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Landscape characteristics analysis of Rawa Bunder Resort at Way Kambas National Park

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Abstract. *The importance of research on the Rawa Bunder Resort's landscape characteristics at Way Kambas National Park (WKNP) is as a basis for area management according to its function in a lowland tropical rainforest ecosystem. The purpose of this study is to find out the current characteristics of landscape, including physical and biological characteristics as well as the driving factors for establishing good habitat restoration for flora and fauna life. The results showed that the landscape characteristics of the Rawa Bunder Resort consisted of natural forest and open land containing shrubs with almost the same area composition. The position of the forest appears to be united in the middle to the east of the WKNP. The pressure of Imperata fires can threat the existence of forests. If preventive action is not taken immediately, the forest will decrease in size. The driving factor for reducing the forest matrix is the frequent occurrence of forest fires every year. These fires were triggered by humans who were intentionally or unintentionally driven by the wind so that it spread widely.*

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INTRODUCTION

Landscapes in all parts of the world have changed due to natural disturbances and human actions. These changes are becoming increasingly recognized, especially as remote sensing technologies, geographic information systems, and computer capabilities improve. Forman and Godron (1986) –a leading landscape ecologist, stated that the landscape is a heterogeneous area formed from various types of interacting ecosystems, Urban et al. (1987) added that the landscape is a pattern (pattern) that is composed of the fragmented mosaic. The landscape approach can facilitate various interests related to conflicting land uses between economic and ecological functions. This approach is done by a participatory process, so it is hoped that a spatial layout and management of various interests will be formed, supported by all parties who play a role in the landscape.

The spatial structure of the landscape is the main object of investigation in landscape ecology. This structure finds expression in landscape patterning, which integrates both the complex conditions of the natural environment (land cover, soil, topography, vegetation, local climate) and human-induced changes, especially land use and human impacts. Landscape patterns are very important for understanding the relationship with ecological processes. Therefore the measurement of various spatial structure parameters is an important part of landscape ecology. Disruption to function does not always change the structure, but disturbance to a structure will definitely change landscape function. Structure's change of the landscape through the process of natural forest deforestation will definitely change the forest landscape function. Deforestation causes a decrease in biodiversity and abundance of flora and fauna and carbon stocks and changes in runoff/erosion (Prasetyo et al. 2009a, 2009b).

Assessing the causes of temporal variation and the spatial distribution of competing species is a fascinating and complex subject. Spatial heterogeneity characterization of the resource landscape is different between species characteristics influencing dispersal, formation, and competition. Changes in disturbance regimes are rarely measured at space and time intervals (Prasetyo 2017). As an example case, Rohman et al. (2019) reported that Sumatran elephants in Bukit Barisan Selatan National Park tend to choose home ranges at a very close distance from rivers. Abdullah and Japisa (2013) stated that the range of elephants from their habitat to water sources ranges from 0–250 m. If the small rivers, which are the sources of drinking water are removed, it is strongly suspected that they will affect the movement areas of the elephants.

The importance of landscape studies is to make decisions regarding the management of ecosystems and wildlife habitats. Wildlife spends a great deal of time occupying spaces that can meet their needs. Habitat selection is a process for wild animals in selecting the habitat components to be utilized (Arini and Nugroho 2016). According to Rohman et al. (2019) preferences for land slopes show the result that elephants are more likely to be in the 2–7% slope class, the land is classified as sloping. Human activities that often change forest ecosystems will cause the loss of landscape structure and function of forests. This condition will cause natural disasters, including loss of flora and fauna biodiversity. Ecosystems that have undergone this change need to be restored (restoration) back to their original state. This effort requires current and past data information that describes the characteristics of the landscape.

One of the important landscapes in Lampung as protection of ecosystems and flora and fauna is the Way Kambas National Park. In this study, the location was taken at the Rawa Bunder Resort. This area is thought to have undergone a drastic change from lowland tropical rain forest to grassland and shrubs. Based on the 2018 Landsat imagery, the expanse of bushes appears very wide. This condition can expand if it is not anticipated immediately because during the dry season, it is very prone to fires. The aims of this study are; (a) to analyze the landscape characteristics of the Rawa Bunder Resort based on biophysical information and the surrounding community, (b) to analyze the driving factors for changes and efforts to restore the ecosystem, (c) to map the characteristics of the Rawa Bunder Resort landscape.

METHODS

Location and Time of Research

The research was carried out for three months, from July–September 2022. The first month conducted a preliminary survey and secondary data collection through research reports and journals. In the second and third months, primary data collection was carried out taken from the research location. The research site was at the Rawa Bunder of National Park Management Resort (NPMR), Way Kambas National Park (WKNP). Rawa Bunder Resort is one of twelve resorts in WKNP. This resort is bordered by buffer villages, namely Labuhan Ratu IX, Rajabasa Lama I, Rajabasa Lama II. Rawa Bunder Resort consists of a core zone, jungle zone, conservation zone, and utilization zone.

