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Invasive alien plants on the northern slopes of Mount Merapi National Park (MMNP), Central Java, Indonesia

Tumbuhan asing invasif di lereng utara Taman Nasional Gunung Merapi (TNGM), Jawa Tengah, Indonesia

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Abstrak. *Fadhilah RN, Foresty RS, Fatin SK, Wela SMD, Izdihar RS, Setyawan AD. 2024. Tumbuhan asinga invasif di lereng utara Taman Nasional Gunung Merapi (TNGM), Jawa Tengah, Indonesia. Pros Sem Nas Masy Biodiv Indon 10: 45-53.* Salah satu tantangan besar bagi keberlanjutan keanekaragaman hayati adalah munculnya spesies asing invasif, yaitu organisme yang berasal dari suatu ekosistem yang memasuki ekosistem baru di luar habitat aslinya, yang dapat mengancam keberadaan spesies asli di dalamnya. Penelitian ini bertujuan untuk mengidentifikasi spesies asing invasif yang tersebar di kawasan Taman Nasional Gunung Merapi (TNGM), khususnya di lereng utara di Desa Samiran, Kecamatan Selo, Kabupaten Boyolali, Jawa Tengah, Indonesia. Penelitian ini dilaksanakan pada bulan November sampai dengan Desember 2023 di lereng utara TNGM dengan menggunakan metode eksploratif, yaitu metode penelitian yang dilakukan dengan menjelajahi seluruh wilayah penelitian. Penelitian ini menemukan data spesies asing invasif sebanyak 28 spesies, 17 famili, dan 3 habitus. Famili yang paling banyak ditemukan adalah Asteraceae dengan 6 spesies. Famili Oxalidaceae, Euphorbiaceae, Fabaceae, Poaceae, Polygonaceae, dan Solanaceae masing-masing memiliki 2 spesies. Famili Araceae, Cannabaceae, Commelinaceae, Convolvulaceae, Eupatoriceae, Mimosaceae, Lamiaceae, Piperaceae, Polygalaceae, dan Rubiaceae masing-masing memiliki 1 spesies. Dua spesies asing invasif, yaitu *Acacia decurrens* (Wendl.) Willd dan *Leucaena leucocephala* (Lam.) de Wit. perlu diwaspadai karena pertumbuhannya dapat mengancam keberhasilan pemulihan tanaman asli.

Kata kunci: Keanekaragaman hayati, metode eksplorasi, tumbuhan asing invasif, Taman Nasional Gunung Merapi

Abstract. *Fadhilah RN, Foresty RS, Fatin SK, Wela SMD, Izdihar RS, Setyawan AD. 2024. Invasive alien plants on the northern slopes of Mount Merapi National Park (MMNP), Central Java, Indonesia. Pros Sem Nas Masy Biodiv Indon 10: 45-53.* One of the big challenges to biodiversity sustainability is the emergence of invasive alien species, namely organisms originating from an ecosystem that enter a new ecosystem outside its natural habitat, which can threaten the existence of native species in it. This research aims to identify species of invasive alien species spreading in the Mount Merapi National Park (MMNP) area, especially on the northern slopes in Samiran Village, Selo Sub-district, Boyolali District, Central Java, Indonesia. The research was carried out from November to December 2023 on the northern slopes of MMNP using the exploratory method, a research method carried out by exploring the entire research area. This research found that data on invasive alien species amount to 28 invasive alien species, 17 families, and 3 habitus. The most commonly found family is Asteraceae with 6 species. Oxalidaceae, Euphorbiaceae, Fabaceae, Poaceae, Polygonaceae, and Solanaceae family have 2 species each. Araceae, Cannabaceae, Commelinaceae, Convolvulaceae, Eupatoriceae, Mimosaceae, Lamiaceae, Piperaceae, Polygalaceae, and Rubiaceae family each have 1 species. Two invasive alien species, namely *Acacia decurrens* (Wendl.) Willd and *Leucaena leucocephala* (Lam.) de Wit. need to be watched out for because their growth can threaten the success of restoration of native plants.

Keywords: Biodiversity, exploratory methods, invasive alien plants, Mount Merapi National Park

INTRODUCTION

Biodiversity is the variability between living organisms, including terrestrial, marine, and other aquatic ecosystems, and the ecological complexes of which these organisms are part (Haahtela 2019). Indonesia has a high biodiversity where many endemic or native species live; this is because Indonesia is a tropical country located on the equator (Suwarso et al. 2019). Biodiversity includes three levels, namely species diversity, genetic biodiversity, and ecosystem biodiversity, which have an important role in maintaining environmental balance (Siboro 2019). Biodiversity includes various morphological habitus such as herbaceous, shrubs, and trees. Herbaceous are plants whose stems are soft, contain water, and do not have wood (Hasan et al. 2023). Shrubs are plants that have branches

from the base and woody stems but are shorter and less large than trees (Bedair et al. 2020). Meanwhile, trees are perennial woody plants that have thin, tall stems and tend to have hardwood (Treml et al. 2019). Through long evolution, biodiversity continues to adapt to various environmental conditions. Likewise, biodiversity can also decrease due to several challenges, including climate change, extraction, pollution, and invasive alien species.

Invasive alien species are one of the big challenges for sustainable biodiversity. Invasive alien species originate from an ecosystem and then enter a new ecosystem outside their natural habitat (Pyšek et al. 2020). This species movement can be intentional or unintentional. This movement can occur in international trade, agricultural experiments, human travel, etc. (Montagnani et al. 2022). Suppose invasive alien species enter a new environment without natural predators or effective competitors. In that case, their development will accelerate, and the risk of competition between endemic or native species will increase. Competition occurs due to challenges in competing for areas or nutrients for use between endemic species and invasive alien species (Erarto and Getahun 2020). If invasive alien species consume excessive resources, it can cause nutrient availability for native species to decrease or disappear; the area will be controlled by invasive alien species, which will slowly displace endemic or native species (Salimi et al. 2021).

The Merapi area was designated as Mount Merapi National Park (MMNP), Indonesia in 2004 based on the Decree of the Minister of Forestry No.134/Menhut-II/2004 (Wijayati and Rijanta 2020). Mount Merapi National Park is a conservation area with the most active volcano in Indonesia, which functions as a water catchment area for the Central Java Province and Yogyakarta Special Region, Indonesia as well as an enclave of biodiversity (Marhaento and Faida 2015). Mount Merapi National Park is a type of tropical mountain forest that protects various species of flora and fauna (Sulaksono and Hadiyan 2015).

Part of the MMNP forest area was once a production forest. It was surrounded by community land, thereby increasing the potential for various species of invasive alien species that could threaten the native species and natural ecosystem of Mount Merapi (Gunawan et al. 2015). Several studies show that there are several species of dominant invasive plants that grow in the MMNP area, such as Green Acacia (*Acacia decurrens* (Wendl.) Willd), Anggrung (*Trema orientalis* (L.) Blume), and Anggring (*Trema canabina* Lour.) (Sadili et al. 2017). The Green Acacia plant is known to dominate the MMNP area, which is experiencing succession after the volcanic eruption (Ramadhan et al. 2020). The Green Acacia plant has unique characteristics that can reproduce in areas affected by the eruption because the plant seeds can grow easily (Afrianto et al. 2017). This plant can grow to be a pioneer, fast, and dominant in areas affected by the eruption of Mount Merapi (Suryawan et al. 2015). Therefore, *A. decurrens* has become an invasive plant in the Mount Merapi area. This research aims to identify invasive alien plant species spreading in the Mount Merapi National Park (MMNP) area, especially on the northern slopes located in Selo Sub-district, Boyolali District, Central Java, Indonesia.

