BIODIVERSITAS
Volume 22, Number 3, March 2021
Pages: 1580-1591

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d220365

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

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Manuscript received: 24 February 2021. Revision accepted: 28 February 2021.

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 titanum* (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 Laumonier 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 tapanuliensis* (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 SHAF, 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 vegetations, 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 4 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 vegetations in SAHF.

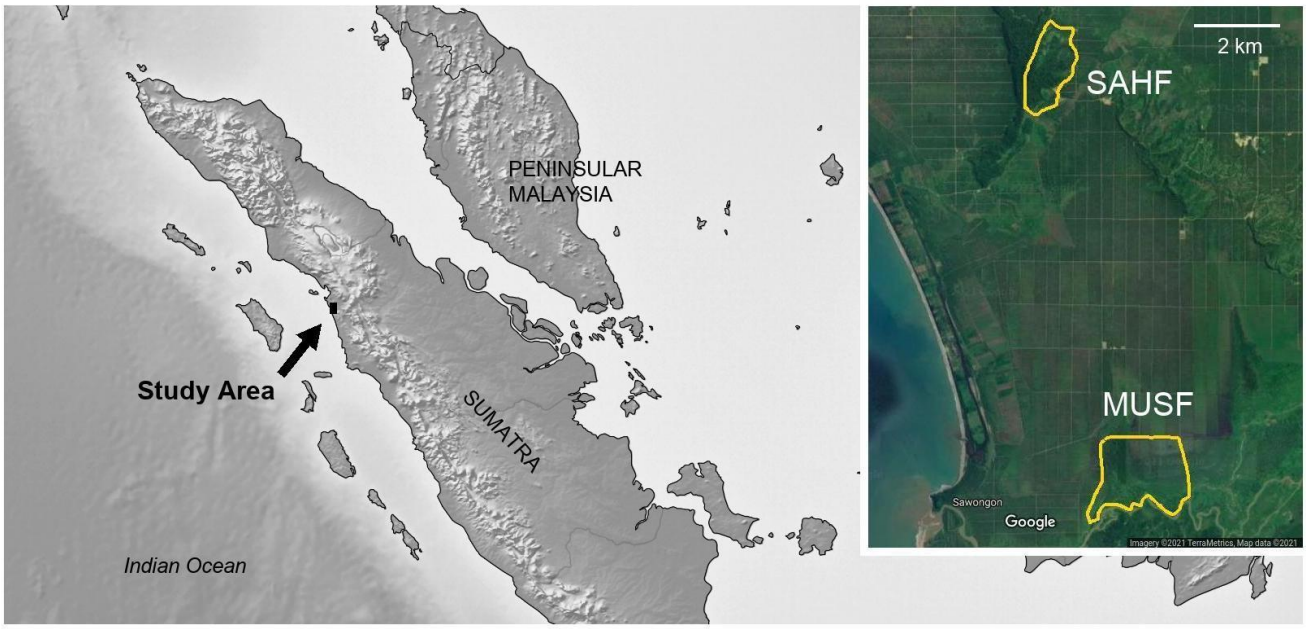

Figure 1. Map of study area in Muara Upu Swamp Forest and Simulak Anjing Hill Forest, Batang Toru, Tapanuli Selatan Regency, North Sumatra Province

