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Research Article

DISTRIBUTION OF THE THALLOID LIVERWORT GENUS *MARCHANTIA* (MARCHANTIACEAE) IN NORTH SUMATRA, INDONESIA

Etti Sartina Siregar*, Nursahara Pasaribu, Muhammad Zaidun Sofyan

Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara, Medan 20155, Indonesia.

ARTICLE HIGLIGHTS

- The survey method was successful in identifying the species *Marchantia* and mapping their distribution in North Sumatra
- Eight taxa of *Marchantia* confirmed in North Sumatra, *M. emarginata subsp. cuneiloba* has the most widely distributed species.
- Species distribution linked to environmental factors like elevation, humidity, rainfall, soil types, slope, solar intensity, and types of land cover

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Corresponding author, e-mail:
etti1@usu.ac.id

ABSTRACT

Marchantia is a large genus of complex thalloid liverworts (Marchantiophyta), widely distributed globally, and thriving across various substrates. Despite the relatively abundance widespread, the presence and distribution of *Marchantia* species are still limited in North Sumatra. Therefore, this research aimed to conduct a comprehensive inventory of *Marchantia* species and map their distribution in North Sumatra. The inventory was carried out using a survey method, covering 9 locations, namely Aek Nauli Forest, Bukit Barisan National Forest Park, Bukit Lawang, Resort Cinta Raja, Dolok Tinggi Raja Nature Reserve, Sibayak Mountain, Sicike-cike Natural Park, Silima-lima Waterfall, and Taman Eden 100 Natural Park. Subsequently, Geographic Information System (GIS) was used to map species distribution. The results showed that there were eight taxa of *Marchantia* in North Sumatra, including *M. acaulis, M. emarginata* subsp. *emarginata, M. emarginata* subsp. *cuneiloba, M. geminata, M. paleacea, M. polymorpha, M. treubii*, and *Marchantia* sp. The most widely distributed species was *M. emarginata* subsp. *cuneiloba*, found in 7 locations, while *M. treubii* and *Marchantia* sp. were identified in one location. In North Sumatra, *Marchantia* spp. spread at an altitude of 77 to 1,976 masl, occupying habitats with 6 types of soil (orthic acrisol, humic andosol, humic acrisol, and humic cambisol), at a rainfall of 1,800-3,600 mm/year. These species are found on sloping plains to steep, thriving in various habitats, including secondary forest, as well as primary and secondary forest borders, dryland farming, primary and plantation borders. Considering the numerous benefits, this research provided valuable information for the conservation of *Marchantia* spp. in North Sumatra.

Keywords: *distribution, liverwort, Marchantia*

INTRODUCTION

The genus *Marchantia* is characterized by a dichotomously branched and dorsoventrally flattened thallus, bearing compound air pores, gemma cups, archegonium, and antheridium on the dorsal of thallus, along with ventral scales appendages on the ventral side. *Marchantia* is distinguished from all other genera of Marchantiaceae by bearing gemma cups on the dorsal thalli. The male and female thalli can reproduce asexually by producing multicellular 'gemmae' (singular: gemma) in 'gemma cups' (or 'cupules') (Shimamura 2016). Gemma is the asexual reproduction, where each gemma grows into a new individual when supported by environmental conditions. Furthermore, gemmae are usually dispersed by rainwater, insects, and small mammals, such as mice (Barbé *et al.* 2017). *Marchantia* also has sexual reproduction organs in the form of archegonia (female) and antheridia (male), which are separated in different thalli (dioicous). However, species such as *M. acaulis*, show monoicous characteristics, where both archegonium and antheridium occur in the same thallus (Bischler-Causse 1989; Gradstein 2011; Siregar *et al.* 2013; Linde *et al.* 2020). This genus has oil bodies which can be usually observed in

gemmae, appendage of the ventral scale of thallus, gemma cups or cupules, and involucre (Zheng & Shimamura 2019a; 2020; 2022).

Marchantia is composed of approximately 40 species globally (Söderström *et al.* 2016), and is represented by 19 accepted taxa in Asia (Bischler-Causse 1989; Xiang *et al.* 2016; Long & Crandall-Stotler 2020). This genus has a cosmopolitan distribution and the greatest diversity of species occurs in tropical Asia and Oceania. *Marchantia* is found in moist to wet habitats, open or shady places, side of the road, usually neutral or basic soils, sandy or clayey soils, on wet rocks, trench walls, riverside cliffs, waterfall cliffs, limestones, boulders in open or shaded places. Moreover, it is occasionally found on mineral soils in depressions or in the shade of fallen logs following hot forest fires. *Marchantia* frequently associates with human activity, rapidly colonizing in the open, burnt soil, and thriving in cultivated farmland. For example, species such as *M. polymorpha* commonly intrude into gardens, greenhouse, and areas around human settlements (land that has been disturbed by human activities) (Bishler-Causse *et al.* 2005; Siregar *et al.* 2013; Ho 2013; Shimamura 2016; Zheng & Shimamura 2022). Some of these species can be found below an altitude ranging from 100 m to 4,000 m above sea level, and are abundant at 1,000 to 2,500 m (Lu & Huang 2017).

Marchantia has ecological roles as a pioneer plant on barren lands, preventing erosion by colonizing cliffs and forming dense populations (Sahu *et al.* 2014; Bowman *et al.* 2017). Economically, *Marchantia* serves as a potential source of medicine due to the presence of antibacterial, antifungal, and antioxidant contents (Tanaka *et al.* 2016; Fatma 2018; Siregar *et al.* 2021; Romani *et al.* 2022; Zang *et al.* 2022). This genus has also been used as a traditional medicine in China and India for treating various ailments, such as skin tumefaction, liver protection, hepatitis, tumors, ulcers, open wounds, burns, poisonous snake bites, hepatotoxicity, and as an antipyretic (Gupta *et al.* 2015; Purkon *et al.* 2022).

Despite the numerous benefits of *Marchantia,* only a few investigations focused on exploring its distribution in Indonesia, including in North Sumatra. Among the exploration reports are: (1) Siregar *et al.* (2013) who reported seven species in Sibayak Forest; (2) Siregar *et al.* (2020) who found the morphological variations of *M. emarginata*; and (3) Siregar *et al.* (2021) who identified the antioxidant activity of *M. paleacea*. Therefore, this research aimed to investigate distribution of *Marchantia* species in North Sumatra.