MATERIALS AND METHODS

Study area

The research was conducted from November to December 2023 in the Mount Merapi National Park (MMNP) area, especially on the northern slopes located in Selo Sub-district, Boyolali District, Central Java, Indonesia (Figure 1). The MMNP area is geographically located at coordinates 07°22'33"-07°52'30" South Latitude and 110°15'00"-110°37'30" East Longitude. Administratively, MMNP is located in Magelang, Boyolali, Klaten, and Sleman districts, with an altitude of 600-2,968 m above sea level (Rahmayanti 2022). MMNP has a temperature between 22-33°C with air humidity between 22-33°C with air humidity between 80-99% (Nastiti and Suryani 2018).

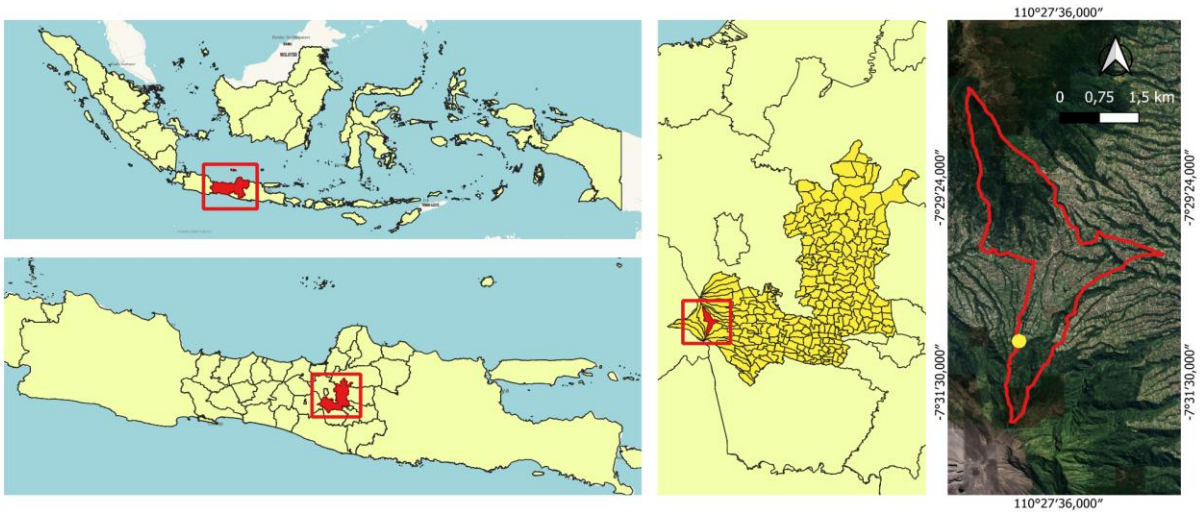

Figure 1. Map of the study area in the northern slope of Mount Merapi National Park, Boyolali District, Central Java, Indonesia

Procedures

The data obtained in this research is primary data and secondary data. Primary data is data taken through direct observation in the field in the form of data collection on plant species identified based on their morphological characteristics (Amboupe et al. 2019). Secondary data was obtained by conducting a literature study regarding invasive alien plant types in Indonesia, especially Mount Merapi, to identify invasive plant types in the research location. Maps of Mount Merapi were also collected via the GIS website. Discovering invasive species in this research was carried out using an exploratory method. Plant species observations were carried out directly in the observation area, namely along the edge of the northern slope of MMNP. The exploratory method is carried out by exploring the entire research area (Manlea et al. 2016). The book that is a reference for identifying invasive species is the book by Setyawatiet al. (2015). Each plant species was observed and identified based on its morphological characteristics, and then documentation was carried out on each type to facilitate the identification by literature study. The tools and materials used in this research were plants, tally sheets, and smartphones for taking pictures (Yuliana and Lekitoo 2018).

Data analysis

The obtained data is identified by species in the form of scientific name, family, and habitus. Then, a descriptive analysis is explained and presented in tables and pictures (Ratu et al. 2021).

RESULTS AND DISCUSSION

The MMNP area is a forest area that has experienced invasion, specifically on the northern slopes of Mount Merapi. The invasion in this area was caused by 28 species of invasive plants from various habitats, ranging from herbaceous, shrubs, and trees. It is recorded in Table 1 that there are 28 species of invasive alien species.

The data on invasive alien species in the table comprise 28 invasive alien species, 17 families, and 3 habitus. The Asteraceae family has the largest number of 6 species, followed by the families Euphorbiaceae, Fabaceae, Oxalidaceae, Poaceae, Polygonaceae, and Solanaceae (2 species each), as well as Araceae, Cannabaceae, Commelinaceae, Convolvulaceae, Eupatoriceae, Mimosaceae, Lamiaceae, Piperaceae, Polygalaceae, and Rubiaceae (1 species each). Meanwhile, according to habitat species, herbaceous species of alien invasive plants are the most common species with 17, followed by shrubs with 9, and trees with 2 invasive alien species (Some of species can be seen in Figures 2 and 3).

The dominant invasive plants in the Asteraceae family consist of *Conyza bonariensis* (L.) Cronquist, *Eupatorium intermedium* DC, *Erigeron bonariensis* L, *Mikania scandens* (L.) Willd, *Galinsoga parviflora* Cav, and *Gamochaeta purpurea* (L.) Cabrera. Meanwhile, the dominant species in the family of Commelinacea is *Tradescantia fluminensis* Vell; the Convolvulaceae family is *Ipomoea indica* (Burm.) Merr; the Eupatorieae family is *Eupatorium riparium* Sch.Bip. ex Schnittsp, the family of Lamiaceae is *Coleus scutellarioides* (L.) Benth.; the Oxalidaceae family, there are 2 species identified: *Oxalis latifolia* Kunth and *Oxalis corniculata* L. Furthermore, the Poaceae family identifies 2 species of plant species, namely *Eleusine indica* (L.) Gaertn and *Pennisetum purpureum* Schumach. In the Solanaceae family, 2 plant species are identified, namely *Brugmansia suaveolens* (Humb. & Bonpl. ex Wild.) Bercht. & J.Presl and *Physalis angulata* L. There are also 2 species in the Polygonaceae family, namely *Fallopia japonica* (Houtt.) Ronse Decr and *Persicaria barbata* (L.) H. Hara. Then there are also 2 species in the Fabaceae family, namely *A. decurrens* (Figure 4) and *Leucaena leucocephala* (Lam.) de Wit. Then, in the Polygalaceae family, one dominant species is *Polygala paniculata* L. The Rubiaceae family's dominant species is named *Borreria alata* L.

