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# Plant trees species for restoration program in Ranupani, Bromo Tengger Semeru National Park Indonesia

Luchman Hakim[1*] & Hideki Miyakawa[2]

[1]Department of Biology, Faculty of Mathematics and Natural Sciences, Brawijaya University, Malang 65145, Indonesia; email: luchman@ub.ac.id; lufehakim@yahoo.com
[2]Japan International Cooperation Agency (JICA), Manggala Wana Bakti, Jakarta 10270, Indonesia; e-mail: Miyakawahi@aol.com
Corresponding author

**ABSTRACT** Restoration programs in conservation areas need a basis data regarding plant species diversity which is indigenous for the restoration area target. The availability of such data is useful for selecting appropriate plant species for reintroduction programs as a crucial part in restoration programs. The aim of this paper is to identify potential plant trees species for a restoration program in tropical highland ecosystem. There are potential plant trees species for Ranupani area, including *Acer laurinum*, *Acmena acuminatissima*, *Casuarina junghuhniana*, *Dacrycarpus imbricatus*, *Engelhardtia spicata*, *Myrsine korthalsii*, *Lithocarpus sundaicus*, *Lithocarpus korthalsii*, *Macropanax dispermum*, *Trema orientalis*, *Turpinia sphaerocarpa*, *Omalanthus giganteus*, and *Astronia spectabilis*. Some of them, i.e. *Engelhardtia spicata*, *Omalanthus giganteus*, *Astronia spectabilis*, *Trema orientalis* and *Casuarina junghuhniana* play an important role as pioneer species. In the first step of restoration program implementation, these species can be planted with some pioneer native shrubs and herbs to initiate and accelerate the succession process in the restoration areas.

**KEY WORDS** Mountain biodiversity; degradation; restoration; native species; lakes ecosystem; succession.

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## INTRODUCTION

Recently, problems related to the habitat degradation in national parks became one of the crucial issues in the world. As a mega biodiversity country, the role of national parks in Indonesia was considered important. While the objective of national parks has been addressed to conserve biodiversity, threats to the Indonesian national parks increase significantly (MoE, 2005).

Habitat degradation in Indonesian national parks has been reported by many authors. Several significant causes of degradation, however, come from the anthropogenic factor. Scholars point out that forest fire, illegal logging, mining and unsustainable uses of resources inside the national parks have been the causes of rapid degradation of many habitats (Salim, 2002; Miyakawa, 2010; Hakim et al., 2012).

Attempts to recover habitats that have been degraded became the focus of restoration projects. In Europe and America, restoration has been developed and implemented since past decades as an integral part of biodiversity conservation strategy (Phillips, 1996; Lowry, 2009). In Indonesia, however, restoration could be considered as a new concept and, therefore, it becomes crucial agendas in biodiversity management (Miyakawa, 2010). It is particularly crucial in Indonesian protected areas such as its national parks. Previously, in order to improve degraded areas, there were national programs called National Movement of Land Reha-

bilitation, which were intensively carried out in degraded water catchment areas, but not in protected areas system. There are many guidelines for degraded land recovery beyond protected areas, but are not available for protected areas. Absence of guidelines will lead to poor understanding of the basic philosophy and techniques for restoration. Since the objectives of management of watershed areas and national parks are different, as well as the biodiversity content, the recovery of disturbed habitats in these areas will differ both in philosophy and implementation.

Scholars stressed that the basic principle of restoration is creating original ecosystem before the area degrades (Aronson et al., 2007). In such a case, reintroduction of native plants into the degraded area is one of the main activities in restoration project (Falk et al., 1996). Efforts to recognize and identify native species become crucial in restoration programs. Plant trees species are one of the crucial components in tropical forest structure and function. Plant trees provide significant habitat for fauna and epiphytes flora, provide food and shelter for wildlife and are beneficial to water cycle in forest ecosystems. In other perspectives, trees are the ultimate resources for people surrounding forest and, for a long time, trees have been targets for exploitation (Salim, 2002; Miyakawa, 2010). Reintroduction of trees species has become the focus of many restoration projects in the world, reflecting its significance in ecosystem recovery efforts (Falk et al., 1996).