MATERIALS AND METHODS

Research Area

The research was conducted in nine locations in North Sumatra Province, which has abundant existence of *Marchantia*. These locations were: (1) Aek Nauli Forest, Simalungun District; (2) Bukit Barisan National Forest Park, Karo District; (3) Bukit Lawang, Langkat District; (4) Resort Cinta Raja, Langkat District; (5) Dolok Tinggi Raja Nature Reserve, Simalungun District; (6) Sibayak Mountain, Karo, Deli Serdang District; (7) Sicike-cike Natural Park, Dairi District; 8) Silima-lima Waterfall, South Tapanuli District; and (9) Taman Eden 100 Natural Park, Toba Samosir District, as shown in Figure 1.

Data Collection

An exploratory survey was carried out along the path at each predetermined location. Species that have been recognized in previous research were only photographed and not collected for analysis. However, unknown or doubtful species were photographed, collected, and placed in a ziplock bag containing water-moistened tissue paper. These species were taken to Herbarium Medanense (MEDA), Biology Department, Faculty of Mathematics and Sciences, Universitas Sumatera Utara Medan, Indonesia for identification. The ordinal point of global positioning system (GPS) was recorded and physical factors were measured at each location, including altitude, humidity, soil pH, air temperature, and light intensity. Data on *Marchantia* spp. that were previously collected from North Sumatra and stored in the MEDA herbarium were also used in this research.

Data Analysis

Morphological observations were carried out at the Plant Systematics Laboratory, Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara, Medan, Indonesia. Species identification was based on various available literatures, particularly Bischler (1989), Singh & Singh (2013), Siregar *et al.* (2013), Lu & Huang (2017), and Zheng & Shimamura (2022). Validation of the scientific names was based on the Tropicos website: https://www.tropicos.org/home. Data on distribution of *Marchantia* spp. in North Sumatra was obtained using Global Positioning System (GPS). Subsequently, the coordinate point data were analyzed using the Arcgis 10.8 software mapping program based on rainfall, altitude, slope of the habitat, light intensity, humidity, land cover, and soil type.

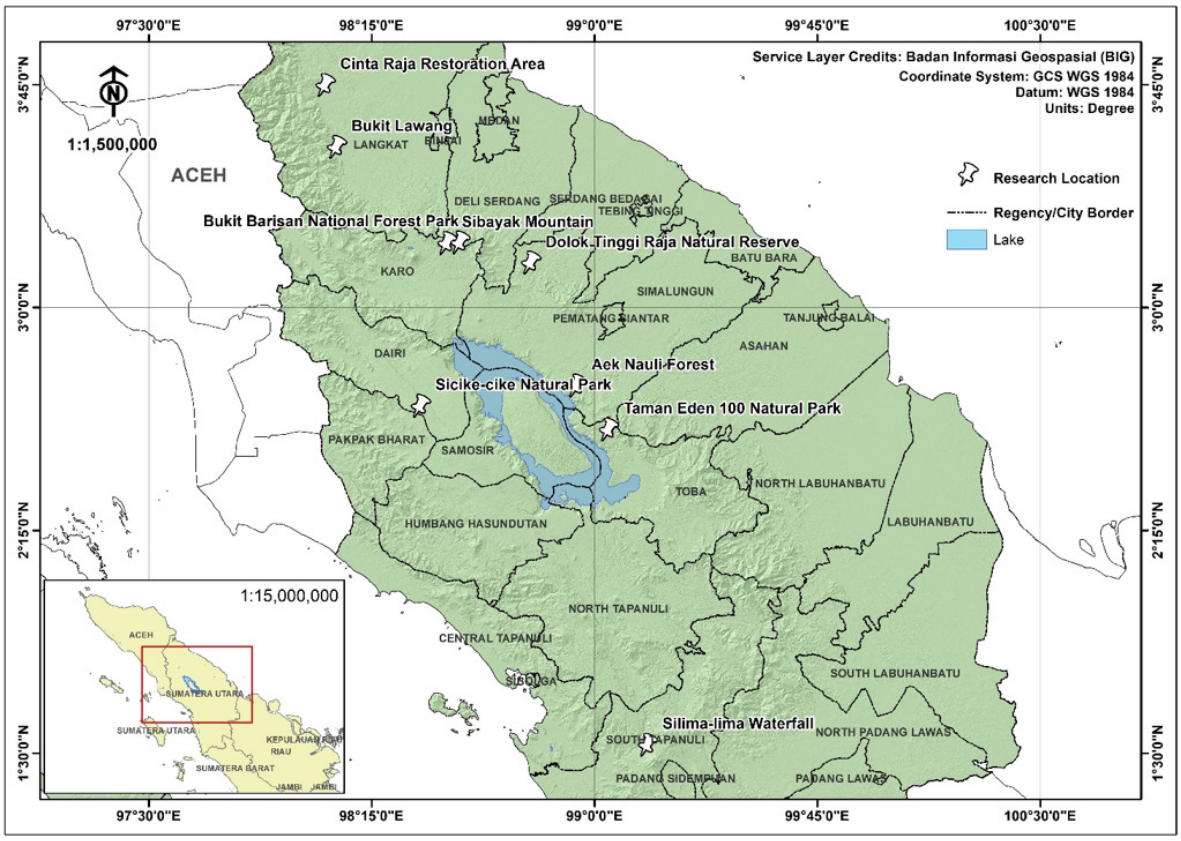

Figure 1 Map of *Marchantia* spp. research locations in North Sumatra, Indonesia

RESULTS AND DISCUSSION

Marchantia species in North Sumatra

A total of eight *Marchantia* taxa were identified, consisting of seven species with two subspecies, namely *M. acaulis* Steph., *M. emarginata* Reinw., Blume & Nees subsp. *emarginata, M. emarginata* subsp. *cuneiloba* (Steph.) T.X. Zheng & Shimamura, *M. geminata* Reinw., Blume & Nees, *M. paleacea* Bertol., *M. polymorpha* L., *M. treubii* Schiffn. and *Marchantia* sp. Although *Marchantia* sp. is closely related to *M. rubribarba* Steph., there is no specimen of the species, leading to pending confirmation. The number of species obtained in this research was not different from *Marchantia* spp. found in Sibayak Forest by Siregar *et al.* (2013). However, two subspecies of *M. emarginata,* namely *M. emarginata* subsp. *emarginata* and *M. emarginata* subsp. *cuneiloba* were found to show significantly large morphological variations in thallus and archegonium. *Marchantia emarginata* subsp. *emarginata* is characterized by the dorsal thallus with dark median band and distinctly rounded protrusion on the dorsal archegonium. Meanwhile, *M. emarginata* subsp. *cuneiloba* has dorsal thallus without a median band and archegonium with indistinct or flat protrusions (Siregar *et al.* 2020).