Table 1. List of invasive alien plant species in the northern slope of Mount Merapi National Park (MMNP), Selo Sub-district, Boyolali District, Central Java, Indonesia

Invasive alien species	Family	Habitus
Conyza bonariensis (L.) Cronquist	Asteraceae	Herbaceous
Eupatorium intermedium DC.	Asteraceae	Herbaceous
Erigeron bonariensis L.	Asteraceae	Herbaceous
Mikania scandens (L.) Willd	Asteraceae	Herbaceous
Galinsoga parviflora Cav.	Asteraceae	Herbaceous
Gamochaeta purpurea (L.) Cabrera	Asteraceae	Herbaceous
Tradescantia fluminensis Vell.	Commelinaceae	Herbaceous
Ipomoea indica (Burm.) Merr.	Convolvulaceae	Herbaceous
Eupatorium riparium Sch.Bip. ex Schnittsp	Eupatorieae	Herbaceous
Coleus scutellarioides (L.) Benth	Lamiaceae	Herbaceous
Oxalis latifolia Kunth	Oxalidaceae	Herbaceous
Oxalis corniculata L.	Oxalidaceae	Herbaceous
Eleusine indica (L.) Gaertn.	Poaceae	Herbaceous
Pennisetum purpureum Schumach.	Poaceae	Herbaceous
Polygala paniculata L.	Polygalaceae	Herbaceous
Persicaria barbata (L.) H. Hara	Polygonaceae	Herbaceous
Borreria alata L.	Rubiaceae	Herbaceous
Arisaema ringens (Thunb.) Schott	Araceae	Shrub
Trema orientalis (L.) Blume	Cannabaceae	Shrub
Croton hirtus L' Herit	Euphorbiaceae	Shrub
Claoxylon indicum (Reinw. ex Blume) Hassk.	Euphorbiaceae	Shrub
Calliandra calothyrsus Meisn.	Mimosaceae	Shrub
Piper aduncum L.	Piperaceae	Shrub
Fallopia japonica (Houtt.) Ronse Decr.	Polygonaceae	Shrub
Brugmansia suaveolens (Humb. & Bonpl. ex Wild.) Bercht. & J.Presl	Solanaceae	Shrub
Physalis angulata L.	Solanaceae	Shrub
Acacia decurrens (Wendl.) Willd	Fabaceae	Tree
Leucaena leucocephala (Lam.) de Wit.	Fabaceae	Tree

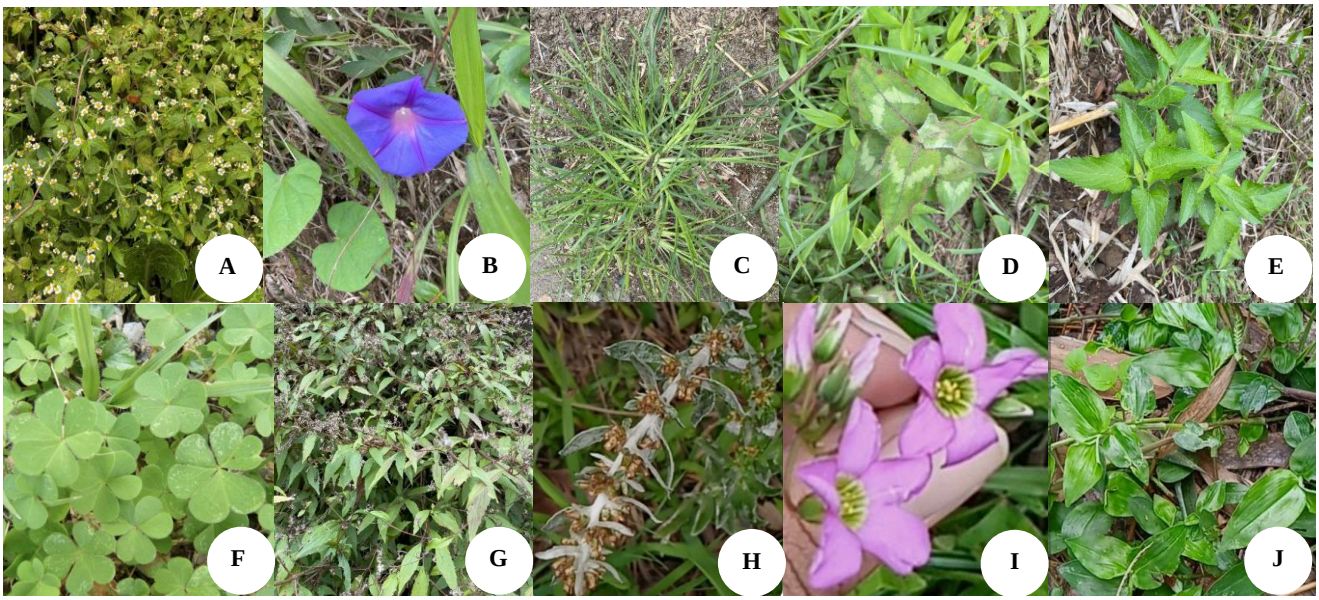

Figure 2. Herbaceous invasive alien plants on the northern slope of MMNP, Boyolali District, Central Java, Indonesia: A. *Galinsoga parviflora*; B. *Ipomoea indica*; C. *Eleusine indica*; D. *Coleus scutellarioides*; E. *Eupatorium riparium*; F. *Oxalis corniculata*; G. *Persicaria barbata;* H. *Gamochaeta purpurea;* I. *Oxalis latifolia;* J. *Tradescantia fluminensis*

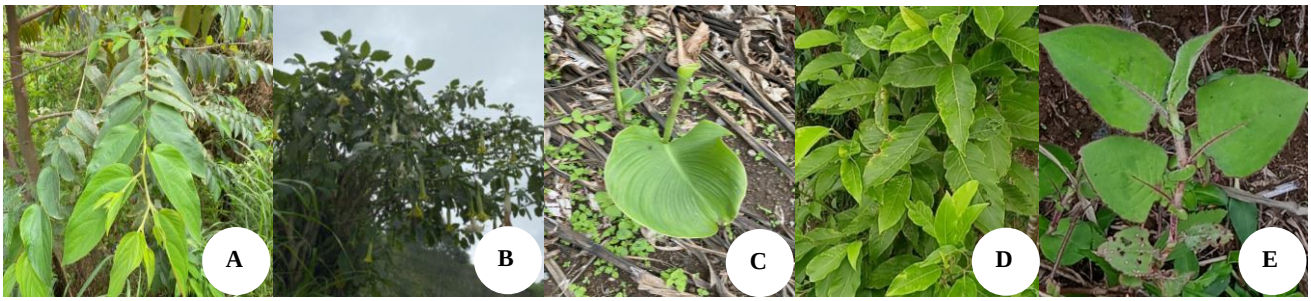

Figure 3. Shrub invasive alien plants on the northern slope of MMNP, Boyolali District, Central Java, Indonesia: A. *Trema orientalis;* B. *Arisaema ringens;* C. *Brugmansia suaveolens;* D. *Claoxylon indicum;* E. *Fallopia japonica*

Figure 4. Dominant tree invasive alien plants on the northern slope of MMNP, Boyolali District, Central Java, Indonesia: *Acacia decurrens*

Discussion

The identified invasive alien herbaceous species comprise 10 families, with the most numerous families namely Asteraceae. In Table 1, it can be seen that the most frequently identified species are herbaceous habitus species. The abundance of herbaceous species can be related to suitable microclimatic conditions in MMNP, especially light intensity (Cahyanto et al. 2021). Light intensity is an environmental limiting factor because high light intensity supports the regeneration of herbaceous vegetation growth (Rosleine et al. 2014). Basic vegetation grow abundant because it is in an open national park area and there are not many trees covering the land, so intense sunlight can easily enter. The most common herbaceous species are found in the Asteraceae family because this family grows well in tropical environments with high light intensity (Yuliana and Lekitoo 2018). In addition, this species is also considered invasive because it grows fast, is dominant, and has high adaptability (Suryawan et al. 2015). Herbaceous plants have high competitiveness, the ability to adapt quickly to all soil types, and high to dry humidity levels (Anaputra et al. 2015). These characteristics can

decrease the growth of other species because they can cause competition with native species, disrupt the food web, reduce biodiversity, and reduce the quality of the original habitat within it (Hermawan et al. 2017). In contrast, these invasive species also have the potential to become pioneer plants and even help increase soil fertility (Septiani et al. 2015).