The development of restoration activities using particular demo plot is rarely done in Indonesia. One of the efforts, however, was promoted by JICA through the project entitled Project on Capacity Building for Restoration of Ecosystems in Conservation Areas. The objective of the project is to support the highland biodiversity conservation through the recovery of degraded ecosystem (restoration). In this paper, we describe the restoration planning and management of a degraded forest area surrounding two lakes in highland ecosystem. In particular, we report the first step in restoration programs in line with the attempt to provide basic data for native trees species of the study area. It is particularly important in developing countries due to the fact that people in such countries lack of experience regarding protected areas restoration programs.

## MATERIALS AND METHODS

This study was set up in Ranupani area at Bromo Tengger Semeru National Park (50,276.2 hectares), East Java, Indonesia. The national park is characterized by highland ecosystem with two active volcanoes, Mt. Bromo (2,329 m) and Mt. Semeru (3,666 m). The park is famous with its huge sand sea caldera (called Tengger Caldera) and several mountain fresh water lakes in the southern slope of Mt. Semeru.

The vegetation of the park is composed of lowland to upper mountain forest types. In the lower mountain forest (about 1,200 to 1,800 m asl.) the forest species encompass *Ficus* spp., *Erythrina* sp., and *Artocarpus* spp. Understorey plants include *Brugmansia* sp., *Costus speciosus* (J. Koenig) Sm. (Costaceae), *Datura metel* L. ( Solanaceae), *Musa* spp., *Colocasia* sp., *Alocasia* sp., *Pandanus* sp., palm and bamboo. The best ecosystem of lower mountain forest is located at the southern part of the park which is known as the richest habitat for orchid species. In the upper mountain forest (from 1,800 to 3,000 m asl.), the dominant tree species include *Casuarina junghuhniana* Miq (Casuarinaceae) and *Acacia decurrens* Willd. (Fabaceae). Shrubs and herbs encompass *Vaccinium* sp., *Myrica javanica* Blume (Myricaceae), *Myrsine* sp., *Lantana camara* L. (Verbenaceae), *Pimpinella* sp., *Veronica* sp., *Widelia* sp., *Dahlia* sp., *Anaphalis longifolia* (Bl.) DC (Asteraceae), *A. viscid*a (Bl.) DC (Asteraceae ) and numerous grasses. The sub alpine forest (above 3,000 m asl.) is dominated by shrubs and grasses, including *Anaphalis longifolia*, *A.viscida*, *Imperata cylindrica* (L.) P.Beauv. (Poaceae) and other dwarf shrubs (Hakim, 2011).

Ranupani area consists of several ecosystems, namely Pani Lake (locally called Ranu Pani), Regulo Lake (Ranu Regulo), Ranupani Village and tropical mountainous forest (Fig. 1). Geographically, this area is located at 2,000 to 2,200 m asl, in the southern slope of Mt. Semeru. In this area, the two lakes ecosystem and its surrounding areas became the targets for restoration project by Japan International Cooperation Agency (JICA) through the project entitled Capacity Building for Restoration of Ecosystems in Conservation Areas. Recently, Pani Lake (8 ha.) has been degraded which led it to its extinction due to rapid sedimentation, eutrophication and exotic plants invasion. The Regulo Lake

(4 ha.) is relatively less disturbed, but abandoned lands in an area surrounding lake are potential threats to lake ecosystem in the near future. Illegal logging, forest clearing and forest fire in the past seem to be the responsible factors leading to forest disturbance near lakes. Nowadays, many exotic shrubs species are identified to grow strives in such areas (van Steenis, 1972; Hakim, 2011).

