus speciosus* (J.Koenig) C.D.Specht | √  | H  | LC |     |     |
| Cucurbitaceae           |    |    |    |      |     |
| *Melothria pendula* L.  | √  | C  | -  |     |     |
| *Trichosanthes costata* Blume | √  | C  | NE |     |     |
| Cyperaceae              |    |    |    |      |     |
| *Cyperus iria* L.       | √  | H  | NE |     |     |
| *Scleria sumatrensis* Retz. | √  | H  | NE |     |     |
| Family                  | Species                                                                 | IUCN | HABITAT |
|------------------------|-------------------------------------------------------------------------|------|--------|
| Dilleniaceae           | Acrotrema costatum Jack                                                 | √    | H      |
|                        | Dillenia indica L.                                                      | √    | T      |
|                        | Tetracera arborenses Jack                                               | √    | C      |
|                        | Tetracera indica (Christm. & Panz.) Merr.                               | √    | C      |
| Dipterocarpaceae       | Cotylelobium melanoxyylon (Hook.f.) Pierre                              | √    | T      |
|                        | Dipterocarpus caudatus subsp. penangianus (Foxy.) P.S.Aston               | √    | T      |
|                        | Dipterocarpus costulatus Slooten                                        | √    | T      |
|                        | Dipterocarpus crinitus Dyer                                             | √    | T      |
|                        | Dryobalanops sumatrensis (J.F.Gmel.) Kosterm.                           | √    | T      |
|                        | Hopea cf. sangal Korth                                                 | √    | T      |
|                        | Shorea acuminata Dyer                                                  | √    | C      |
|                        | Shorea leprosula Miq                                                    | √    | T      |
|                        | Shorea multiflora (burck) Symington                                     | √    | T      |
|                        | Vatica perakensis King                                                 | √    | T      |
|                        | Vatica cf. venulosa subsp. simularensis (Slooten) Ashton                 | √    | T      |
| Elaeocarpaceae         | Elaeocarpus mastersii King                                              | √    | T      |
| Euphorbiaceae          | Aporosa nitida Merr                                                    | √    | S      |
|                        | Endospermum diadenum (MIq.) Airy Shaw                                   | √    | T      |
|                        | Homalanthus populneus (Geiseler) Pax                                    | √    | T      |
|                        | Macaranga bancana (MIq.) Miull.Arg.                                    | √    | T      |
|                        | Macaranga heynei I.M.Johnst.                                            | √    | T      |
|                        | Macaranga hystoeuca (Rchb.f. & Zoll.) Miull.Arg.                        | √    | T      |
|                        | Macaranga gigantea (Rchb.f. & Zoll.) Miull.Arg.                         | √    | T      |
|                        | Macaranga lowii King. ex Hook.f.                                        | √    | T      |
|                        | Macaranga motleyana (Miull.Arg.) Miull.Arg.                             | √    | T      |
| Fabaceae               | Dalbergia rostrata Hassk.                                               | √    | C      |
|                        | Derris trifoliata Lour.                                                 | √    | C      |
|                        | Dialium indum L.                                                        | √    | T      |
|                        | Mimosa pigra L.                                                         | √    | S      |
|                        | Mucuna bracteata DC. ex Kurz                                           | √    | C      |
|                        | Phanera semibifida (Roxb.) Benth.                                       | √    | C      |
|                        | Paraderris elliptica (Wall.) Adema                                      | √    | C      |
|                        | Senegalia kekapur (I.C.Nielsen) Maslin, Seigler, Ebinger                | √    | C      |
|                        | Spatholobus ferrugineus (Zoll. &Moritzi) Bent.                          | √    | C      |
| Fagaceae               | Castanopsis lucida (Nees) Soepadmo                                      | √    | T      |
|                        | Lithocarpus conoocarpus (Oudem.) Rehder                                 | √    | T      |
| Flagellariaceae        | Flagellaria indica L.                                                   | √    | C      |
| Glehoniaceae           | Dicranopteris linearis (Burm.f.) Underw.                                | √    | H      |
| Gnetaceae              | Gnetum cuspidatum Blume                                                 | √    | C      |
| Hanguanaceae           | Hanguana anthelmintica (Blume ex Schult. & Schult.f.) Masam.            | √    | H      |
| Lamiaceae              | Vitex pinnata L.                                                        | √    | T      |
|                        | Vitex gamosepala Griff                                                  | √    | S      |
| Lauraceae              | Actinodaphne glabra Blume                                               | √    | T      |
|                        | Cinnamomum iners (Reinw. ex Nees & T.Nees) Blume                        | √    | T      |
|                        | Dehaasia cuneata (Blume) Blume                                          | √    | T      |