In the Asteraceae family, the species *C. bonariensis* is considered invasive because it can colonize its environment (Diez de Ulzurrun et al. 2020). This plant can grow and adapt to various environmental conditions and produce seeds that can be spread easily through wind and water. The next species is *E. intermedium*; it is invasive because it produce many seeds, allowing it to grow and spread fast while inhibiting other species' growth. *Mikania scandens* also can produce many seeds, including invasive plant species (Hewavitharana et al. 2018).

Then, in the Commelinaceae family, the species *T. fluminensis* is an invasive species originating from Brazil and Argentina that has spread to Indonesia (Seitz and Clark 2016). This species can grow rapidly over several meters in one year, forming a dense cover in the ecosystem of native species in its area (Bidarlord et al. 2021). This plant effectively kill other plants by reducing exposure to natural light and competing with native plants for nutrition (Hogan and Myerscough 2017). This species has the ability to develop into new individuals quickly due to the ease of spreading their fragments carried by machines, humans, and animals (Macedo et al. 2016).

In the Convolvulaceae family, there is the species *I. indica* is considered invasive because it has a rapid and widespread development level, so it can quickly threaten and cover an area (Ẹshkevari et al. 2020). These invasive plant species in MMNP can undermine the conservation or restoration goals of biodiversity within it (Sohrabi et al. 2023). This species is invasive because it forms stem tangle that disrupts the ecosystem (Franco et al. 2021).

The Eupatorieae family has the species *E. riparium* is considered invasive because it has a high dispersal ability and grows so rapidly that it disturbs native species (Kusmana and Suwandhi 2019). This species can grow thickly and quickly in soil that is not very fertile and lacks nutrients, so that it can cause disturbance to other plants in the cultivation garden (Haryadi et al. 2019).

Then, the Lamiaceae family has *C. scutellarioides* is considered invasive because it has a higher level of nutrient absorption than other species, which can lead to competition between species for reproduction (Das and Paul 2023). This ability to absorb nutrients will result in competition with local species.

Then, the Oxalidaceae family has 2 species of species, one of which is *O. latifolia*, which is considered invasive because it has the ability to spread quickly and take over the natural habitat of other species (Handayani and Hidayati 2020). This species absorbs most soil's nutrients and moisture, inhibiting the growth of nearby plants and significantly impacting the nursery by causing the loss of other plants (Poudel et al. 2023); this species can be considered a threat to biodiversity (Benhabylès et al. 2020).

The Poaceae family has 2 species, one of which is *E. indica*, which is invasive because it has a high level of adaptation and grows rapidly at high light intensity (Rahmawati and Rosleine 2023). This species can develop very rapidly because its growth can produce more than 50,000 small seeds, which are easy to spread and have the ability to survive, making it an invasive species (Luchian et al. 2019).

The Polygalaceae family has 2 species, one of which is *P. paniculata*, which is considered invasive because of its strong presence that is difficult to control and can affect native biodiversity (Sunardi et al. 2017). This species originates from Brazil and has a negative impact on the environment because of its high resistance and ability to absorb nutrients from other plants (Cruz et al. 2021).

Finally, in the Rubiaceae family, the herbaceous habitus has *B. alata*, which is considered invasive because its rapid development and damage threaten biodiversity, giving rise to competition (Motmainna et al. 2021). This invasive plant has a greater ability than other plants to colonize other habitats (Freeman et al. 2015) and easily react to environmental changes caused by humans and other factors (Wahyuni et al. 2016).

The species of invasive alien species identified in the shrub habitus comprise 7 families, and the Euphorbiaceae and Solanaceae have 2 species, respectively, followed by Araceae, Polygonaceae, Cannabaceae, Mimosaceae, and Piperaceae with 1 species each. Invasive alien plants from shrub habits include *Arisaema ringens* (Thunb.) Schott, *T. orientalis*, *Croton hirtus* L' Herit, *Claoxylon indicum* (Reinw. ex Blume) Hassk., *Calliandra calothyrsus* Meisn., *Piper aduncum* L., *F. japonica*, *B. suaveolens*, and *P. angulata*. The results of this study follow Sutomo (2018), who reported that several invasive alien plants acted as pioneers in the vegetation of Mount Merapi after the eruption; some of these species are *Imperata cylindrica* (L.) Raeusch., *E. riparium*, *Anaphalis javanica* Sch.Bip., *C. calothyrsus*, and *Polyosma ilicifolia* Blume.

Invasive plants with a shrub habit dominate many ecosystems because they spread easily, have high growth rates, colonize areas quickly, and have seeds that can be easily carried by animals or humans (Mukarromah et al. 2020). Shrub vegetation can grow rapidly in areas where sunlight can penetrate the forest floor (Azrai and Heryanti 2015). Invasive plants with a shrub habitus have the potential to form dense and dense clumps after invading and taking over an area. This causes the growth of seeds and seedlings from native plants to be hampered or even unable to grow well (Yuliana and Lekitoo 2018).

Arisaema ringens is an invasive alien plant from the Araceae family and a native species from Asia, especially Japan (Ono et al. 2022). Invasive alien species from the Araceae family were introduced globally through horticulture by growing on house walls, fences, and roadsides and multiplying very quickly vegetatively so that they are so dense that it is difficult to count the number of individuals (Rahma et al. 2024).

Trema orientalis is a fast-growing and pioneering plant that can reproduce on critical land and has a larger canopy diameter than other species (Utami et al. 2021). According

to Rahadiantoro (2021), *T. orientalis* is an advanced pioneer plant often used for land rehabilitation. This species can grow in nutrient-poor soil and chromite overburden (Florentino et al. 2021). *Trema orientalis* is classified as a fast-growing species because it has a good level of dominance, regeneration, and invasive potential (Mangopang 2016).

Croton hirtus and *Claoxylon indicum* are alien wild plants from the Euphorbiaceae family known in Indonesia as distance; this is a native American plant that has the potential to become a weed in tea plants (Setyawati et al. 2015). According to Bhavana et al. (2020), this plant is an aggressive weed that can grow anywhere, such as trash cans, plantations, and roadsides.