Distribution of *Marchantia* in North Sumatra

Table 1 shows information regarding the locations of *Marchantia* species found in this research. The most widespread species was found to be *M. emarginata* subsp. *cuneiloba* and was identified in seven locations on various substrates. This was followed by *M. geminata,* found in humid and open habitat, such as on the cliffs of household wastewater, soil, and moist rocks in areas along the track and around forests with human activities. *M. emarginata* subsp. *cuneiloba* was found in open and humid habitat on the outskirts of waterways, water waste rock walls, and soil cliffs, while *M. emarginata* subsp. *emarginata* was found alongside *M. emarginata subsp. cuneiloba* in the field in a very dense population covering exposed land cliffs. The ability of both subspecies to form dense populations facilitates soil retention, reducing erosion on open ground cliffs.

Table 1 Distributional and ecological aspects of North Sumatran species of *Marchantia*

No.	Species	Location	Substrate	Elevation (m)	Soil acidity
1	*M. acaulis*	AN, SC, SM, BB	Soil	800-1,373	5-6.4
2	*M.emarginata* subsp.*emarginata*	TE, AN, SW, SM	Soil, rocks	88-1,570	6-6.6
3	*M.emarginata* subsp.*cuneiloba*	TE, SC, AN, WS, SM, CR, BL	Soil, rocks	77-1,570	5-6.4
4	*M. geminata*	TE, SC, AN, BB, TR, SM	Soil, rocks	870-1,976	4.2-6.2
5	*M. paleacea*	SM, BB	Rocks	1,150- 1,250	6.2-6.4
6	*M. polymorpha*	AN, SM, BB	Soil, rocks	800-1,570	6.2
7	*M. treubii*	SM	Soil, rocks	870-1,680	5.9
8	*Marchantia* sp.	SM	Soil	984-1,027	6.4-6.6

Notes: AN = Aek Nauli; BL = Bukit Lawang; CR = Cinta Raja; SC = Sicike-cike; SM = Sibayak Mountain; SW = Silima-lima Waterfall; BB = Bukit Barisan National Forest Park; TE = Taman Eden; TR = Tinggi Raja.

Marchantia polymorpha was found in three locations, namely Aek Nauli, Sibayak Mountain, and Bukit Barisan National Forest Park. This species was predominantly found in rock cliffs of watercourses, concrete walls, moist soil near streams, and open fields such as strawberry gardens in Bukit Barisan National Forest Park.

The species having a narrow distribution in North Sumatra, namely *M. treubii and Marchantia* sp., were found only in Sibayak Forest. This limited number of species samples was attributed to disturbances, which could threaten the existence of plants, including *Marchantia.* All species that were identified are cosmopolitan in the Malesiana region, extending to Asia and parts of Europe such as *M. polymorpha* and *M. paleacea* (Siregar *et al.* 2013).

Habitat Preferences

The habitat characteristics of *Marchantia* in North Sumatra are relatively different. These species mainly inhabit forest outskirts, secondary forests, slightly shaded or open vegetation, roadside areas, plantations, and around human settlements. For example, *M. paleacea* with a very dense population inhabits concrete walls in open habitats, along with *M. geminata* at an altitude of 1,400 m in Bukit Barisan National Forest Park.

Marchantia spp. generally grow on wet soil, watercourses on riverbanks, bare soil, gardens, drains, rocks, damp brick walls, and concrete walls. The most widely distributed species are *M. emarginata* subsp. *emarginata* and *M. emarginata* subsp. *cuneiloba*, found on stone walls in waterways (moats), riverbanks, cliffs of waterfalls, roadside soil banks, stone walls, and land around human settlements.

Distribution of this genus based on the altitude from sea level varies from lowlands to highlands between 400 m and above 1,600 masl (Fig. 2). In this research, only *M. emarginata* was found in the range below 400 masl, while *M. emarginata* subsp. *emarginata* was distributed at an altitude of 88 to 1,570 masl. (Singh & Singh 2013) found *M. emarginata* subsp. *emarginata* in India at an altitude of 1,400-1,650 masl, while other species were found in the highlands at altitudes 800 to 1,900 masl. Although *M. acaulis* was found at 800-1,200 masl, Lu and Huang (2017) reported this species at 1,800 masl. *Marchantia geminata* was also discovered at 800 masl to more than 1,600 masl, while *M. paleacea* was found within 800-1,600 masl.

Marchantia geminata showed a fair distribution, thriving on the ground of waterfall cliffs, concrete along ditch, rock walls, and soil cliffs with an altitude range of 800-1,900 masl. *Marchantia polymorpha* lives on rock walls of watercourses, flat and open land near rivers, predominantly found in horticultural gardens and city parks, at 800-1,600 masl. Similarly, Cykowska (2011) found *M. polymorpha* between 865 masl and 1,560 masl in Poland, while Zheng *et al.* (2020) discovered this species at 223 masl on concrete walls and artificial substrates in semi-natural environments in Japan. *Marchantia treubii* was found on sloping, soil, and rock cliffs, while *M. acaulis* was identified on cliff substrates from open ground to shaded. The species *M. acaulis* in Singapore was found in habitats with partial shade on rock or concrete surfaces (Ho 2013).