| Lygodiaceae            | Lygodiummicrophyllum (Cav.) R.Br.                                       | √    | H      |
| Lythraceae             | Cuphea carthagenensis (Jacq.) J.F.Macbr.                                | √    | H      |
| Malvaceae              | Ceiba pentandra (L.) Gaertn.                                            | √    | T      |
|                        | Durio griffithii (Mast.) Bakh.                                          | √    | T      |
|                        | Grewia laevigata Vahl                                                   | √    | S      |
| Family               | Genus                          | Status | Location |
|---------------------|--------------------------------|--------|----------|
| Pterospermum javanicum | Jungh.                        | T      | LC       |
| Scaphium macropodum | (Miq.) Beumée ex K.Heyne      | T      | LC       |
| Sterculia rubiginosa | Vent.                         | T      | NE       |
| Urena lobata        | L.                            | S      | LC       |
| **Melastomataceae** |                               |        |          |
| Clidemia hirta      | (L.) D.Don                    | S      | -        |
| Dissochaeta conica  | (Bakh.) Clausing              | C      | NE       |
| Macrolenes tuberculata | Karton.                      | C      | NE       |
| Melastoma malabathricum | L.                           | S      | NE       |
| Melastoma penicillatum | Naudin                      | S      | NE       |
| **Menispermaceae**  |                               |        |          |
| Arcangelisia flava  | (L.) Merr.                    | C      | NE       |
| Cyclea barbata      | Miers                         | C      | NE       |
| **Moraceae**        |                               |        |          |
| Artocarpus elasticus | Reinv. ex Blume              | T      | LC       |
| Ficus deltoidea     | Jack                          | S      | NE       |
| Ficus fistulosa     | Reinv. ex Blume              | T      | LC       |
| Ficus grossularioides | var. stenoloba Comer      | T      | LC       |
| Ficus hispidu       | L.f.                          | T      | LC       |
| Ficus microcarpa    | L.f.                          | T      | LC       |
| Ficus padana        | Burm.f.                       | T      | LC       |
| Ficus punctata      | Thunb.                        | C      | NE       |
| **Myristicaceae**   |                               |        |          |
| Horsfeldia grandis | (Hook.f.) Warb.              | T      | LC       |
| Horsfeldia irya     | (Gaertn.) Warb.              | T      | LC       |
| Horsfeldia wallichii | (Hook.f. & Thomson) Warb.    | T      | LC       |
| Knema furfuracea    | (Hook.f. & Thomson) Warb.     | T      | LC       |
| Knema laurina       | (Blume) Warb.                | T      | NE       |
| Myristica iners     | Blume                         | T      | LC       |
| Myristica maxima    | Warb.                         | T      | LC       |
| **Myrtaceae**       |                               |        |          |
| Rhodanania cinerea  | Jack                          | T      | LC       |
| Syzygium papillosum | (Duthie) Merr. & L.M.Perry    | T      | NE       |
| Syzygium cf. pycanthum | Merr. & L.M.Perry         | T      | -        |
| Syzygium zeylanicum | (L.) DC.                     | T      | NE       |
| **Nepenthaceae**    |                               |        |          |
| Nepenthes ampullaria | Jack                         | C      | LC       |
| Nepenthes gracilis  | Korth.                        | C      | LC       |
| Nepenthes mirabilis | (Lour.) Druce                | C      | LC       |
| Nepenthes sumatrana | (Miq.) Beck ex Tamin & M.Hotta | C      | CR       |
| **Nephrrolepidaceae** |                             | H      | NE       |
| Nephrolepis hirsutula | (Forst.) C.Presl            | H      | LC       |
| **Nymphaeaceae**    |                               |        |          |
| Nymphaea alba       | L.                            | H      | LC       |
| **Onagraceae**      |                               |        |          |
| Ludwigia peravi ana | (L.) H.Hara                  | H      | -        |
| Ludwigia hyssopifolia | (G.Don) Exell               | H      | -        |
| **Pandanaceae**     |                               |        |          |
| Pandanus helicopus  | Kurz ex Miq.                 | SL     | NE       |
| **Pentaphylacaceae** |                               |        |          |
| Adinandra damosa    | Jack                          | T      | LC       |
| **Phyllanthaceae**  |                               |        |          |
| Antidesma stipulare | Blume                         | T      | LC       |
| Baccara parviflora  | (Müll.Arg.) Müll.Arg.        | T      | NE       |
| Baccaraea sumatrana | (Miq.) Müll.Arg.             | T      | NE       |
| Breynia macrantha   | (Hassk.) Chakrab. & N.P.Balakr. | S   | LC       |
| Breynia racemosa    | (Blume) Müll.Arg.            | S      | LC       |
| Glochidion superbum | Baill.                       | T      | NE       |
| Phyllanthus lutescens | (Blume) Müll.Arg.          | T      | LC       |
| **Poaceae**         |                               |        |          |
| Ottocloa nodosa     | (Kunth) Dandy                | H      | NE       |
| Paspalum conjugatum | P.J.Bergius                  | H      | -        |
| Phragmites karka    | (Retz.) Trin. ex Steud.      | H      | LC       |
| Urochloa mutica     | (Forssk.) T.Q.Nguyen         | H      | LC       |
| **Polygalaceae**    |                               | H      | -        |
| Polyscias paniculata | L.                            |        |          |
| **Polypodiaceae**   |                               |        |          |
Dipterocarpus caudatus *subsp*. Penangianus *in mainland Sumatra*