Calliandra calothyrsus is an alien plant from southwest Panama to southern Mexico, which was introduced in the 1930s to provide firewood and animal feed (Sayfulloh et al. 2020). Calliandra can grow in various species of soil, including sandy loam and acid soil, is easy to plant, has great productivity, and is able to adapt to new environments (Amirta et al. 2016). *Calliandra calothyrsus* becomes an invasive species because it easily germinates and grows so that it has a high density, which will eventually defeat native species and reduce biodiversity (Supartono et al. 2019). The spread of this species can occur because arable land within an area has become open land (Utami et al. 2022). Therefore, *C. calothyrsus* must be avoided to conserve both in-situ and ex-situ plants (Suhendar et al. 2020).

Piper aduncum is an alien plant from South America, first introduced in 1860 as an ornamental plant (Wibawa et al. 2019). This species is considered the most invasive species of the Piper genus that displaces native species, slows forest recovery, and has the potential to become weeds on vacant land, especially on land that does not have a canopy (Padmanaba and Sheil 2014). *Piper aduncum* has a detrimental effect on soil microbiota, namely reducing soil microbiota biomass and nutrients in it, being able to inhibit the process of nutrient replacement, and reducing its availability so that plant growth in the affected soil becomes inhibited (Kukla et al. 2022).

Fallopia japonica are invasive alien species originating from the Polygonaceae family. The species from the Polygonaceae family, namely *F. japonica* is reportedly very competitive towards native plants, invertebrate groups, and soil nutrient cycles and is even considered one of the worst invasive alien species in the world (Mincheva et al. 2016). This plant invasion is increasing globally and threatens biodiversity, ecosystems, and agriculture (Keshavarzi and Mosaferi 2020). This plant invades a habitat by blocking sunlight due to its rapid growth and dense root tissue, which causes soil collapse and erosion of river banks in the alluvial zone, increasing the risk of flooding (Quinty et al. 2022).

Brugmansia suaveolens and *P. angulata* are two invasive alien species from the Solanaceae family. *Brugmansia suaveolens* was first recorded as coming to Indonesia in 1893 in Jakarta, where this species is native to South America (Kudo et al. 2014). *Brugmansia suaveolens* is reported to spread rapidly and reduce forest productivity (Handayani and Hidayati 2020). This species generally invades along river streams, river banks, and highlands (Witt et al. 2018). *Brugmansia suaveolens* can grow and develop into invasive alien species easily in any moist area; this species has seeds that are easily spread by the wind (Abimanyu 2021).

Physalis angulata is an invasive alien plant from America with a relatively high growth rate and large fruit productivity. It can adapt to varying environmental conditions to attack native species communities (Balah and Balah 2022). *Physalis angulata* has a good survival ability and is able to survive in various water pressures and high salinity conditions (Ozaslan et al. 2016). In addition, *P. angulata* is an annual plant capable of producing large quantities of seeds stored in soil seed banks even under adverse environmental conditions (Ozaslan et al. 2017). This certainly increases the invasiveness rate of this species.

The invasive alien species identified in tree habitus from Fabaceae are 2 species. Invasive alien plants from tree habitus include *A. decurrens* and *L. leucocephala*. According to Pambudi and Purwaka (2019), invasive alien plants in Indonesia are dominated by tree habitus with a percentage of 32%, herbs 17%, and shrubs 15%. *Acacia decurrens* is a native species from Australia, which was introduced to the Merapi area by Perhutani. However, this species dominates the Merapi area, which is experiencing succession after the 2010 eruption by changing the structure and composition of the vegetation (Ramadhan et al. 2020). *Acacia decurrens* is invasive in a way that threatens the success of restoration of native plant areas because it is a fast-growing species in both diameter and height (Sutomo 2019).

Leucaena leucocephala from the Fabaceae family is an invasive alien species originating from Mexico and Central America; this species is included in the top five terrestrial invasive plant species globally (Sharma et al. 2022). *Leucaena leucocephala* dominates roadsides, hillsides, forest edges, riverine habitats, and wastelands by inhibiting the regeneration process of native species and producing seeds throughout the year in large quantities that can be carried by animals and can survive for more than three decades (Kato-Noguchi and Kurniadie 2022). *Leucaena leucocephala* has fast biomass growth and tends to dominate an area, inhibiting other species' development (Hidayati et al. 2023).

The research concluded that on the northern slopes of MMNP, many invasive alien species can threaten this protected area; 28 invasive alien species are embedded in 3 habitats and 17 families. Herbaceous habitus is the habitat with the most invasive species (17 species), dominated by the Asteraceae family (6 species), followed by shrubs with 9 and trees with 2. Among all the invasive species found in the area, the presence of *A. decurrens* and *L. leucocephala* need to be wary because it can threaten the restoration of native plants' success.

REFERENCES

Abimanyu E. 2021. Analisis Risiko Invasive Alien Species (IAS) Kecubung (*Brugmansia suaveolens*) di Resort Cibodas Taman Nasional Gunung Gede Pangrango. Institut Pertanian Bogor, Bogor. [Indonesian]

Afrianto WF, Hikmat A, Widyatmoko D. 2017. Growth and habitat preference of *Acacia decurrens* Willd. (Fabaceae) after the 2010 eruption of Mount Merapi, Indonesia. Asian J Appl Sci 5 (1): 65-72.

Amboupe DS, Hartana A, Purwanto DY. 2019. Kajian etnobotani tumbuhan pangan Masyarakat Suku Bentong di Kabupaten Barru Sulawesi Selatan-Indonesia. Media Konservasi 24 (3): 278-286. DOI: 10.29244/medkon.24.3.278-286. [Indonesian]

Amirta R, Yuliansyah AEM, Ananto BR, Setiyono B, Haqiqi MT, Septiana HA, Lodong M, Oktavianto RN. 2016. Plant diversity and energy potency of community forest in East Kalimantan, Indonesia: Searching for fast growing wood species for energy production. Nusantara Biosci 8 (1): 22-31. DOI: 10.13057/nusbiosci/n080106.

Anaputra D, Miswan M, Ramadhanil R. 2015. Komposisi jenis tumbuhan herba di areal kampus Universitas Tadulako Palu. Biocelebes 9 (2): 26-34. [Indonesian]

Azrai E, Heryanti E. 2015. Biodiversitas tumbuhan semak di hutan tropis dataran rendah Cagar Alam Pangandaran, Jawa Barat. Semirata 4 (1): 403-408. [Indonesian]

Balah MA, Balah AM. 2022. Growth and ecological characteristics of *Physalis angulata* invasive weed species in several invaded communities. Biologia 77 (2): 325-338. DOI: 10.1007/s11756-021-00944-1.

Bedair H, Shaltout K, Ahmed D, Sharaf El-Din A, El-Fahhar R. 2020. Characterization of the wild trees and shrubs in the Egyptian flora. Egypt J Bot 60 (1): 147-168.

Benhabylès L, Djebbar R, Miard F, Nandillon R, Morabito D, Bourgerie S. 2020. Biochar and compost effects on the remediative capacities of *Oxalis pes-caprae* L. growing on mining technosol polluted by Pb and As. Environ Sci Pollut Res 27: 30133-30144. DOI: 10.1007/s11356-020-08833-x.