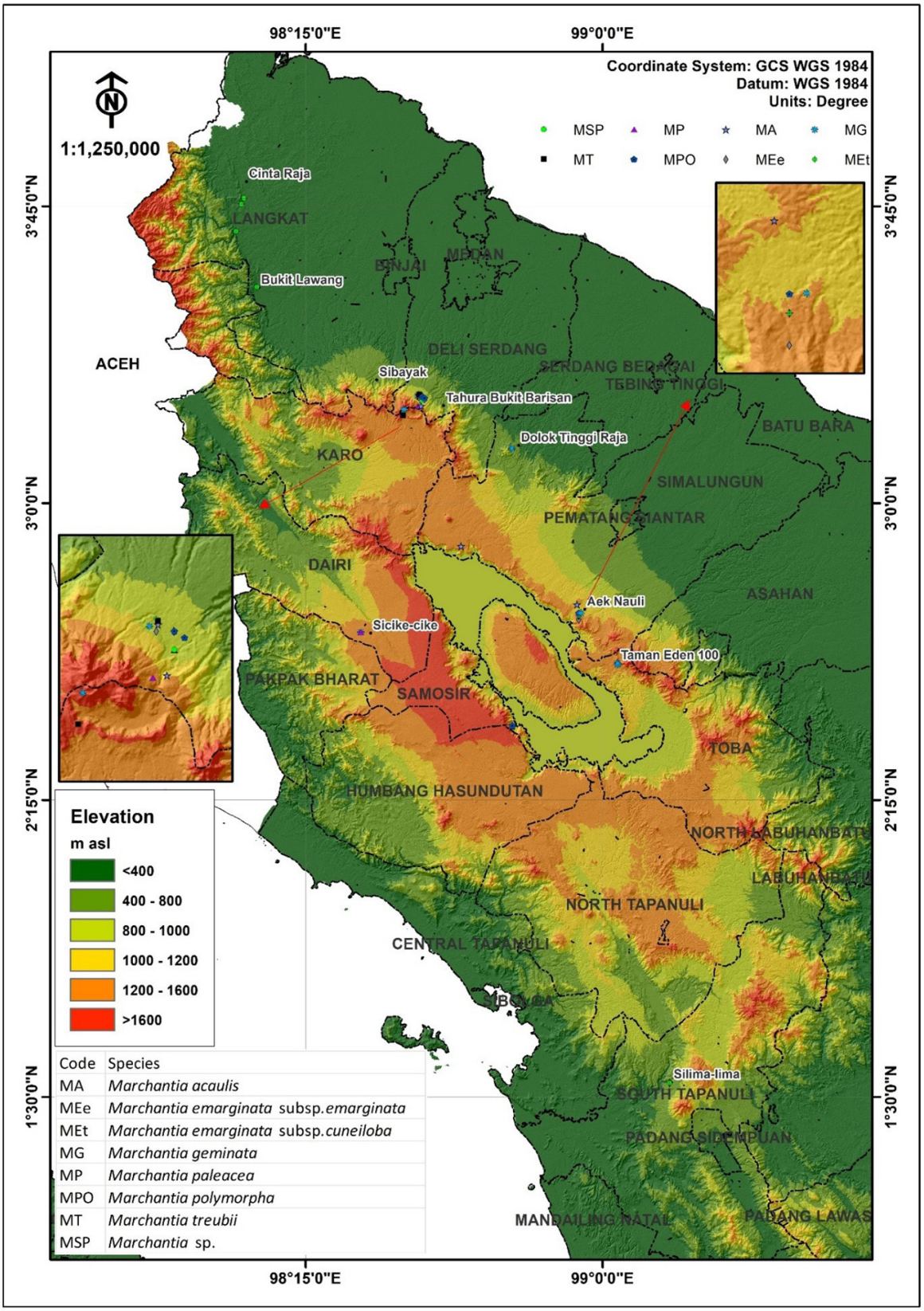

Figure 2 Map of the relationship between elevation and distribution of *Marchantia* species

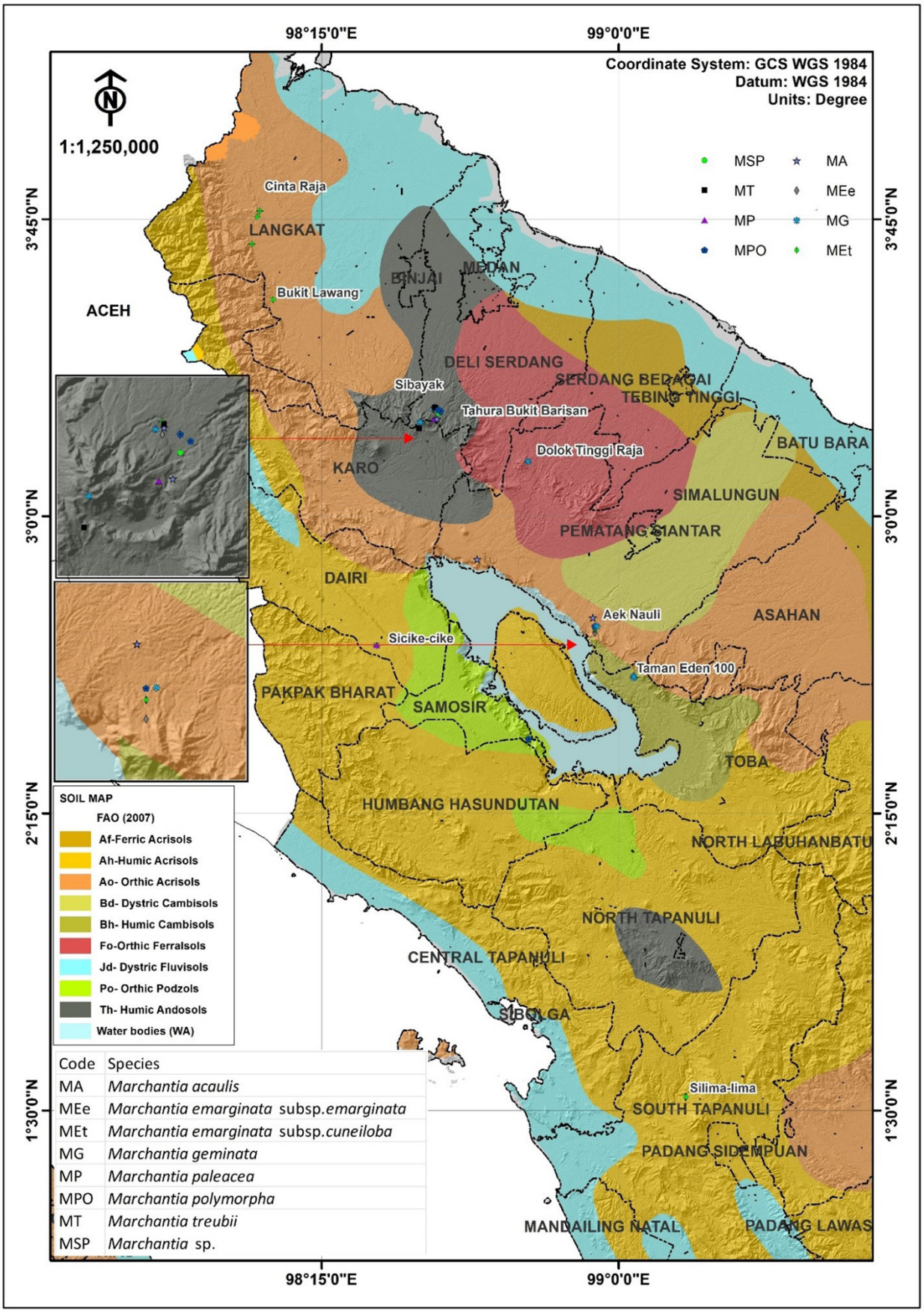

Figure 3 Map of the relationship between soil type and distribution of *Marchantia* species

Marchantia paleacea was found in the rock walls of the canal on the roadside of the road and open areas at 1,100 masl. Lu and Huang (2017) discovered *M. paleacea* on a dump brick wall from 300 masl to 2,500 masl in Taiwan, as well as in Japan at 136 masl and 459 masl. This species was also found on a vertical stone wall in the shade (Zheng & Shimamura 2019b) and in Russia at 370 masl (Borovichev & Bakalin 2014).