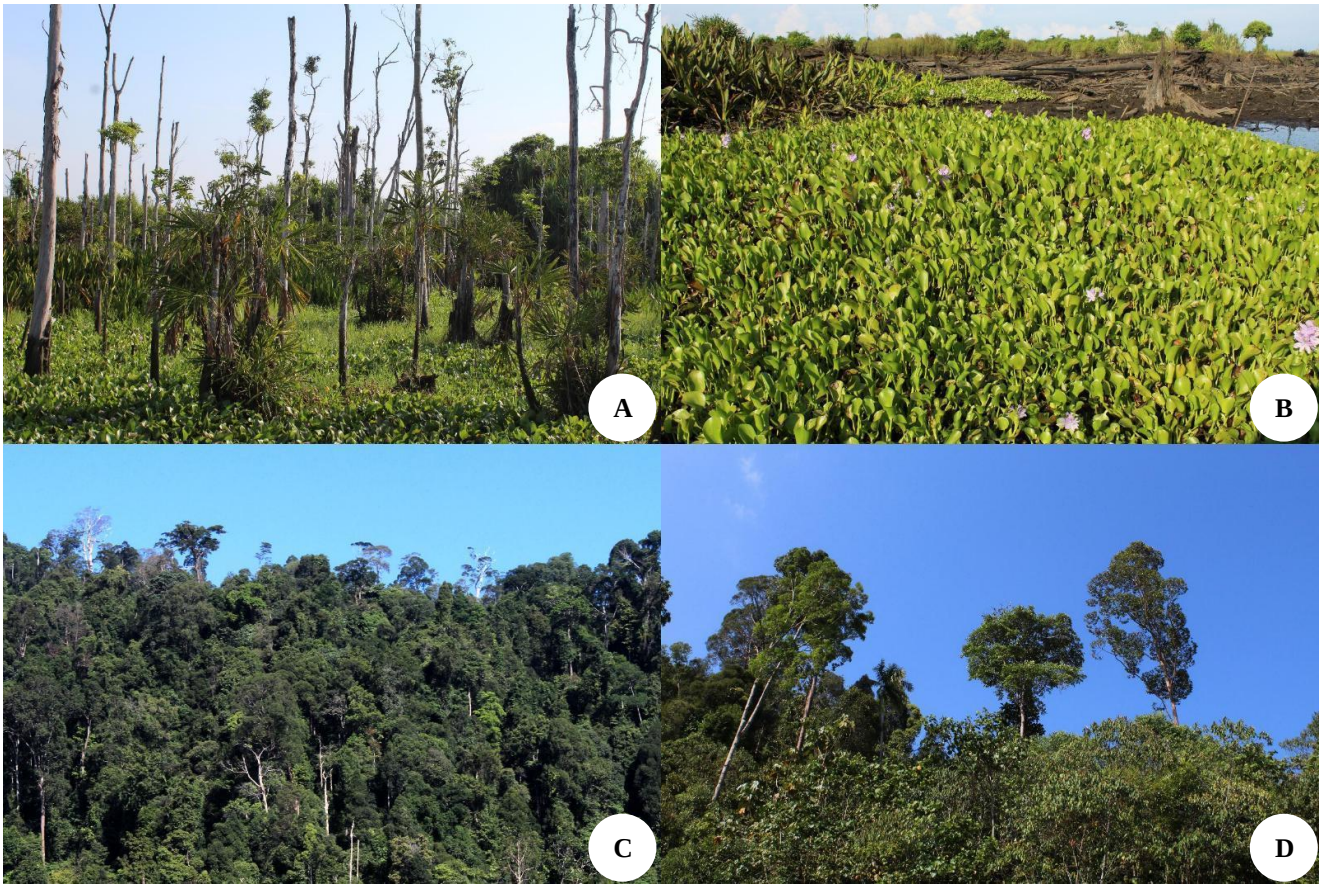

Figure 2. Vegetations in Muara Upu Swamp Forest (A-B) and Simulak Anjing Hill Forest (C-D), Batang Toru, Tapanuli Selatan Regency, North Sumatra Province

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.