*Dipterocarpus caudatus* contains two subspecies. The first is *subsp. caudatus*, a Philippines endemic, while the second is a more widespread subspecies, named *subsp. penangianus*. The recently collected specimens (specimens Mustaqim et al. 2309&2315) from Simulak Anjing belonged to the *subsp. penangianus*, which differs from *subsp. caudatus* with 1.5–2.5 cm long petiole and applicate leaves (Figure 5J). Randi Agusti (2020 pers. comm.), stated that the *subsp. penangianus* has also been found in some areas of Sumatra, although, unfortunately, no formal publication has been made. This time, the sterile specimens collected from the Simulak Anjing have been identified as the *subsp. penangianus*, which is additional information for the geographical distribution of the species in mainland Sumatra. Before study, *subsp. penangianus* in Sumatra is formally known from two islands outside the mainland, i.e. Karimun and Mursala (Ashton 1978, 1982). Recent explorations showed that the subspecies still exist in Mursala Island, growing together with the recently rediscovered *Dipterocarpus cinereus* (Kusuma et al. 2013). Mursala is one of the closest islands to Simulak Anjing and, therefore, the knowledge of this species in Mursala-

| Family                | Genus                        | Cartoon | Conservation Status | Subarten |
|-----------------------|------------------------------|---------|---------------------|----------|
| Drynaria              | *Drynaria quercifolia* (L.) J.Sm. | ✓       | H                    | NE       |
| Pontederiaceae        | *Pontederia crassipes* Mart.  | ✓       | H                    |          |
| Primulaceae           | *Ardisia complanata* Wall.     | ✓       | S                    | NE       |
| Elenegeta             | *Embelia lampani* Scheff.      | ✓       | C                    | NE       |
| Elesia ribes          | *Embelia ribes* Burm.f.        | ✓       | C                    | NE       |
| Elesia samatana       | *Musa samatana* Scheff.        | ✓       | C                    | NE       |
| Rhamnaceae            | *Ziziphus cf. elegans* Wall.   | ✓       | C                    |          |
| Rhizophoraceae        | *Carallia brachiata* (Lour.) Merr. | ✓       | S                    | NE       |
| Rubiaceae             | *Hynoptium formicarum* Jack    | ✓       | H                    | NE       |
| Elesia congesta       | *Ixora congesta* Roxb.         | ✓       | S                    | NE       |
| Elesia javanica       | *Ixora javanica* (Blume) DC.   | ✓       | S                    | LC       |
| Elesia speciosa       | *Mitragyna speciosa* Korth.    | ✓       | T                    | NE       |
| Elesia frondosa       | *Massaenda frondosa* L.        | ✓       | S                    | NE       |
| Nauclea                | *Nauclea officinalis* (Pierre ex Pt.) Merr. & Chun | ✓       | T                    | NE       |
| Neolamarckia          | *Neolamarckia cadamba* (Roxb.) Bosser | ✓       | T                    | NE       |
| Elesia anisophylla    | *Porterandia anisophylla* (Jack ex Roxb.) Ridl. | ✓       | T                    | NE       |
| Elesia viridiflora    | *Psychotria viridiflora* Reinv. ex Blume | ✓       | S                    | NE       |
| Elesia acida          | *Uncaria acida* (W.Hunter) Roxb. | ✓       | C                    | NE       |
| Elesia cordata        | *Uncaria cordata* (Lour.) Merr. | ✓       | C                    | NE       |
| Rutaceae              | *Lavunga sarmentosa* (Blume) Kurz | ✓       | C                    | NE       |
| Elesia accedens       | *Medeloce accedens* (Blume) T.G.Hartley | ✓       | T                    | NE       |
| Selaginellaceae       | *Selaginella willdenowii* (Desv.) Baker | ✓       | H                    | NE       |
| Simaroubaceae         | *Eurycoma longifolia* Jack     | ✓       | S                    | NE       |
| Smilacaceae           | *Smilax setosa* Miq.           | ✓       | C                    | NE       |
| Stemonuraceae         | *Cantleya cundiculata* (Becc.) R.A.Howard | ✓       | T                    | VU       |
| Theaceae              | *Eurya nitida* Korth.          | ✓       | S                    | NE       |
| Schima wallichii      | *Schima wallichii* (DC.) Korth. | ✓       | T                    | LC       |
| Thelypteridaceae      | *Theletperis decorata* (Dom.) C.F.Reed | ✓       | H                    | NE       |
| Thymelaeaceae         | *Aquilaira hirta* Ridl.        | ✓       | T                    | VU       |
| Vitaceae              | *Ampelocissus thyrsiflora* (Blume) Planch. | ✓       | C                    | NE       |
| Catarrhia triloba     | *Cayratia triloba* (L.) Mabb. & j.Wen | ✓       | C                    | NE       |
| Leura indica          | *Leura indica* (Burm.f.) Merr. | ✓       | S                    | LC       |
| Pterisantes cissoides| *Pterisantes cissoides* Blume  | ✓       | C                    | NE       |
| Tetrastigma dichotomum| *Tetrastigma dichotomum* (Miq.) Planch. | ✓       | C                    | NE       |
| Zingiberaceae         | *Globba aurantiaca* Miq.       | ✓       | H                    | NT       |