Field survey was carried out in mountainous forest at southern slopes of Mt. Semeru and two villages at Tengger highland, namely, Ngadas and Ranupani Villages. Related information regarding the study sites was collected and analyzed comprehensively. There were encompassed the First-year Ranupani Restoration Project Report (Hakim et al., 2011), some official documents of the national park, and the demography report of Lumajang Regency. The plant trees species diversity of the Ranupani forest area was identified through floristic surveys from July to September 2011. Prior to the field survey, several textbooks of Malesian plants diversity and phytogeography were examined, including the main literature of Javan flora, such as The Mountain Flora of Java by van Steenis (1972), Flora of Java by Backer & van den Brink (1965), and Flora Malesiana series (van Steenis, 1972). In this study, the primary focus was woody plant trees species. In the floristic survey, firstly, four hectare observation plots in two locations were set up as the sites for plants inventory. Such plots were set up in relatively undisturbed mountainous tropical forest in southern slopes of Mt. Semeru at 1,500 -2,500 m asl. In every observation plot, kinds of tree species were identified based on the morphological characteristics. Experts from Purwodadi Botanical Garden (East Java) and local people were invited during the identification process, particularly with regard to the species' scientific names and the verification of

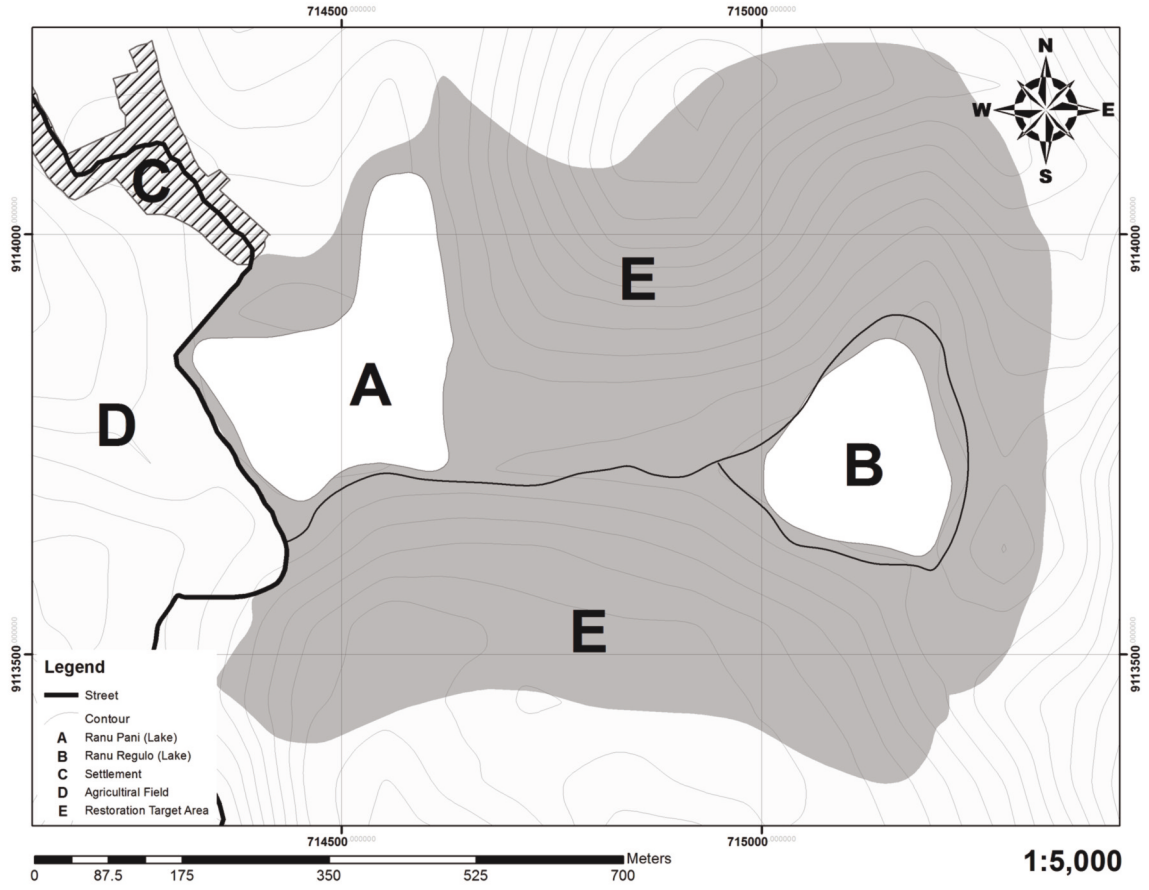


Figure 1. Restoration target area. A. Pani Lake (Ranu Pani), B. Regulo Lake (Ranu Regulo), C-D, Local settlement and intensive agriculture field in steppes land, E. Restoration target area.

their local name. Some parts of the plants were collected as herbarium samples for a detailed study in Purwodadi Botanical Garden and Plant Taxonomy Laboratory, University of Brawijaya in Malang, East Java. In the field, some important features of the tree species were recorded and documented using a digital camera. Interviews with the local people were conducted in order to get the species' economic value and characters. Ten local people which were identified as frequently entering to the forest and able to provide information were selected as informants. During the interviews, the experts from Purwodadi Botanical Garden gave some advice that the authors needed to collect information through interactive interviews. Then the data and information were analyzed descriptively.

## RESULTS AND DISCUSSION

### *The profile of restoration target areas*

Two lakes and their surrounding area have been heavily threatened due to anthropogenic factors. According to the informants, the area surrounding Pani Lake in the past was the centre of human activities. In 1908, Pani-Regulo and Kumbulo Lakes were declared as a protected area by Dutch colonial government. In the beginning of 1920, a Dutchman family had a concession to rent land surrounding Pani Lake. The family introduced European vegetables and