The results showed that *Marchantia* species in North Sumatra occupied 5 soil types, namely orthic acrisols, humic andosols, orthic ferrasols, humic cambisols, orthic podzols, and the most common are humic andosols and orthic acrisols (Fig. 3). *Marchantia geminata* occupied the most variations in soil types, namely orthic acrisols, humic andosols, orthic ferralsols, and humic cambisols. Furthermore, *M. emarginata* subsp. *emarginata* was found to occupy orthic acrisol, humic andosol, and humic cambisol. *Marchantia acaulis* and *M. polymorpha* occupied orthic acrisols, humic andosols, and orthic podzols. *Marchantia treubii* and *Marchantia* sp. showed a specific distribution pattern, spreading only on humic andosols.

Acrisols or podzolic soils are characterized by high leaching, which appears light gray to yellowish on the surface horizon, with underlying layers often showing red or yellow. These soils contain low organic matter content and base saturation, with soil acidity levels ranging from pH 4.2 to 4.8. In the subsurface horizon, there is an accumulation of clay with a lumpy soil structure with low permeability. Despite being predominantly present in lowlands at 50-350 masl (FAO 2014), acrisols in this research were found at altitude from less than 100 masl to 1,300 masl.

Marchantia in North Sumatra is distributed in high humidity and almost the same in all locations with a range of 82% to 86% (Fig. 4), showing that *Marchantia* can grow optimally in an environment having high humidity, as most species are found in streams, riverbanks, stream walls, and wet areas. Based on the results, all species found were scattered in areas with medium to high rainfall between 200-300 mm/month or 2,400-3,600 mm/year (Fig. 5). The widest distribution range was observed in *M. emarginata* subsp. *emarginata* and *M. emarginata* subsp. *cuneiloba* with rainfall in the medium to high category, with value of 150-300 mm/month or 1,800-3,600 mm/year.

In terms of land slope, *Marchantia* was found generally on flat to steep land surfaces in North Sumatra. Species found on a flat to sloping surface were *M. polymorpha, Marchantia* sp. *M. emarginata* subsp. *emarginata* and *M. emarginata* subsp. *cuneiloba* were found on a sloping to a bit steep surface. Meanwhile, *M. acaulis, M. paleacea,* and *M. treubii*. were found on a slope to steep surface (Fig. 6).

Marchantia spp. in North Sumatra were found in open areas with the light intensity of 50% to 60%. *Marchantia geminata* has the highest light intensity ranging from 50% to 60%, while *M. acaulis, M. emarginata* subsp. *emarginata, M. emarginata* subsp. *cuneiloba,* and *M. paleacea* were found at light intensity of 50-57%. The narrowest range was observed in *M. treubii, M. polymorpha,* and *Marchantia* sp. at light intensity of 54% to 57% (Fig. 7).

Marchantia species in North Sumatra were found in varied land cover, including plantation forests, primary forest border, including those with open ground, and dryland farming (Fig. 8). Furthermore, *M. emarginata* subsp. *cuneiloba* occupied the most varied land cover, including secondary dryland forest, primary border with dryland farming, primary border with plantation, and dryland farming. *M. emarginata* subsp. *emarginata* occupied secondary dryland forest land cover, secondary dryland forest border with plantation forest, and primary dryland farming border. *Marchantia acaulis* was found in plantation forest, primary border, as well as primary border with open ground, and dryland farming. *Marchantia polymorpha* occupied two types of land cover, namely scrub and dryland farming. Bowman (2015) described that the species *M. polymorpha* thrived in disturbed anthropogenic habitats throughout Europe and other continents.

Marchantia paleacea occupied two types of land cover, namely primary and dryland farming. Zheng and Shimamura (2022) reported that this species thrived in shaded or semi-shaded areas and anthropogenic regions. *Marchantia treubii* also occupied primary, and near the primary border with dryland farming, *M. geminata* thrives in primary and secondary dryland forest, while *Marchantia* sp. occupied only primary dryland forest.

Habitat characteristics occupied by *Marchantia* spp. in North Sumatra can be used as information for conservation efforts in future research due to their predominant distribution in lowlands. Additionally, the accessibility of some species shows the need for conservative efforts to prevent disturbance from humans.