Note: MU: Muara Upu; SA: Simulak Anjing; LF: Life form; IUCN: Conservation status according to IUCN Red List where only native species are examined and any alien species are indicated with ‘–’. Species with uncertain identification (shown by cf.) also given as ‘–’; IDN: Protection by Indonesian Government No. 106/2018; C: H: herbs; S: shrub; SL: shrub-like; T: tree; TL: tree-like; NE: Not Evaluated; LC: Least Concern; NT: Near Threatened; VU: Vulnerable; EN: Endangered; CR: Critically Endangered.
Simulak Anjing is now improved.

**Sumatra endemic plant species**

Three species in SAHF are endemic to Sumatra. The first one is *Nepenthes sumatrana* (Nepenthaceae) that has only been found in North to West Sumatra (Cheek and Jebb 2001). The species inhabits the lowland habitat up to 1500 m asl. (Cheek and Jebb 2001; Fadillah et al. 2014) and listed under IUCN (2020) as Critically Endangered species.

The second is shrubby *Thottea tapanuliensis* (Aristolochiaceae) (Figure 5K) which was also recently described in 2020. The species is endemic to Sumatra, and is only known from SAHF with the preliminary IUCN Red List conservation status is Critically Endangered (Mustaqim and Putra 2020). The third is *Macrolenes tuberculata* (Melastomataceae) (Figure 5L), a woody climber that has been described in 2019.

![Figure 5. Selected plant species from Muara Upu Swamp Forest and Simulak Anjing Hill Forests, Batang Toru, North Sumatra, Indonesia: the Vulnerable species *Aquilaria hirta* (A), *Cantleya corniculata* (B), *Dipterocarpus crinitus* (C), and *Dryobalanops sumatrensis* (D); Endangered *Vatica perakensis* (E); Critically Endangered *Shorea johorensis* (F) and, also protected and endemic, *Nepenthes sumatrana* (G); distribution confirmed in Sumatra for *Acrotrema costatum* (H-I); record for mainland Sumatra for *Dipterocapus penangianus* subsp. *penangianus* (J); as well as other two endemics *Thottea tapanulensis* (K) and *Macrolenes tuberculata* (L).](image-url)
Table 2. Checklist of main NTFPs of plants according to PROSEA for the species in Muara Upu and Simulak Anjing, Batang Toru, North Sumatra, Indonesia

| Uses categories                      | Number of species | List of species                                                                                                                                 |
|--------------------------------------|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| Medicinal and poisonous plants       | 63                | Acrostichum aureum, Acrotrema costatum, Alstonia spatulata, Anisophyella disticha, Arcangelies flava, Artocarpus elastis, Aspleniun nius, Blechnum orientale, Breynia racemosa, Chromolaena odorata, Carallia brachiata, Caryatia trifolia, Chellocostus speciosus, Cinnamomum iners, Cnestis palata, Colocasia esculenta, Commelina diffusa, Cyclea barbarata, Cyperus iria, Derris trifoliata, Dicranopteris linearis, Dillenia indica, Dryobalanops sumatrensis, Ekaocarpus mastersii, Embelia ribes, Endospermum diadenum, Eurycoma longifolia, Ficus deltoidea, Ficus hispida, Ficus microcarpa, Ficus padana, Flagellaria indica, Guita wallichii, Goniothalamus macrophyllus, Homalanthus populneus, Hydrophytum formicariun, Knema furfuracea, Lea indica, Lophopetalum javanicum, Macaranga bancana, Macaranga gigantea, Macaranga hypoleuca, Melastoma malabarticum, Mitragyna speciosa, Oncosperma horridum, Paraderes elliptica, Panarea semibijida, Pothos scandens, Psychotria viridiflora, Preisanthes cissoides, Rhaphido phora korhalisii, Rhodanmia cinerea, Scaphium macropodum, Schima wallichii, Scleria sumatrensis, Spatholobus ferrugineus, Stenochlaena palustris, Tetracera indica, Trichosanthes costata, Uncaria acida, Urena lobata, and Vitex pinnata |