employed local people from Probolinggo and Malang. After Indonesia held its independence in 1945 and many Westerns went out from Indonesia, the area surrounding Pani Lake was occupied by local people. In 1960, Ranupani Village was opened with ten Tenggerese families from Argosari Village as a pioneer group to open new Tenggerese settlement in Tengger highland. During 1970-1990, the population in Ranupani increased significantly. There was also a fast-growing, intensive agriculture in Ranupani Village. The growth of settlement and agriculture in Ranupani Village has given negative impacts to the lakes and forest area. Valuable woods were extracted to provide raw materials for traditional buildings and infrastructure of the village. There were also increases in fuel wood consumption. All informants argue that *Casuarina junghuhniana* and *Acacia decurrens* became the target of exploitation to provide fuel wood.

Barren lands in Ranupani area have been invaded by numerous exotic plants species. The abundance of many exotic species in open canopy is an ecological consequence of the ecosystem degradation. Recently, among the important exotic species is *Eupatorium odoratum* L. (Asteraceae). This species is considered native to South America and spread everywhere. The ability of such species to produce seeds and grow fast supports its invasion in barren lands. In Ranupani, however, local people collect old bark as fuel wood for daily purposes.

The loss of vegetation surrounding lakes has decreased the riparian structure and its function to protect the lakes. Recently, such a structure is insufficient to overcome sedimentation and pollution problems in the aquatic ecosystems. According to the respondents, in the past *Casuarina junghuhniana* and *Acacia decurrens* were abundant, but later slightly decreased due to the fact that the people cut and collected the trees as fuel wood. The water quality of Pani and Regulo Lakes has been affected heavily by pollution leading to eutrophication. This situation occurs due to the addition of exogenous substances, such as nitrates and phosphates, through fertilizers or sewage to the aquatic system. According to the respondents, most farmers in Ranupani Villages use pesticide intensively in order to improve crops and vegetables production.

### *Trees Species for Restoration Programs*

Trees are the main component of tropical forest and their functions in hydrological and mechanical protection for lakes are considered significant. In the restoration of degraded ecosystems, trees are the plants categories which receive special attention. Identifying plant trees species is one of the crucial steps in any restoration program. Lack of such information will prevent the success of the restoration. The benefits of such information are numerous, one of which is providing the basic information regarding the native trees species and their status in the vegetation succession process. Through the field survey, several tree species notable for the restoration purposes are given below.