Bhavana R, Rajan R, Thomas B. 2020. Comparative studies on morphology, anatomy and phytochemistry of selected species of *Croton* L. (Euphorbiaceae). Plant Arch 20 (1): 639-656.

Bidarlord M, Kahneh E, Tokasi S, Mirghasemi ST. 2021. Introducing the invasive species, *Tradescantia fluminensis* for the flora of Iran, with emphasis on its risk assessment. Rostaniha 22 (1): 56-66.

Cahyanto T, Yuni BN, Efendi M. 2021. Zonation drives the abundance of understory exotic plant species in Ir. Djuanda Forest Park, West Java. Elkawnie: J Islamic Sci Technol 7 (1): 156-171. DOI: 10.22373/ekw.v7i1.6950.

Cruz FN, Ferreira de Paula A, Nogueira CT, Marques de Andrade PH, Borges LM, Lacava PT, Camargo ILBC, Anibal F, Paiva de Sousa C. 2021. Discovery of a novel lineage *Burkholderia cepacia* ST 1870 endophytically isolated from medicinal *Polygala paniculata* which shows potent in vitro antileishmanial and antimicrobial effects. Intl J Microbiol 2021: 1-17. DOI: 10.1155/2021/6618559.

Das P, Paul KK. 2023. Hydroponic rhizofiltration of dairy wastewater by *Coleus Scutellarioides* & *Portulaca oleracea*. J Water Process Eng 52: 103589. DOI: 10.1016/j.jwpe.2023.103589.

Diez de Ulzurrun P, Acedo MB, Garavano ME, Gianelli V, Ispizua VN. 2020. Analysis of the agronomic interest characteristics for the management of *Conyza blakei*, *Conyza bonariensis*, *Conyza sumatrensis*, and *Conyza lorentzii*. Agrociencia (Uruguay) 24 (1): 1-14. DOI: 10.31285/AGRO.24.112.

Erarto F, Getahun A. 2020. Impacts of introductions of alien species with emphasis on fishes. Intl J Fish Aquat Stud 8 (5): 207-216.

Ẹshkevari TA, Jalili A, Zare H. 2020. Investigation of invasive species and their biological hazards on the biodiversity of *Hyrcanian* species and introduction of *Ipomoea indica* as an invasive species for the first time from Iran. Iran Nat 5 (3): 35-48.

Florentino K, Pogosa JO, Armecin RB, Bande MJM. 2021. Growth performance of *Trema orientalis* L. (Blume) Ulm. seedlings in response to mineral nutrient omission. Environ Rural Dev 12 (1): 60-65.

Franco LA, Moreno-Casasola P, Cisneros RL, Pérez-Salicrup D. 2021. Ecological and hydrological considerations for climber weed control in freshwater forested wetland restoration project on the Gulf of Mexico. Preprint 2021: 1-18. DOI: 10.21203/rs.3.rs-392954/v1.

Gunawan H, Heriyanto NM, Subiandono E, Mas'ud AF, Krisnawati H. 2015. Invasi jenis eksotis pada areal terdegradasi pasca erupsi di Taman Nasional Gunung Merapi. Pros Sem Nas Masy Biodiv Indon 1 (5): 1027-1033. DOI: 10.13057/psnmbi/m010511. [Indonesian]

Haahtela T. 2019. A biodiversity hypothesis. Allergy 74 (8): 1445-1456. DOI: 10.1111/all.13763.

Handayani A, Hidayati S. 2020. Utilization of Invasive Alien Species (IAS) by communities around Cibodas Biosphere Reserve (CBR): A recommendation for invasive alien species management and policy. IOP Conf Ser: Earth Environ Sci 533 (1): 012017. DOI: 10.1088/1755-1315/533/1/012017.

Haryadi, Sunarto, Sugiyarto. 2019. Vegetation analysis of the secondary forest area in Cangkringan Resort, Mount Merapi National Park. J Biodjati 4 (1): 50-57. DOI: 10.15575/biodjati.v4i1.4239.

Hasan H, Mayefis D, Silvyana AE, Yusuf B, Nisaa NRK, Sari DRT, Sari DM. 2023. Botani Farmasi. Get Press Indonesia, Padang. [Indonesian]

Hermawan R, Hikmat A, Prasetyo LB, Setyawati T. 2017. Model sebaran spasial dan kesesuaian habitat spesies invasif mantangan (*Merremia peltata* (L.) Merr.) di Taman Nasional Bukit Barisan Selatan. J Nusa Sylva 17 (2): 80-90. [Indonesian]

Hewavitharana N, Kannangara SDP, Jayasekera LR, Weerasinghe P. 2018. Determination of nutrients and fiber contents of seven invasive plants and their decomposition rates. Trop Plant Res 5 (3): 286-291. DOI: 10.22271/tpr.2018.v5.i3.036.

Hidayati E, Syafikri D, Ramdhani MR, Salsabila NP. 2023. Keanekaragaman jenis dan kerapatan vegetasi hutan pantai di Selatan Pulau Sumbawa, Kecamatan Labangka, Kabupaten Sumbawa. J Sains Teknologi Lingkungan 9 (2): 352-367. DOI: 10.29303/jstl.v9i2.437. [Indonesian]

Hogan AB, Myerscough MR. 2017. A model for the spread of an invasive weed, *Tradescantia fluminensis*. Bull Math Biol 79: 1201-1217. DOI: 10.1007/s11538-017-0280-7.

Kato-Noguchi H, Kurniadie D. 2022. Allelopathy and allelochemicals of *Leucaena leucocephala* as an invasive plant species. Plants 11 (13): 1672. DOI: 10.3390/plants11131672.

Keshavarzi M, Mosaferi S. 2020. Genetic variability of invasive species, *Fallopia convolvulus* (Polygonaceae) in Iran. Plant Biosyst-Intl J Deal Aspects Plant Biol 154 (3): 369-375. DOI: 10.1080/11263504.2019.1635218.

Kudo Y, Mutaqien Z, Simbolon H, Suzuki E. 2014. Spread of invasive plants along trails in two national parks in West Java, Indonesia. Tropics 23 (3): 99-110. DOI: 10.3759/tropics.23.99.

Kukla J, Heděnec P, Baldrián P, Cajthaml T, Novotný V, Moradi J, Frouz J. 2022. The invasive tree *Piper aduncum* alters soil microbiota and nutrient content in fallow land following small scale slash-and-burn farming in tropical lowland forest in Papua New Guinea. Appl Soil Ecol 176: 1-9. DOI: 10.1016/j.apsoil.2022.104487.

Kusmana C, Suwandhi I. 2019. Diversity of plant species and the presence of Invasive Alien Species (IAS) in the Sub-Montane Forest at Pakenjeng Region, Southern Part of Garut, West Java. IOP Conf Ser: Earth Environ Sci 399 (1): 012035. DOI: 10.1088/1755-1315/399/1/012035.

Luchian V, Georgescu MI, Savulescu E, Popa V. 2019. Some aspects of morpho-anatomical features of the invasive species *Eleusine indica* (L.) Gaertn. Sci Papers Ser A Agron 62 (1): 529-537.

Macedo DM, Pereira OL, Júnior BTH, Weir BS, Barreto RW. 2016. Mycobiota of the weed *Tradescantia fluminensis* in its native range in Brazil with particular reference to classical biological control. Australas Plant Pathol 45: 45-56. DOI: 10.1007/s13313-015-0388-x.