| Fiber plants                         | 19                | Acrostichum aureum, Artocarpus elastis, Cnestis palata, Dicranopteris linearis, Ficus hispida, Ficus padana, Ficus indica, Homalanthus populneus, Oncosperma horridum, Pandanthes nigricans, Pandanthes helicopus, Pothos scandens, Scaphium macropodum, Spatholobus ferrugineus, Stenochlaena palustris, Tetracera indica, Thebyteris decorata, and Urena Lobata |
| Vegetables                           | 18                | Acrostichum aureum, Artocarpus elastis, Blechnum orientale, Commelina diffusa, Colocasia esculenta, Chellocostus speciosus, Caryatia trifolia, Embelia ribes, Ficus fistulosa, Ficus grossularioideas var. stenoloba, Lea indica, Melastoma malabarticum, Oncosperma tigillarium, Schismatoglottis calyptrata, Stenochlaena palustris, Trena cannabinum, Trichosanthes costata, and Uncaria acida |
| Edible fruits and nuts               | 14                | Artocarpus elastis, Antidesma stipulare, Baccaurea parviflora, Castanopsis lucida, Dialium indum, Dryobalanops sumatrensis, Embelia ribes, Ficus hispida, Ficus padana, Lea indica, Mangifera griffithii, Pinelodendron griffithianum, Rhodamnia cinerea, and Trichosanthes costata |
| Dye and tannin producing plants     | 12                | Arcangelies flava, Castanopsis lucida, Dillenia indica, Durio griffithii, Dialium indum, Ficus padana, Macaranga gigantea, Melastoma malabarticum, Psychotria viridiflora, Rhodamnia cinerea, Syzygium zeylanicum, and Urena lobata |
| Ornamental                           | 11                | Acrostichum aureum, Aspleniun nius, Carallia brachiata, Dillenia indica, Ficus deltoidea, Ixora congesta, Melastoma malabarticum, Oncosperma horridum, Oncosperma tigillarium, Schismatoglottis calyptrata, and Stenochlaena palustris |
| Forages                              | 7                 | Colocasia esculenta, Derris trifoliata, Ficus hispida, Ficus padana, Uotchoha nodosa,Schima wallichii, and Urochloa mutica |
| Fern and fern allies                 | 6                 | Acrostichum aureum Aspleniun nius, Blechnum orientale, Dicranopteris linearis, Drynaria quercifolia, Stenochlaena palustris, and Thebyteris decorata |
| Auxiliary plants                    | 3                 | Adinandra dumosa Ficus hispida, and Schima wallichii |
| Essential-oil plants                | 2                 | Cananga odorata and Dipterocarpus crinitus |
| Plants producing exudates           | 2                 | Dyera costulata and Shorea acuminata |
| Plants yielding non-seed carbohydrates | 2                 | Colocasia esculenta and Cheilocostus speciosus |
| Rattans                              | 1                 | Calamus melanochaetes |
| Spices                               | 1                 | Cinnamomum iners |
| Vegetable oils and fats              | 1                 | Shorea leprosula |
Alien plants