***Acer laurinum*** Hassk.

Aceraceae. Local people call this species Putih Dada. This species is native to Assam (India),

Nepal, Myanmar, Cambodia, Indonesia, Laos, Malaysia, the Philippines, and Thailand. Phytogeographically, there are about 200 *Acer* species on earth with the northern hemisphere as the hot spot area of Aceraceae. *Acer laurinum* is one of the members of Aceraceae which is found in Malesian Region. In Bromo Tengger Semeru forest area, this species is easily known due to the color of its whitish leaves. *Acer laurinum* grows scattered in mountain forest from Ngadas to Ireng-Ireng forest at 800-2,250 m asl. An individual tree can reach 20-30 m in height. The quality of the wood is not very high (Sosef et al., 1998), but local people in Tengger highland use *Acer* wood for limited civil construction.

***Acmena acuminatissima*** (BI.) Merr et Perry

Myrtaceae. Geographically, this species is distributed in the Malesian Region and Solomon Island. It is also found in Myanmar, Thailand and southern China as native species (Sosef et al., 1998). Local people call this species Jambon/Tinggan. According to Backer & van den Brink (1965), this species grows at 25 - 1,800 m asl in West, Central and East Java. In Bromo Tengger Semeru forest, *A. acuminatissima* can grow up to 25 m in height. *A. acuminatissima* grows patchly in Ranu Pani and its surrounding area at 2,000-2,200 m asl. They grow mixed with some secondary forest trees along Ngadas to Jemplang. According to the respondents, this species is rarely used as civil material due to the low quality of the wood.

***Casuarina junghuhniana*** Miq.

Casuarinaceae. *C. junghuhniana* is considered native to Eastern Java and Lesser Sundas Islands (Nusa Tenggara). This species is naturally found in mountain volcanic slopes at 1,500 -3,100 m asl. (Hanum & van der Maesen, 1997). According to van Steenis (1972), it plays an important role in mountain forest succession. It is known as a fire resistant plant and considered a pioneer species in degraded lands and volcanic ash and sand. In Tengger, *C. junghuhniana* is one of the species which is intensively used by the local people and considered a multipurpose tree species. *C. junghuhniana* provides good wood for civil construction. People also prefer to collect *C. junghuhniana* as charcoal and fuel wood (Heyne, 1987). In an area surrounding the restoration sites, this species is abundant in Ngadas, Jemplang, Ranupani and northern slopes of Mt. Semeru. According to the informants, it is one of the fuel wood sources for people in Tengger Highland. Wood heat is common among Tenggerese in Tengger Highland. Biologically, *C. junghuhniana* is one of the fast-growing trees species in Tengger and, therefore, plays an important role in the initial stages of restoration program in Ranupani Area.

***Dacrycarpus imbricatus*** (Blume) de Laub

Podocarpaceae. Geographically, *D. imbricatus* is distributed across Java, Lesser Sundas and central Celebes. This species grows at altitude of 1,000-2,500 m asl (De Laubenfels, 1972). In Bromo Tengger Semeru, *D. imbricatus* (locally called Jamuju) is very rare and difficult to find in primary and secondary forest. There were only small populations in Ngadas and Ranupani mostly in secondary forest. Some individuals grow solitary and there are no seedling and juvenile individuals found. According to the respondents, in the past there were many individuals of Jamuju in forest area, but nowadays the population is decreasing. The wood of Jamuju has been known as one of the high-quality wood for many purposes. Therefore, it is easy to understand that in the past it became the target for illegal logging.