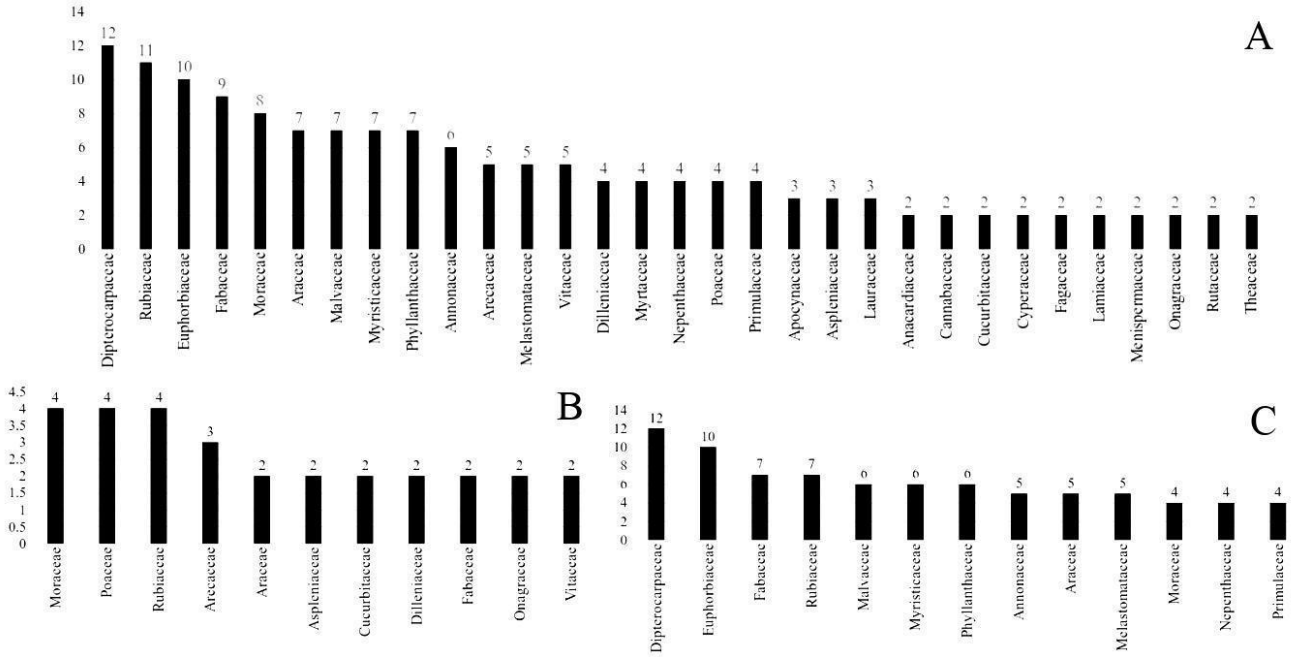

Figure 3. Number of species in largest plant families in both areas (A), Muara Upu Swamp Forest (B), and Simulak Anjing Hill Forest (C), , Batang Toru, North Sumatra, Indonesia