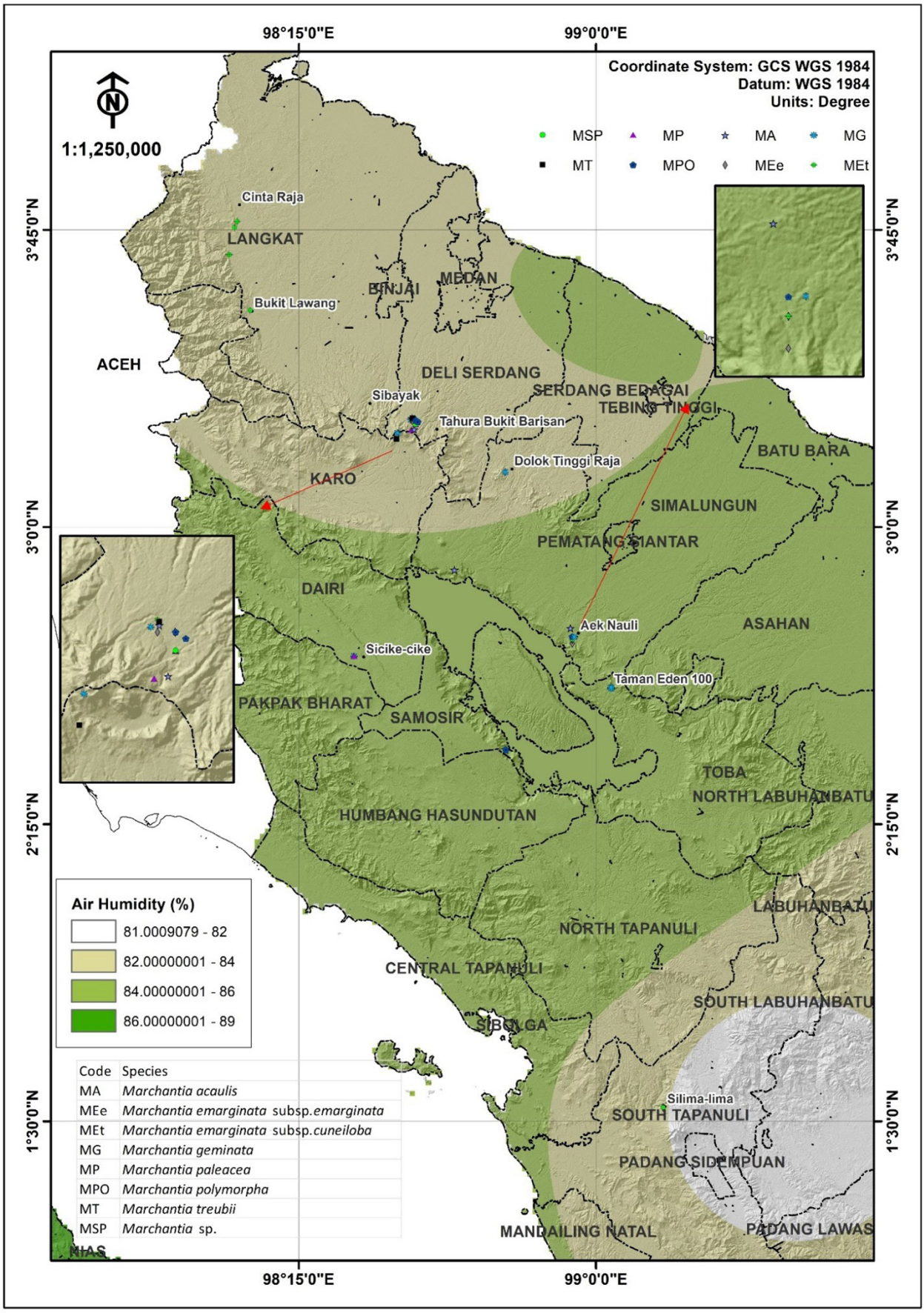

Figure 4 Map of the relationship between air humidity and distribution of *Marchantia* species

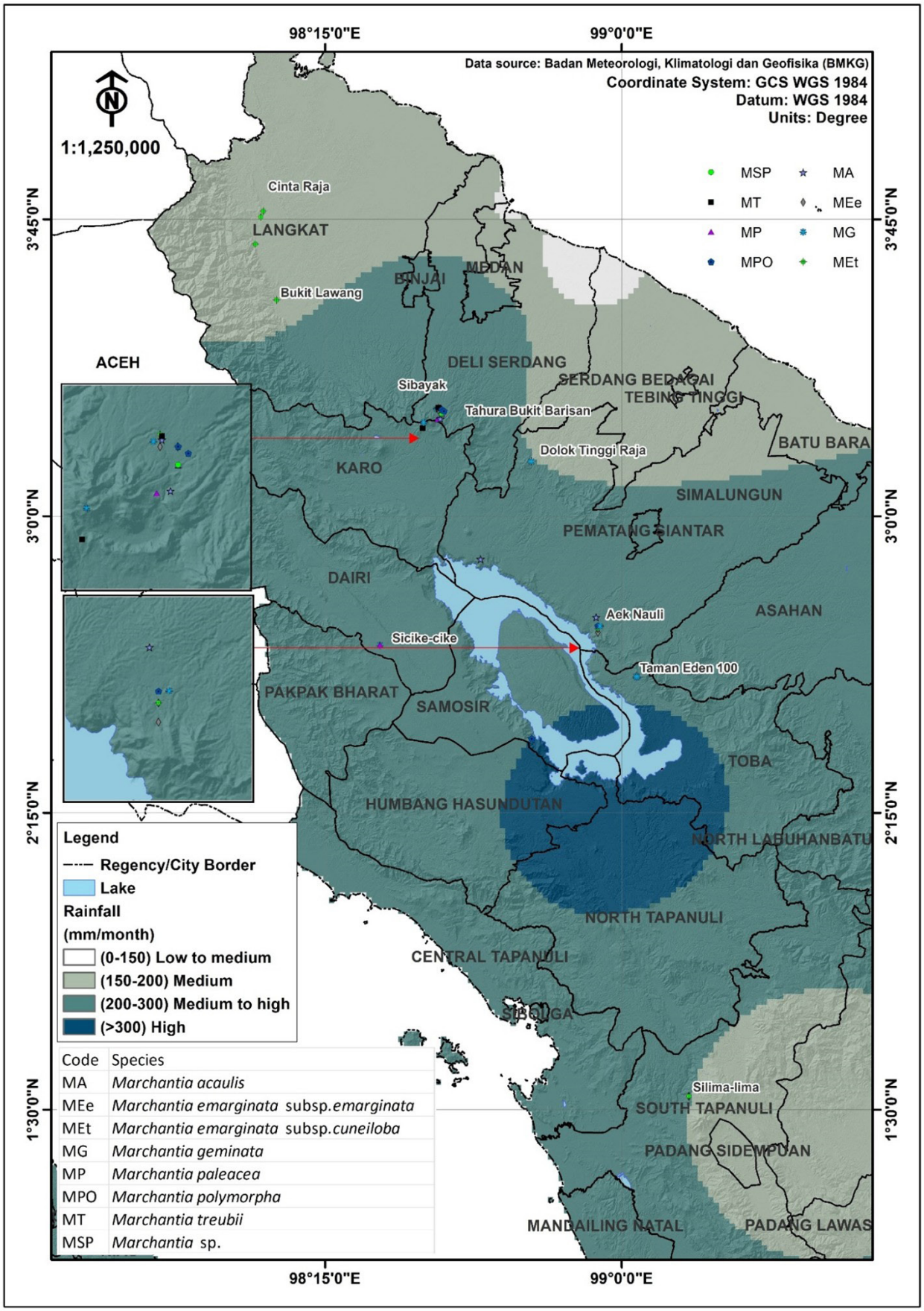

Figure 5 Map of the relationship between rainfall and distribution of *Marchantia* species