Data Collection Methods

Tools used in this study were a set of computers with imagery mapping applications and drones to get a closer look at conditions in the field. The materials used are the Rawa Bunder Resort area, imagery 2018, soil type maps, river network maps, and topographical maps. Landsat Images 2018 collection was continued with a map overlay of the Rawa Bunder Resort location. Likewise, with topography, soil type, and hydrology. Furthermore, mapping was carried out with drones to see more detail at current conditions.

Determination of vegetation types and other land cover is carried out using remote sensing techniques and geographic information systems. The position of the observation point is marked using the *Global Positioning System* (*GPS*). The recorded data includes vegetation type, level of land disturbance, photographs, and land morphology and geographic coordinates. Land cover will be generated from the interpretation of Landsat satellite imagery, which will be assisted by the interpretation of Landsat imagery with satellite imagery. For remote sensing, data processing will be assisted by using ArcGIS.

The data collected included: (a) physical data collected, such as air temperature, rainfall, slope, soil type, and hydrology; (b) biological data collected, such as tree species, birds, and mammals; (c) social data collected such as history area and local community perceptions. Recently, the trend of mapping using aircraft has been replaced by drones (Unmanned Aerial Vehicles/UAV) (Ahmad 2011; Pacina and Sládek 2015). The price of mapping using aircraft is high; on the other hand, the price of drones is getting cheaper with increasingly sophisticated technology. Drone applications have shifted from being only for military and surveillance purposes to drones for conservation (conservation drone/eco-drone) (Ivošević et al. 2015; Trevors *and* Weiler 2013). The type of drone used in this study is the DJI Mavic. Software *Agisoft Metashape Professional output* is exported in *tiff* (Salim et al. 2018). The x, y, and z coordinates in the field (GCP) are needed in the photogrammetry process to correct model coordinates from *point clouds* to actual coordinates in the field (Meiarti et al. 2019).

Interview

Interviews were conducted using an open questionnaire to the management at the Rawa Bunder Resort. Key informants are the heads of sections, heads of resorts, and staff and community leaders in the field.

Processing Data

Data processing used a set of computer programs and image mapping applications with *ArcGIS 10.5* and drones with Agisoft Metashape Professional. The processed data is the only area that was restored to see the initial physical condition of the activity.

Data Analysis

Data analysis methods for land cover, topography, soil type, and hydrology were carried out using a Geographic Information System. Meanwhile, data from field surveys and interviews were carried out in a descriptive way and presented in the form of tables and figures.

RESULTS AND DISCUSSION

Land Cover

The landscape of the Rawa Bunder Resort area based on the 2022 mapping is 10,037.7 hectare (ha). Based on the Decree of the Head of Balai dated 12 January 2013 No. 11/BTN.WK-II2013 covers an area of 9,824.47 ha (Indraswati et al. 2018). The land cover in Rawa Bunder Resort is broadly divided into 4,876.3 ha of lowland tropical rainforest, 3,472.9 ha of open bush, and 1,688.5 ha of swamp forest (Figure 1).

The composition of the landscape fragment area is lowland tropical rain forest 48.6%, open area of shrubs and *alang-alang* 34.6%, and swamp forest 16.8%. The extent of the shrub composition (Figure 2) was influenced by the human factor, which at that time was arable land planted with cassava by the community. However, after being disciplined around 2,000, the area changed, which was originally cassava plants to shrubs. The area of shrubs and reeds is increasingly expanding due to land fires that occur every year during the dry season. If it is not immediately controlled, this shrub area will suppress the remaining natural forests and threaten the preservation of flora and fauna.