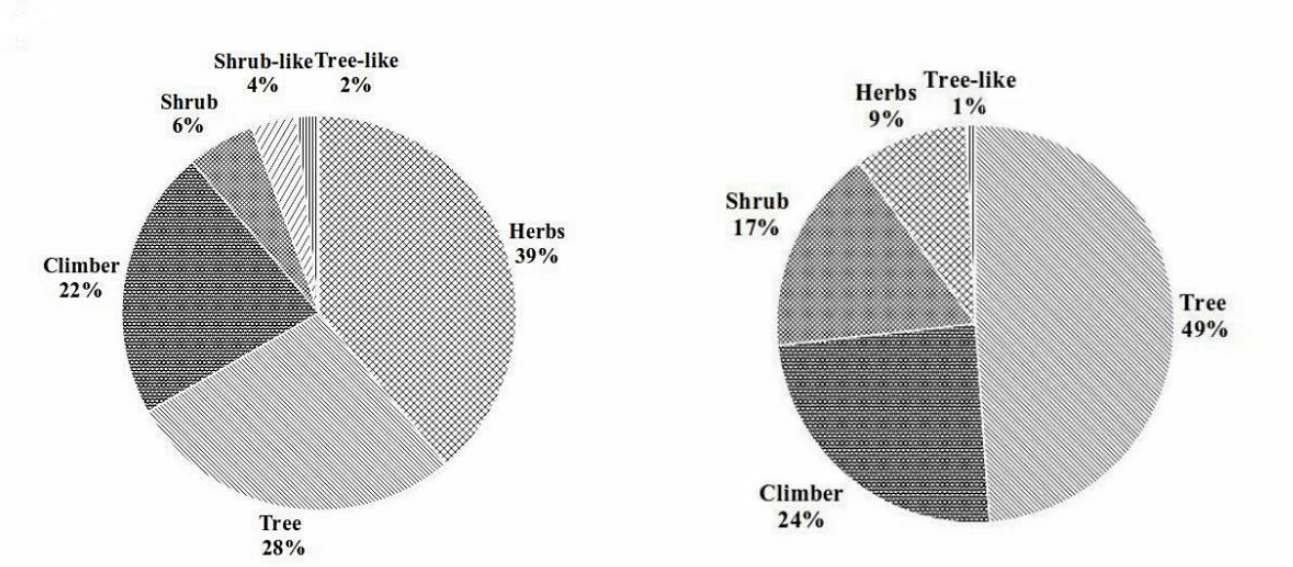

Figure 4. Percentage of life-form of plant species in Muara Upu Swamp Forest and Simulak Anjing Hill Forest, Batang Toru, North Sumatra, Indonesia

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	
Anisophylleaceae					
Anisophyllea disticha (Jack) Baill.		√	S	LC	
Annonaceae					
Cananga odorata (Lam.) Hook.f. & Thomson	√		T	LC	
Dasymaschalon dasymaschalum (Blume) I.M.Turner		√	S	NE	
Goniothalamus macrophyllus (Blume) Zoll.		√	S	NE	
Maasia glauca (Hassk.) Mols, Kessler & Rogstad		√	T	NE	
Popowia pisocarpa (Blume) Endl. ex Walp.		√	S	NE	
Xylopia cf. *oxyantha* (Hook.f. & Thomson) Hook.f. & Thomson		√	T	-	
Apocynaceae					
Alstonia spatulata Blume		√	T	LC	
Dyera costulata (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	
Rhaphidophora korthalsii Schott		√	C	NE	
Schismatoglottis calyptrata (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	
Oncosperma horridum (Griff.) Scheff.		√	TL	NE	
Oncosperma tigillarium (Jack) Ridl.	√		TL	NE	
Aristolochiaceae					
Thottea tapanuliensis Mustaqim		√	H	NE	
Aspleniaceae					
Asplenium nidus L.	√		H	NE	
Blechnum orientale L.		√	H	NE	
Stenochlaena palustris (Burm.f.) Bedd.	√		H	NE	
Asteraceae					
Mikania micrantha Kunth.	√		H	-	
Begoniaceae					
Begonia isoptera Dryand. ex Sm.		√	H	NE	
Burseraceae					
Dacryodes rugosa (Blume) H.J.Lam		√	T	LC	
Cannabaceae					
Gironniera nervosa Planch.		√	T	NE	
Trema cannabinum Lour.		√	T	LC	
Celastraceae					
Lophopetalum javanicum (Zoll.) Turcz.	√		T	LC	
Clusiaceae					
Garcinia nervosa (Miq.) Miq.		√	T	NE	
Commelinaceae					
Commelina diffusa Zoll. ex C.B.Clarke	√		H	LC	
Connaraceae					
Cnestis palala (Lour.) Merr.		√	C	NE	
Costaceae					
Cheilocostus speciosus (J.Koenig) C.D.Specht		√	H	LC	
Cucurbitaceae					
Melothriapendula L.	√		C	-	
Trichosanthes costata Blume	√		C	NE	
Cyperaceae					
Cyperus iria L.	√		H	NE	
Scleria sumatrensis Retz.		√	H	NE	