There are 16 species of alien plants recorded in this study. Four of them belong to 100 of the most invasive species, i.e. *Pontederia crassipes* or water hyacinth (Figure 6), *Clidemia hirta*, or simply known as clidemia, *Mimosa pigra* or bashful plant, and *Mikania micrantha* or American rope (Lowe et al. 2000; GISD 2020). The presence of *P. crassipes* was recorded from MUSF, forming a dense floating population competing with the local species like *Hanguana anthenminthica* and *Thelypteris decorra*. In the MUSF area, the potentially invasive climbing aroids *Syngonium podophyllum* has also been recorded. The species has been reported to grow as abundant naturalized species in Southeast Asia, i.e. Singapore (Chong et al. 2010), and Java (Mustaqqim and Nisyawati 2016), while a new record of *Melothria pendula* (Cucurbitaceae) for Sumatra has also been published recently based on collections from MUSF (Mustaqqim and Putra 2020b). Meanwhile, in the SAHF, a small population of *M. pigra*, one of the 100 most invasive species (Lowe et al. 2000), has been recorded in the margin of the remaining forest.

The presence of alien plant species in the peat swamps of North Sumatra’s west coast has previously been documented. In the Tripa peat swamp forest, Arongan, Aceh Barat Regency, several species of alien plants were also recorded, including *Lantana camara* (Verbenaceae), alongside *Piper aduncum* (Piperaceae), *Sphagnetica trilobata* (Asteraceae), and several herbs or shrubs (Djufri and Samingan 2013). *Lantana camara* also belongs to the 100 most invasive species in the world (GISD 2020), and it has been found either from the disturbed or undisturbed peat swamp forests (Djufri and Samingan 2013). The results of this study confirmed that it is important to note the uniqueness of peat swamp forests (Giesen et al. 2018), alien species are still able to enter and establish themselves in peat swamp forests. The study observed that many alien species are limited to the disturbed areas of MUSF, except for the climbing *S. podophyllum*, a species native to tropical America (Croat 1981).