Mangopang AD. 2016. Morfologi *Trema orientalis* (L.) Blume dan manfaatnya sebagai tanaman pionir restorasi tambang nikel. Prosiding Seminar Nasional Biologi 2 (1): 121-126. [Indonesian]

Manlea H, Ledheng L, Sama YM. 2016. Faktor-faktor penyebab kerusakan ekosistem terumbu karang di Perairan Wini Kelurahan Humusu C Kecamatan Insana Utara Kabupaten Timor Tengah Utara. Bio-Edu: Jurnal Pendidikan Biologi 1 (2): 21-23. DOI: 10.32938/ag.v1i02.100. [Indonesian]

Marhaento H, Faida LRW. 2015. Risiko kepunahan keanekaragaman hayati di Taman Nasional Gunung Merapi: Tinjauan Spasial. J Ilmu Kehutanan 9 (2): 75-84. DOI: 10.22146/jik.10189. [Indonesian]

Mincheva T, Barni E, Siniscalco C. 2016. From plant traits to invasion success: Impacts of the alien *Fallopia japonica* (Houtt.) Ronse Decraene on two native grassland species. Plant Biosyst-Intl J Deal Aspects Plant Biol 150 (6): 1348-1357. DOI: 10.1080/11263504.2015.1115437.

Montagnani C, Gentili R, Brundu G, Caronni S, Citterio S. 2022. Accidental introduction and spread of top invasive alien plants in the European Union through Human-Mediated Agricultural Pathways: What should we expect? Agronomy 12 (2): 423. DOI: 10.3390/agronomy12020423.

Motmainna M, Juraimi AS, Uddin MK, Asib NB, Islam AM, Hasan M. 2021. Bioherbicidal properties of *Parthenium hysterophorus*, *Cleome rutidosperma* and *Borreria alata* extracts on selected crop and weed species. Agronomy 11 (4): 643. DOI: 10.3390/agronomy11040643.

Mukarromah M, Hayati A, Zayadi H. 2020. Analisis keanekaragaman tumbuhan invasif di Kawasan Hutan Pantai Balekambang Desa Srigonco Kecamatan Bantur Kabupaten Malang. J Ilmiah Biosaintropis (Bioscience-Tropic) 6 (1): 46-53. DOI: 10.33474/e-jbst.v6i1.296. [Indonesian]

Nastiti KA, Suryani T. 2018. Eksplorasi dan Inventarisasi Tumbuhan Pteridophyta di Kawasan Hutan Bagian Timur Lereng Gunung Merapijawa Tengah Via Selo Boyolali. Prosiding Seminar Nasional Pendidikan Biologi dan Saintek Ke-3. [Indonesian]

Ono T, Nejima R, Kinoshita K, Mori Y, Iwasaki T, Miyata K. 2022. *Pseudomembranous conjunctivitis* following Exposure to *Arisaema ringens* sap: A case report. Case Rep Ophthalmol 13 (2): 350-354. DOI: 10.1159/000524726.

Ozaslan C, Farooq S, Onen H, Bukun B, Ozcan S, Gunal H. 2016. Invasion potential of two tropical Physalis species in arid and semi-arid climates: Effect of water-salinity stress and soiltypeson growth and fecundity. PloS One 11 (10): e0164369. DOI: 10.1371/journal.pone.0164369.

Ozaslan C, Farooq S, Onen H, Ozcan S, Bukun B, Gunal H. 2017. Germination biology of two invasive *Physalis* species and implications for their management in arid and semi-arid regions. Sci Rep 7 (1): 16960. DOI: 10.1038/s41598-017-17169-5.

Padmanaba M, Sheil D. 2014. Spread of the invasive alien species *Piper aduncum* via logging roads in Borneo. Trop Conserv Sci 7 (1): 35-44. DOI: 10.1177/194008291400700108.

Pambudi PA, Purwaka TH. 2019. Analisis kebijakan penyediaan lahan bagi pembangunan dengan kewajiban penanggulangan dan pencegahan dinamika tumbuhan invasif di Indonesia. Enviro Sci 15 (3): 380-389. DOI: 10.20527/es.v15i3.7431. [Indonesian]

Poudel A, Adhikari P, Na CS, Wee J, Lee DH, Lee YH, Hong SH. 2023. Assessing the potential distribution of *Oxalis latifolia*, a rapidly spreading weed, in East Asia under global climate change. Plants 12 (18): 3254. DOI: 10.3390/plants12183254.

Pyšek P, Hulme PE, Simberloff D et al. 2020. Scientists' warning on invasive alien species. Biol Rev 95 (6): 1511-1534. DOI: 10.1111/brv.12627.

Quinty V, Colas C, Nasreddine R, Nehmé R, Piot C, Draye M, Chatel G. 2022. Screening and evaluation of dermo-cosmetic activities of the invasive plant species *Polygonum cuspidatum*. Plants 12 (1): 83. DOI: 10.3390/plants12010083.

Rahadiantoro A. 2021. Inventarisasi tumbuhan dan struktur vegetasi di Kawasan Hutan Ledug, Tahura R. Soerjo. Prosiding Seminar Nasional Biologi 7 (1): 377-388. [Indonesian]

Rahma AM, Mulyana FW, Akbar RTM. 2024. Inventarisasi dan pemanfaatan jenis tumbuhan invasif di Perumahan Bumi Panyileukan Kota Bandung. Konstanta: J Matematika Ilmu Pengetahuan Alam 2 (1): 185-193. [Indonesian]

Rahmawati R, Rosleine D. 2023. Spatial distribution of invasive plants in Bandung, West Java, Indonesia. Biotropia 30 (2): 171-182. DOI: 10.11598/btb.2023.30.2.1780.

Rahmayanti L. 2022. Literature Review: Analisis potensi pengelolaan Kawasan Taman Nasional Gunung Merapi (MMNP) berdasarkan zona untuk pelestarian ekosistem daratan. J Sains Edukatika Indonesia (JSEI) 4 (1): 29-35. [Indonesian]

Ramadhan R, Mursyid H, Adriyanti DT, Triwanto J, Triwaskitho N. 2020. Pertumbuhan jenis invasif *Acacia decurrens* willd. dan pengaruh naungannya terhadap tanaman restorasi. Biotropika: J Trop Biol 8 (2): 71-78. DOI: 10.21776/ub.biotropika.2020.008.02.02. [Indonesian]

Ratu MR, Laoh OEH, Pangemanan PA. 2021. Identifikasi biaya pengendalian hama dan penyakit pada beberapa tanaman hortikultura di Desa Palelon Kecamatan Modoinding. Agri-Sosioekonomi 17 (2): 383-390. DOI: 10.35791/agrsosek.17.2.2021.33893. [Indonesian]

Rosleine D, Suzuki E, Sundawiati A, Septiana W, Ekawati D. 2014. The effect of land use history on natural forest rehabilitation at corridor area of Gunung Halimun Salak National Park, West Java Indonesia. Reinwardtia 14 (1): 85-99. DOI: 10.14203/reinwardtia.v14i1.399.