Dilleniaceae				
Acrotrema costatum Jack		√	H	NE
Dillenia indica L.	√		T	LC
Tetracera arborescens Jack		√	C	NE
Tetracera indica (Christm. & Panz.) Merr.	√		C	NE
Dipterocarpaceae				
Cotylelobium melanoxylon (Hook.f.) Pierre		√	T	LC
Dipterocarpus caudatus subsp. *penangianus* (Foxw.) P.S.Ashton		√	T	NE
Dipterocarpus costulatus Slooten		√	T	NT
Dipterocarpus crinitus Dyer		√	T	VU
Dryobalanops sumatrensis (J.F.Gmel.) Kosterm.		√	T	VU
Hopea cf. *sangal* Korth		√	T	-
Shorea acuminata Dyer		√	T	LC
Shorea johorensis Foxw.		√	T	CR
Shorea leprosula Miq.		√	T	NT
Shorea multiflora (burck) Symington		√	T	LC
Vatica perakensis King		√	T	EN
Vatica cf. *venulosa* subsp. *simalurensis* (Slooten) Ashton		√	T	-
Elaeocarpaceae				
Elaeocarpus mastersii King	√	√	T	LC
Euphorbiaceae				
Aporosa nitida Merr.		√	S	NE
Endospermum diadenum (MIq.) Airy Shaw		√	T	LC
Homalanthus populneus (Geiseler) Pax		√	T	LC
Macaranga bancana (Miq.) Müll.Arg.		√	T	NE
Macaranga heynei I.M.Johnst.		√	T	NE
Macaranga hypoleuca (Rchb.f. & Zoll.) Müll.Arg.		√	T	NE
Macaranga gigantea (Rchb.f. & Zoll.) Müll.Arg.		√	T	NE
Macaranga lowii King. ex Hook.f.		√	T	LC
Macaranga motleyana (Müll.Arg.) Müll.Arg.		√	T	NE
Pimelodendron griffithianum (Müll.Arg.) Benth. ex Hook.f.		√	T	NE
Fabaceae				
Dalbergia rostrata Hassk.		√	C	NE
Derris trifoliata Lour.		√	C	NE
Dialium indum L.		√	T	NE
Mimosa pigra L.		√	S	-
Mucuna bracteata DC. ex Kurz		√	C	LC
Phanera semibifida (Roxb.) Benth.		√	C	NE
Paraderris elliptica (Wall.) Adema	√		C	NE
Senegalia kekapur (I.C.Nielsen) Maslin, Seigler, Ebinger	√		C	NE
Spatholobus ferrugineus (Zoll. &Moritzi) Benth.		√	C	NE
Fagaceae				
Castanopsis lucida (Nees) Soepadmo		√	T	NE
Lithocarpus conocarpus (Oudem.) Rehder		√	T	NE
Flagellariaceae				
Flagellaria indica L.		√	C	NE
Gleicheniaceae				
Dicranopteris linearis (Burm.f.) Underw.		√	H	LC
Gnetaceae				
Gnetum cuspidatum Blume		√	C	LC
Hanguanaceae				
Hanguana anthelminthica (Blume ex Schult. & Schult.f.) Masam.	√		H	LC
Lamiaceae				
Vitex pinnata L.	√		T	LC
Vitex gamosepala Griff.		√	S	LC
Lauraceae				
Actinodaphne glabra Blume		√	T	LC
Cinnamomum iners (Reinw. ex Nees & T.Nees) Blume		√	T	LC
Dehaasia cuneata (Blume) Blume		√	T	NE
Lygodiaceae				
Lygodiummicrophyllum (Cav.) R.Br.	√		H	LC
Lythraceae				
Cuphea carthagenensis (Jacq.) J.F.Macbr.	√		H	-
Malvaceae				
Ceiba pentandra (L.) Gaertn.	√		T	-
Durio griffithii (Mast.) Bakh.		√	T	NE
Grewia laevigata Vahl		√	S	LC