The presence of non-native alien species should be taken into consideration for all related stakeholders, where the eradication should be started as soon as possible. For the SAHF, the study showed a very low spread of non-native species which supports the previous statement that alien species would not be able to enter more less disturbed vegetations (van Steenis 1972). However, a recent study found that this statement could not be applied to all species because many alien species could also become invasive in a shaded forest. Although this latter statement was based on the study in temperate forests, the possibility of the same situation could happen in a tropical rainforest, so that this should also be taken into consideration (Dyderski and Jagodziński 2018).

In conclusion, SAHF is a home for several endemic, poorly known, and/or threatened plant species, of which one of them just only been described recently. There are also two noteworthy records in Sumatra for *Acrotrema costatum* and *Dipterocarpus penangianus* subsp. *penangianus*. Compared to the published literature, many native plant species have valuable NTFPs that can be

In Sumatra, the species is only known from Aceh and North Sumatra Provinces, with the previously southernmost record coming from Subulussalam, Aceh Province (Kartonagoro et al. 2019), positioned around 150 km north from SAHF. The presence of those three Sumatran endemic species increases the value of SAHF in the future conservation of lowland Sumatran rainforest diversity.

Potential Non-Timber Forest Products (NTFPs) of the native species

Many species in both areas are economically important, especially by the presence of many dipterocarp species which have valuable timber (Ashton 1982). However, this use should be avoided for SAHF or MUSF as they are quite small in area size. Therefore, numerous good alternatives can be acquired from the NTFPs such as medicine. *Dryobalanops sumatrensis* is also known as barus tree, stands among the most historically important species, and became an important commodity since the Dutch East Indies era. Besides the quality of the wood, the species was once the most important source of camphor which has excellent medicinal properties to cure many diseases like asthma, cough, stomach or liver pain, rheumatism, etc. (Lee et al. 1993). Besides that, *Eurycoma longifolia* or tongkat ali or known also as pasak bumi, is a very important medicinal plant, besides the long history of its value as a source of aphrodisiac. It has been proved that the chemical constituents of the species have excellent properties to improve human fertility (Mustaqqim et al. 2020). These are two examples of the popular NTFPs yielding species. All species are checked using the PROSEA database (PROSEA 2020; see also Wulijarni-Soetjipto and del Rosario 2003) and listed according to the main uses. The results of the comparisons showed that 88 species have either single or multiple uses. Most of the plants have been used as medicine and source of poison with 63 species, followed by fiber with 19 species, vegetables with 18 species, and edible fruit or nuts with 14 species (Table 2).

**Figure 6.** Flowering *Pontederia crassipes* in Muara Upu Swamp Forest, Batang Toru, North Sumatra

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**Table 2:**

| NTFP category | Species |
|---------------|---------|
| Medicine      | *Eurycoma longifolia* |
| Medicine      | *Dryobalanops sumatrensis* |
| Fiber         | *Mimosa pigra* |
| Poison        | *Mikania micrantha* |
| Edible fruit  | *Clidemia hirta* |
| Vegetable     | *Acrotrema costatum* |
| Edible nut    | *Dipterocarpus penangianus* |

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*Note: The table is not part of the original text and is for illustrative purposes only.*
optimized for a sustainable conservation effort, with most species have been reported having medicinal values, sources of fiber, or even fruits. In the degraded peat swamp forest of Muara Upu, there are some non-native species that some of them have been reported as invasive elsewhere. This includes the notorious water hyacinth (Pontederia crassipes). Meanwhile, only a few non-native plants were recorded from Simulak Anjing Hill Forests. A proper eradication of the non-native plant species, especially ones that could become invasive, should be started as soon as possible to prevent further spread and minimize the negative impact on the native plants or other biotas.

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