Sadili A, Yulizah S, Deden G. 2017. Analisis tumbuhan invasif dominan paska enam tahun erupsi sebagai tumbuhan pioner di Taman Nasional Gunung Merapi (MMNP) Yogyakarta. Prosiding 2017: 65-74. DOI: 10.1186/s41200-021-00206-8. [Indonesian]

Salimi PA, Creed JC, Esch MM, Fenner D, Jaafar Z, Levesque JC, Sweet M. 2021. A review of the diversity and impact of invasive non-native species in tropical marine ecosystems. Mar Biodivers Rec 14 (1): 11.

Sayfulloh A, Riniarti M, Santoso T. 2020. Jenis-jenis tumbuhan asing invasif di Resort Sukaraja Atas, Taman Nasional Bukit Barisan Selatan. J Sylva Lestari 8 (1): 109-120. DOI: 10.23960/jsl18109-120. [Indonesian]

Seitz JC, Clark MW. 2016. Identification, biology, and control of small-leaf spiderwort (*Tradescantia fluminensis*): A widely introduced invasive plant. EDIS 2016 (6): 7-7. DOI: 10.32473/edis-ss652-2016.

Septiani D, Gunawan H, Sofiyanti N. 2015. Komunitas vegetasi pionir dan perkiraan akumulasi biomassa pada lahan gambut bekas terbakar di Area Transisi Cagar Biosfer Giam Siak Kecil – Bukit Batu Riau. JOM FMIPA 2 (1): 188-197. [Indonesian]

Setyawati T, Narulita S, Bahri IP, Raharjo GT. 2015. A Guide Book to Invasive Plant Species in Indonesia. Bogor: Research, Development And Innovation Agency. Ministry of Environment and Forestry, Indonesia. [Indonesian]

Sharma P, Kaur A, Batish DR, Kaur S, Chauhan BS. 2022. Critical insights into the ecological and invasive attributes of *Leucaena leucocephala*, a tropical agroforestry species. Front Agron 4: 890992. DOI: 10.3389/fagro.2022.890992.

Siboro TD. 2019. Manfaat keanekaragaman hayati terhadap lingkungan. Jurnal Ilmiah Simantek 3 (1): 1-4. [Indonesian]

Sohrabi S, Vilà M, Zand E, Gherekhloo J, Hassanpour-bourkheili S. 2023. Alien plants of Iran: Impacts, distribution and managements. Biol Invasions 25(1): 97-114. DOI: 10.1007/s10530-022-02884-6.

Suhendar S, Ramdhan B, Triana AE. 2020. Kajian jenis pohon dalam pengembangan Hutan Kota Kibitay Sukabumi. Bioeksperimen: J Penelitian Biologi 6 (2): 141-153. DOI: 10.23917/bioeksperimen.v6i2.8609. [Indonesian]

Sulaksono N, Hadiyan Y. 2015. Strategi resolusi konflik ekosistem kawasan Taman Nasional Gunung Merapi: Pelajaran dari Jurang Jero. Pros Sem Nas Masy Biodiv Indon 1 (6): 1370-1374. DOI: 10.13057/psnmbi/m010618. [Indonesian]

Sunardi S, Sulistijorini S, Setyawati T. 2017. Invasion of *Acacia decurrens* Willd. after eruption of mount Merapi, Indonesia. Biotropia 24 (1): 35-46. DOI: 10.11598/btb.2017.24.1.524.

Supartono T, Adhya I, Yudayana B, Ashari OT. 2019. Perkecambahan soil seed bank jenis pohon pioner dalam petak tunggal di semak belukar, Taman Nasional Gunung Ciremai. Prosiding Fahutan 1 (01): 249-256. DOI: 10.25134/jfe.v1i02.1714. [Indonesian]

Suryawan D, Sutyarto E, Umaya R, Kurnia A, Hadiyan Y. 2015. Sebaran spesies asing invasif *Acacia decurrens* di kawasan Taman Nasional Gunung Merapi. Pros Sem Nas Masy Biodiv Indon 1 (4): 738-742. DOI: 10.13057/psnmbi/m010409. [Indonesian]

Sutomo S. 2018. Species composition and role of exotic invasive pioneers in vegetation establishment on Mount Merapi Volcanic Deposits in Java, Indonesia. Intl J Trop Drylands 2 (2): 59-64. DOI: 10.13057/tropdrylands/t020204.

Sutomo S. 2019. Ekologi dan potensi invasif *Acacia decurrens* di sebagian kawasan Taman Nasional Gunung Merapi Yogyakarta. J Metamorfosa 6 (1): 4. DOI: 10.24843/metamorfosa.2019.v06.i01.p01. [Indonesian]

Suwarso E, Paulus DR, Widanirmala M. 2019. Kajian database keanekaragaman hayati Kota Semarang. J Riptek 13 (1): 79-91. [Indonesian]

Treml V, Hejda T, Kašpar J. 2019. Differences in growth between shrubs and trees: How does the stature of woody plants influence their ability to thrive in cold regions? Agric For Meteorol 271: 54-63. DOI: 10.1016/j.agrformet.2019.02.036.

Utami ARD, Nasihin I, Kosasih D. 2022. Analisis perubahan tutupan lahan di Stasiun Penelitian Fakultas Kehutanan Universitas Kuningan Wilayah Taman Nasional Gunung Ciremai. J For Environ 5 (2): 92-103. DOI: 10.25134/jfe.v5i2.9049. [Indonesian]

Utami I, Putra RAP, Wibowo MS, Yusuf FI, Husna F, Eko A, Susanto D. 2021. Tree stratification based on eruption damage level in Mount Merapi National Park Yogyakarta Indonesia. Media Konservasi 26 (1): 71-81. DOI: 10.29244/medkon.26.1.71-81.

Wahyuni I, Sulistijorini, Setiabudi, Meijide A, Nomura M, Kreft H, Rembold K, Tjitrosoedirdjo SS, Tjitrosoedirdjo S. 2016. Distribution of invasive plant species in different land-use systems in Sumatera,

Indonesia. Biotropia 23 (2): 127-135. DOI: 10.11598/btb.2016.23.2.534.
Wibawa IPAH, Saraswaty V, Kuswantoro F, Andila PS, Wardhani PK, Tirta IG, Sujarwo W. 2019. A study of essential oil from an invasive *Piper aduncum* L. J Biologi Udayana 23 (2): 50-58. DOI: 10.24843/JBIOUNUD.2019.v23.i02.p02.
Wijayati D, Rijanta R. 2020. Evaluasi zonasi Taman Nasional Gunung Merapi. J Litbang Sukowati: Media Penelitian dan Pengembangan 3 (2): 15-15. DOI: 10.32630/sukowati.v3i2.93. [Indonesian]
Witt A, Beale T, Van Wilgen BW. 2018. An assessment of the distribution and potential ecological impacts of invasive alien plant species in Northern Africa. Trans R Soc S Afr 73 (3): 217-236. DOI: 10.1080/0035919X.2018.1529003.
Yuliana S, Lekitoo K. 2018. Jenis-jenis tumbuhan asing invasif di Taman Wisata Alam Gunung Meja Manokwari, Papua Barat. J Penelitian Kehutanan Faloak 2 (2): 89-102. DOI: 10.20886/jpkf.2018.2.2.89-102 [Indonesian]