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.f.) 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 Reinw. ex Blume	√		T	LC	
Ficus deltoidea Jack		√	S	NE	
Ficus fistulosa Reinw. ex Blume	√		T	LC	
Ficus grossularioides var. *stenoloba* Corner		√	T	LC	
Ficus hispida L.f.	√		T	LC	
Ficus microcarpa L.f.	√		T	LC	
Ficus padana Burm.f.		√	T	LC	
Ficus punctata Thunb.		√	C	NE	
Myristicaceae					
Horsfieldia grandis (Hook.f.) Warb.		√	T	LC	
Horsfieldia irya (Gaertn.) Warb.	√		T	LC	
Horsfieldia 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					
Rhodamnia cinerea Jack		√	T	LC	
Syzygiumpapillosum (Duthie) Merr. & L.M.Perry	√		T	NE	
Syzygium cf. *pycnanthum* 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	√
Nephrolepidaceae					
Nephrolepis hirsutula (Forst.) C.Presl		√	H	NE	
Nymphaeaceae					
Nymphaea alba L.	√		H	LC	
Onagraceae					
Ludwigia peruviana (L.) H.Hara	√		H	-	
Ludwigia hyssopifolia (G.Don) Exell	√		H	-	
Pandanaceae					
Pandanus helicopus Kurz ex Miq.	√		SL	NE	
Pentaphylacaceae					
Adinandra dumosa Jack		√	T	LC	
Phyllanthaceae					
Antidesma stipulare Blume		√	T	LC	
Baccaurea parviflora (Müll.Arg.) Müll.Arg.		√	T	NE	
Baccaurea 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					
Ottochloa 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					
Polygala paniculata L.	√		H	-	
Polypodiaceae					

Drynaria quercifolia (L.) J.Sm.	√		H	NE
Pontederiaceae				
Pontederia crassipes Mart.	√		H	-
Primulaceae				
Ardisia complanata Wall.		√	S	NE
Embelia lampani Scheff.		√	C	NE
Embelia ribes Burm.f.		√	C	NE
Maesa sumatrana Scheff.		√	C	NE
Rhamnaceae				
Ziziphus cf. *elegans* Wall.		√	C	-
Rhizophoraceae				
Carallia brachiata (Lour.)Merr.		√	S	NE
Rubiaceae				
Hynophytum formicarum Jack	√		H	NE
Ixora congesta Roxb.		√	S	NE
Ixora javanica (Blume) DC.		√	S	LC
Mitragyna speciosa Korth.	√		T	NE
Mussaenda frondosa L.		√	S	NE
Nauclea officinalis (Pierre ex Pit.) Merr. & Chun	√		T	NE
Neolamarckia cadamba (Roxb.) Bosser		√	T	NE
Porterandia anisophylla (Jack ex Roxb.) Ridl.		√	T	NE
Psychotria viridiflora Reinw. ex Blume		√	S	NE
Uncaria acida (W.Hunter) Roxb.	√		C	NE
Uncaria cordata (Lour.) Merr.		√	C	NE
Rutaceae				
Luvunga sarmentosa (Blume) Kurz		√	C	NE
Melicope 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 corniculata (Becc.) R.A.Howard		√	T	VU
Theaceae				
Eurya nitida Korth.		√	S	NE
Schima wallichii (DC.) Korth.		√	T	LC
Thelypteridaceae				
Thelypteris decora (Domin.) C.F.Reed	√		H	NE
Thymelaeaceae				
Aquilaria hirta Ridl.		√	T	VU
Vitaceae				
Ampelocissus thyrsiflora (Blume) Planch.		√	C	NE
Cayratia trifolia (L.) Mabb. & J.Wen	√		C	NE
Leea indica (Burm.f.) Merr.	√		S	LC
Pterisanthes cissoides Blume		√	C	NE
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

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 applanate 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-

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 tapanuliensis* (K) and *Macrolenes tuberculata* (L)