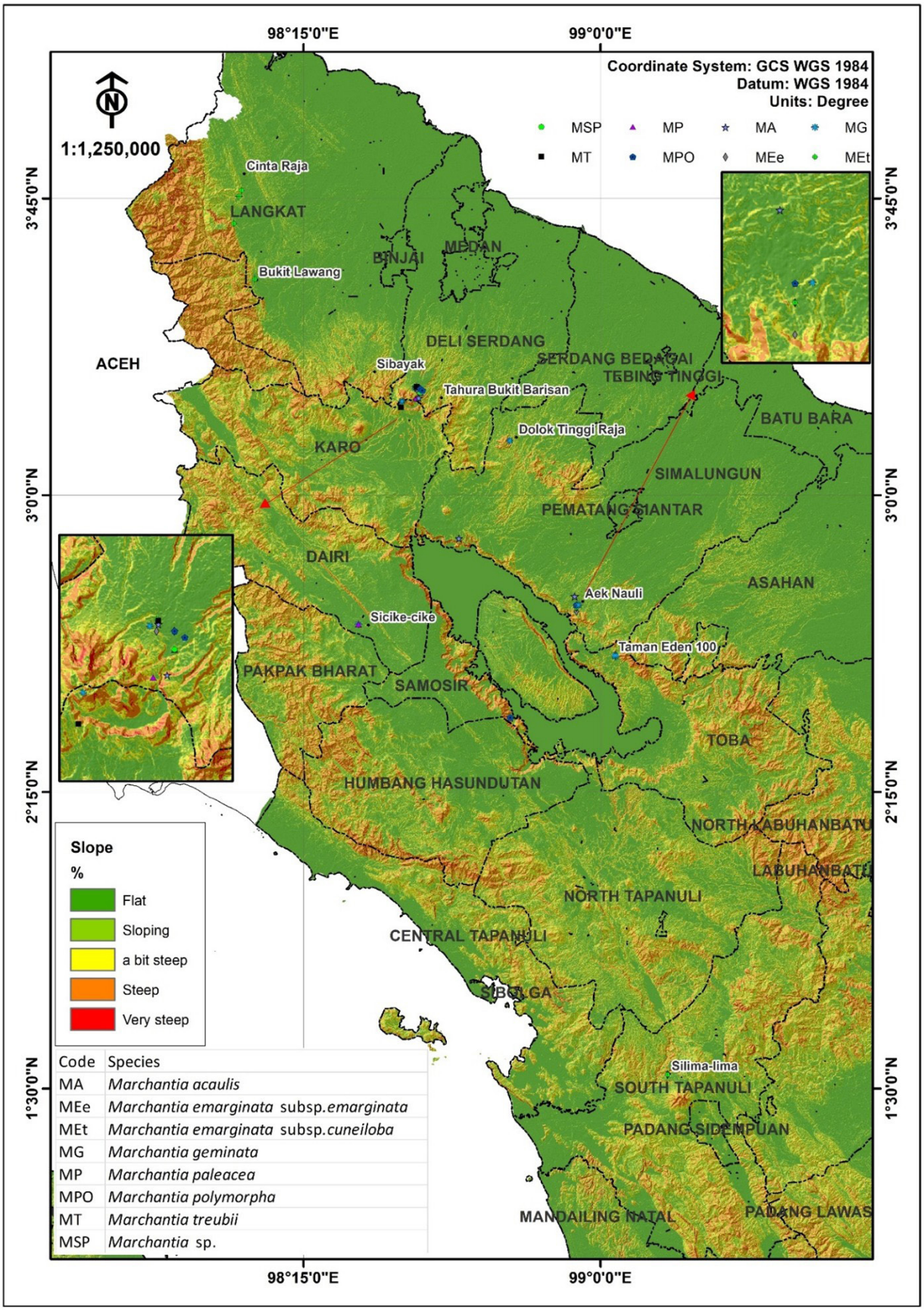

Figure 6 Map of the relationship between slope and distribution of *Marchantia* species