***Engelhardtia spicata*** Blume

Juglandaceae. This species is distributed in India, China, and Southeast Asia regions (Thailand, Laos, Malaysia, the Philippines, Sumatra, Java, Kalimantan, Lesser Sundas Islands). Local people call it Danglu/Kukrup. Backer & van den Brink (1965) consider *E. spicata* as one of the pioneer species in mountainous ecosystem. In two observed plots, these trees grow up to 25 m. According to the respondents, the quality of the wood is weak and, therefore, is rarely used for civil construction. The reproduction rate of *E. spicata* in the field is considered high. It is very easy to find seedling in the wild, particularly in the forest area where *E. spicata* is abundant. In Bromo Tengger Semeru, this species can be found everywhere, particularly in sub-climax forest in Ngadas and Ranupani. The characteristics of its reproduction makes this species important in the initial steps of reintroduction program in restoration areas.

***Myrsine korthalsii*** Miq.

Myrsinaceae. Local people call it Irengan. Backer & van den Brink (1965) report that this species grows in Mt. Slamet (central Java) and Mt. Arjuno (East Java) at mountain forest less than 3,090 m asl. Only a few papers have reported this species, making the information about *M. korthalsii* rare. In Bromo Tengger Semeru, it grows at 1,500-2,200 m asl. Trees of this species grow patchy mostly in secondary forest. Many of them grow solitary and some form small populations. There are no economic benefits generated from this species.

***Lithocarpus sundaicus*** (Blume) Rehder

Fagaceae. *L. sundaicus* is native to the tropical parts of Asia, particularly Thailand, Malaysia, the Philippines and western Indonesia (Sumatra, Java and Kalimantan Islands). The species grows in primary forest in Malesia region at 1,000-1,500 m asl. In Java, it is commonly found in West Java, but scattered in East Java (Soepadmo, 1972). Tenggerese people call *L. sundaicus* Pasang Putih. It has been recognized as one of the species with high-quality wood for many purposes, particularly for civil construction. The respondents state that the good quality of such wood leads to *L. sundaicus* exploitation in the wild. Heyne (1987) states that the wood of *L. sundaicus* is one of the good wood for civil constructions (houses, bridges, ...).

***Lithocarpus korthalsii*** (Endl.) Soepadmo

Fagaceae. Local people call this species Pasang Merah, Pasang Susu, or Pasang Kapur. Soepadmo (1972) notes that the species is distributed in Malesia region. Lemmens et al. (1995) report that this species grows in lowland to mountain forest in Sumatra and Java Islands. In Java it could be found in west to east parts. In Bromo Tengger Semeru, this species is found from 1,800 to 2,200 m asl, as big trees. This species is considered important as material for civil construction (Heyne, 1987).

***Macropanax dispermum*** (Bl.) Kuntze.

Araliaceae. In Malesia this species grows at Sumatra, Malay Peninsula and Java, particularly central and eastern parts of Java. Beyond Malesian phytogeographic region, this species is found in India, Burma and southern China (Philipson, 1979). Naturally it is able to grow at 1,000-2,300 m asl. In Java, it is distributed at west, central and east parts, particularly in mountainous areas. This species is reported to prefer humid environments (Backer & van den Brink, 1965) and can be found everywhere in humid forest areas in the northern slopes of Mt. Semeru at 1,500-2,200 m asl. Local people call it Pampung or Endog-endogan. According to the informants, the species is abundant in the forest and relatively undisturbed by local people. This species is very easy to propagate through vegetative propagation by stem cuttings techniques. Individual trees can reach 18 m in height. It is not mentioned as useful plant (Heyne, 1987).

***Omalanthus giganteus*** Z. & M.

Euphorbiaceae. This species is reported by van Steenis (1972) to be distributed in Java mountain, particularly in the eastern part of the island. Interestingly, it is considered rare and absent in the western part of Java. Ecologically, this species is a pioneer species in tropical mountainous forest. It is one of the fast-growing trees. In the study area it is able to survive under pressure of its competitors such as *Eupatorium odoratum* L. and *E. riparium* Regel (Asteraceae). The respondents argue that the wood cannot be used for civil construction and other purposes.