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, Anisophyllea disticha, Arcangelisia flava, Artocarpus elasticus, Asplenium nidus, Blechnum orientale, Breynia racemosa, Chromolaena odorata, Carallia brachiata, Cayratia trifolia, Cheilocostus speciosus, Cinnamomum iners, Cnestis palala, Colocasia esculenta, Commelina diffusa, Cyclea barbata, Cyperus iria, Derris trifoliata, Dicranopteris linearis, Dillenia indica, Dryobalanops sumatrensis, Elaeocarpus mastersii, Embelia ribes, Endospermum diadenum, Eurycoma longifolia, Ficus deltoidea, Ficus hispida, Ficus microcarpa, Ficus padana, Flagellaria indica, Gluta wallichii, Goniothalamus macrophyllus, Homalanthus populneus, Hydnophytum formicarum, Knema furfuracea, Leea indica, Lophopetalum javanicum, Macaranga bancana, Macaranga gigantea, Macaranga hypoleuca, Melastoma malabathricum, Mitragyna speciosa, Oncosperma horridum, Paraderris elliptica, Phanera semibifida, Pothos scandens, Psychotria viridiflora, Pterisanthes cissoides, Rhaphidophora korthalsii, Rhodamnia 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 elasticus, Cnestis palala, Dicranopteris linearis, Ficus hispida, Ficus padana, Ficus indica, Homalanthus populneus, Oncosperma horridum, Oncosperma tigillarium, Pandanus helicopus, Pothos scandens, Scaphium macropodum, Spatholobus ferrugineus, Stenochlaena palustris, Tetracera indica, Thelypteris decora*, and *Urena Lobata*
Vegetables	18	*Acrostichum aureum, Artocarpus elasticus, Blechnum orientale, Commelina diffusa, Colocasia esculenta, Cheilocostus speciosus, Cayratia trifolia, Embelia ribes, Ficus fistulosa, Ficus grossularioides var. stenoloba, Leea indica, Melastoma malabathricum, Oncosperma tigillarium, Schismatoglottis calyptrata, Stenochlaena palustris, Trema cannabinum, Trichosanthes costata,* and *Uncaria acida*
Edible fruits and nuts	14	*Artocarpus elasticus, Antidesma stipulare, Baccaurea parviflora, Castanopsis lucida, Dialium indum, Dryobalanops sumatrensis, Embelia ribes, Ficus hispida, Ficus padana, Leea indica, Mangifera griffithii, Pimelodendron griffithianum, Rhodamnia cinerea,* and *Trichosanthes costata*
Dye and tannin producing plants	12	*Arcangelisia flava, Castanopsis lucida, Dillenia indica, Durio griffithii, Dialium indum, Ficus padana, Macaranga gigantea, Melastoma malabathricum, Psychotria viridiflora, Rhodamnia cinerea, Syzygium zeylanicum,* and *Urena lobata*
Ornamental	11	*Acrostichum aureum, Asplenium nidus, Carallia brachiata, Dillenia indica, Ficus deltoidea, Ixora congesta, Melastoma malabathricum, Oncosperma horridum, Oncosperma tigillarium, Schismatoglottis calyptrata,* and *Stenochlaena palustris*
Forages	7	*Colocasia esculenta, Derris trifoliata, Ficus hispida, Ficus padana, Ottochloa nodosa,Schima wallichii*, and *Urochloa mutica*
Fern and fern allies	6	*Acrostichum aureum Asplenium nidus, Blechnum orientale, Dicranopteris linearis, Drynaria quercifolia, Stenochlaena palustris,* and *Thelypteris decora*
Auxiliary plants	3	*Adinandra dumosa Ficus hispida*, and *Schimawallichii*
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*

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

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 Indie 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 (Mustaqim 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).

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 anthelminthica* and *Thelypteris decora*. In the MUSF area, the potentially invasive climbing aroids *Syngonium podophylllum* 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 (Mustaqim and Nisyawati 2016), while a new record of *Melothria pendula* (Cucurbitaceae) for Sumatra has also been published recently based on collections from MUSF (Mustaqim 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), *Sphagneticola 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

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.

ACKNOWLEDGEMENTS

This work was supported by Unilever and PTPN III via the Faculty of Agriculture, IPB University, Bogor, Indonesia c.q. Dr. Supijatno. The authors thanked all of Dr. Supijatno team members as well as staff from PTPN III Muara Upu, South Tapanuli, Indonesia for invaluable help during the fieldwork where the materials used in this paper have been collected. Also thanks to the Laboratory of Ecology and Plant Resources, Department of Biology, IPB University, for facilities during the preparation of the manuscript.

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