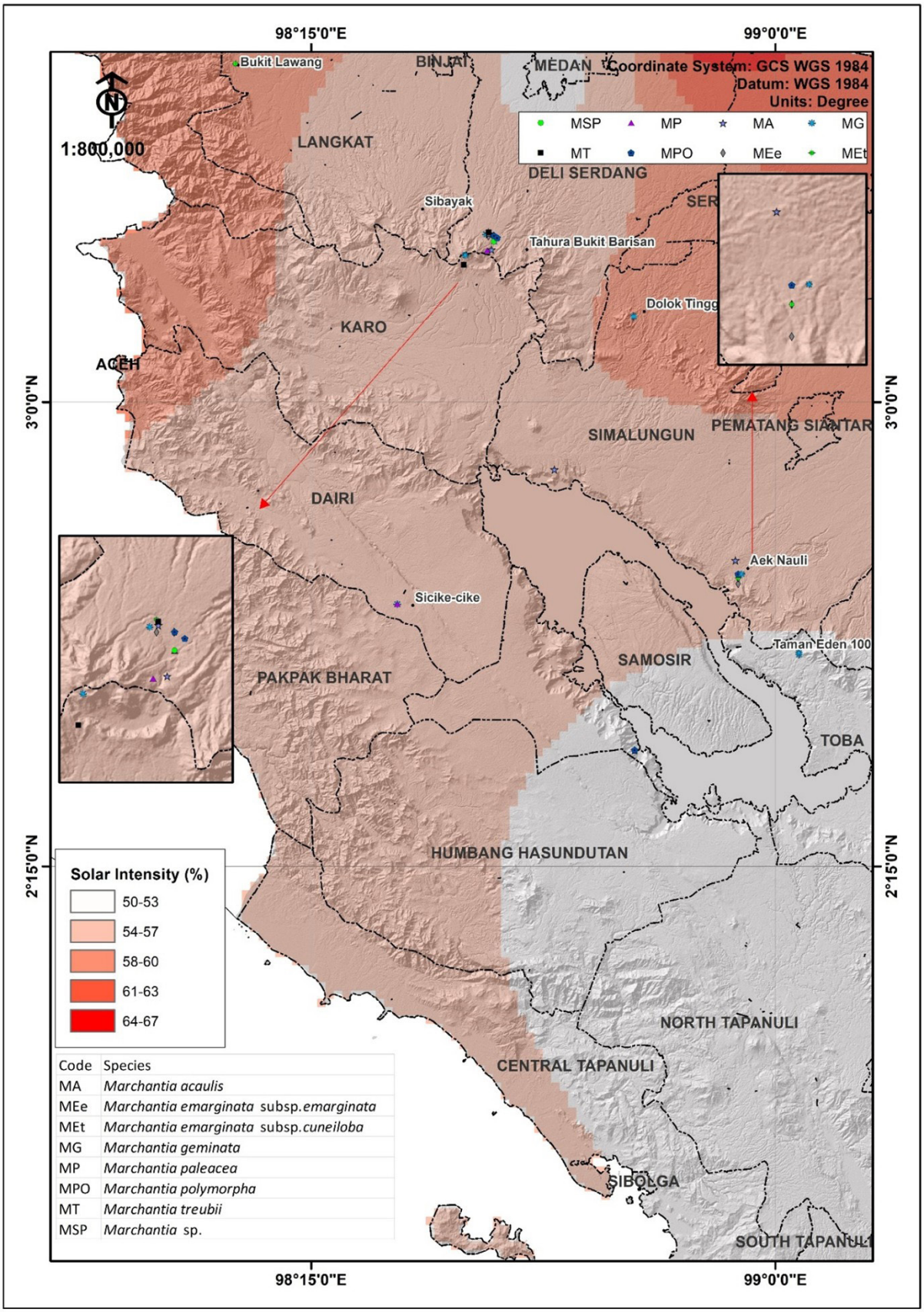

Figure 7 Map of the relationship between solar intensity and distribution of *Marchantia* species

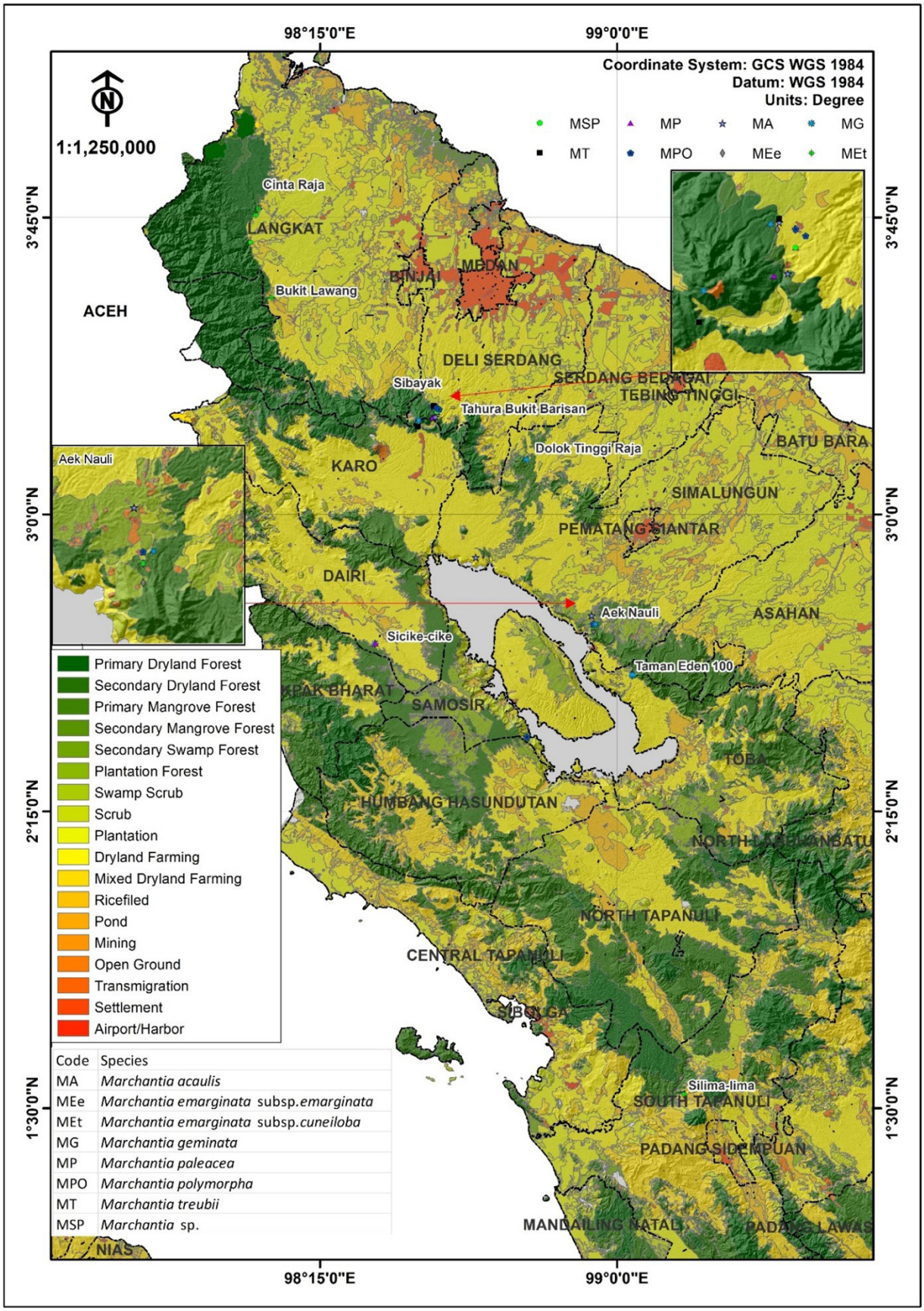

Figure 8 Map of the relationship between land cover and distribution of *Marchantia* species

CONCLUSION

Eight *Marchantia* taxa were found in North Sumatra, consisting of seven species and two subspecies, namely *M. acaulis, M. emarginata* subsp. *emarginata, M. emarginata* subsp. *cuneiloba*, *M. geminata, M. paleacea, M. polymorpha, M. treubii* and *Marchantia* sp. The most widely distributed species was *M. emarginata* subsp. *cuneiloba*, found in seven locations, including Bukit Lawang, Resort Cinta Raja, Silima-lima Waterfall, Sicike-cike Natural Park, Sibayak Mountain, Aek Nauli Forest, and Taman Eden 100 Natural Park. Species with the narrowest distribution were *Marchantia* sp. and *M. treubii*, found in Sibayak Mountain.

Distribution of *Marchantia* species in North Sumatra ranged from an altitude below 200 masl to 1,976 masl, with 1,800 mm/year to 3,600 mm/year rainfall, almost evenly distributed humidity of 82-86%, on flat to steep soil, and high light intensity of 52-60%. Distribution area was found to have 5 types of soil, namely orthic acrosols, humic andosols, orthic ferrasols, and humic cambisols. *Marchantia* species were found in various types of land cover, namely secondary forest, primary and secondary forest borders, dryland farming, primary and plantation borders, as well as plantations.

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