***Astronia spectabilis*** Bl.

Melastomataceae. Locally called Kayu Ampet or Gembirung, in Indonesia this species is distributed from west to east Java. It is also found in Bali Island in humid tropical forest. Naturally, it is found at 1,300-2,500 m asl. In Bromo Tengger Semeru, this species is found in some areas, particularly in humid tropical forest at 1,500 to 2,200 m asl. Individual trees can reach 20 m in height (Backer & van den Brink, 1965), but in Ranupani it can reach 25-30 m. The respondents state that the wood of *A. spectabilis* can be used for houses and civil construction.

***Trema orientalis*** (L.) Blume

Ulmaceae. This species is native to Africa, Asia Temperate, Asia Tropical and Australasia (Soepadmo, 1977). Local people call it Angrung. It grows below

2,400 m asl, and is considered as a fast-growing tree species in tropical forest. According to the respondents, there are still abundant Angrung populations in the national park area. Although the wood durability is considered low, the wood of Angrung still is the most important material for civil constructions in some villages around Mt. Semeru. Heyne (1987) points out that there are many ethnobotanical applications of *Trema orientalis*. However, the ethnobotanical application of *T. orientalis* is not recorded in this study, indicating that the people in Tengger do not use such species for any cultural purposes.

***Turpinia sphaerocarpa*** Hassk.

Staphyleaceae. This species is distributed in Malesia region, particularly in the rainy forests (van der Linden, 1960 ). *T. sphaerocarpa* is distributed in West, Central and East Java at 20-2,200 m asl (Backer & van den Brink, 1965). Interestingly, there are no populations reported from New Guinea. Local people call it Kayu Bangkong. *T. sphaerocarpa* produces soft wood. In Java, the wood of *T. sphaerocarpa* is used for furniture, but is not durable for civil construction (Heyne, 1987). In Tengger highland, it grows as shrubs and trees.

Other species found and mentioned by the respondents are *Albizia montana* (Jungh.) Benth. (Fabaceae), *Helicia* sp., *Saurauia pendula* Bl. (Actinidiaceae), *Manglietia glauca* Blume (Magnoliaceae), and *Litsea diversifolia* Blume. (Lauraceae). *Albizia montana* is rarely found in Ranupani and rarely collected by local people as fuel wood. However, two informants state that in the past *A. montana* was also cut and collected as fuel wood. In Ranupani area *A. montana* grows in small populations and mixes into the shrubby areas which are dominated by exotic species such as *Eupatorium odoratum*. *A. montana* is one of the significant species in early succession stages and, therefore, should be considered to be planned in the first step of restoration program in Ranupani.

Some of the trees mentioned above play an important role as pioneer species, i.e. *Engelhardia spicata* Lesch. ex Blume (Juglandaceae), *Omalanthus giganteus* Z. & M. (Euphorbiaceae ), *Astronia spectabilis* Blume (Melastomataceae), *Trema orientalis* (L.) Blume (Cannabaceae) and *Casuarina junghuhniana*. In many degraded places in the national park area, some seedling and juvenile individuals of such species grow under high pressure of *Eupatorium odoratum* and some grass species. They can be a potential candidate for assisting the natural succession programs in Ranupani area. In the first step of the restoration program, these species can be planted with some pioneer shrubs and herbs such as *Dodonaea viscosa* Jacq. (Sapindaceae), *Myrica javanica* Blume (Myricaceae), *Pittosporum moluccanum* (Lam.) Miq. (Pittosporaceae) and *Buddleja asiatica* Lour. (Scrophulariaceae). This could be an effective combination design for the beginning of restoration program in degraded lands in Ranupani area. Other potential plant species for the restoration program in Ranupani area include *Acer laurinum*, *Acmena acuminatissima*, *Dacrycarpus imbricatus*, *Myrsine korthalsii*, *Lithocarpus sundaicus*, *L. korthalsii*, *Macropanax dispermu* and *Turpinia sphaerocarpa*.

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