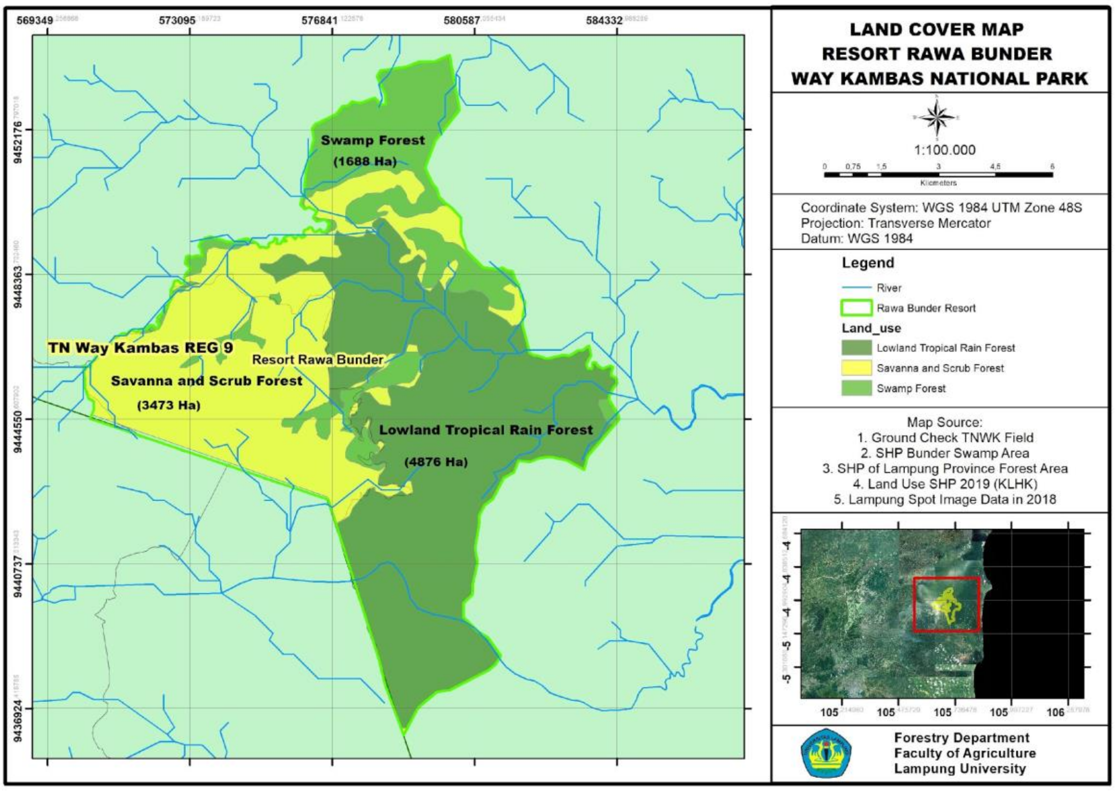

Figure 1 Land cover at Rawa Bunder Resort, WKNP

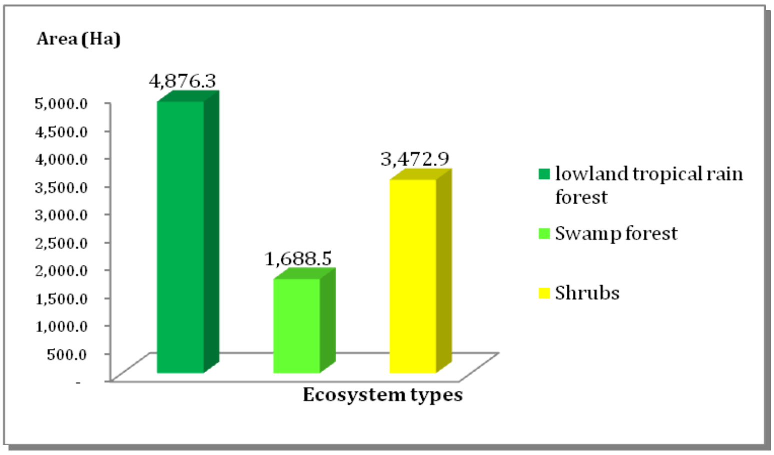

Figure 2 Landscape composition of the Rawa Bunder Resort in WKNP

Topography

The topographical conditions of the Rawa Bunder Resort (RRB/*Resort Rawa Bunder*) are sloping (0–8%), and the elevation above sea level is 39 m (Figure 3). During the rainy season, there will be many puddles, including swamps and edge areas. In the middle of the resort, there are many stretches of swamp overgrown with shrubs and mentru trees. Likewise in the middle there are also many tributaries of the river which will flood during the rainy season and dry up during the dry season.

Climate

The air temperature during the day reaches 34.5 ^{o}C with a humidity of 50.5%. This condition, when associated with the process of land fires, can be said to be very supportive. The environment of reeds that are hot, dry, and exposed to strong winds will easily cause widespread land fires. Rasyid (2014) states that high temperatures due to direct sunlight cause fuel to dry out and burn easily, low humidity increases the chances of forest fires, and wind also influences the process of drying fuel and the speed at which fire spreads.

The climate type is B with a Q value of 28.57% and rainfall ranging from 2,500–3,000 mm per year, slightly lower when compared to mountainous areas. The dry season in Way Kambas National Park is usually around April to September. During the dry season, the rainfall in this area is less than 100 mm per month. The average dry month is in August or September. Usually there is a typical dry season on average 2–6 months in 20 years.

Hydrology

The middle part of Rawa Bunder contains the inner river with many tributaries. When it's dry, it's partially dry, but during the third rainy season, it floods the land until floods and swamps begin to appear at Kali Batin then end at Muara Penet. The distribution of the rivers within the Rawa Bunder Resort is shown in Figure 3.

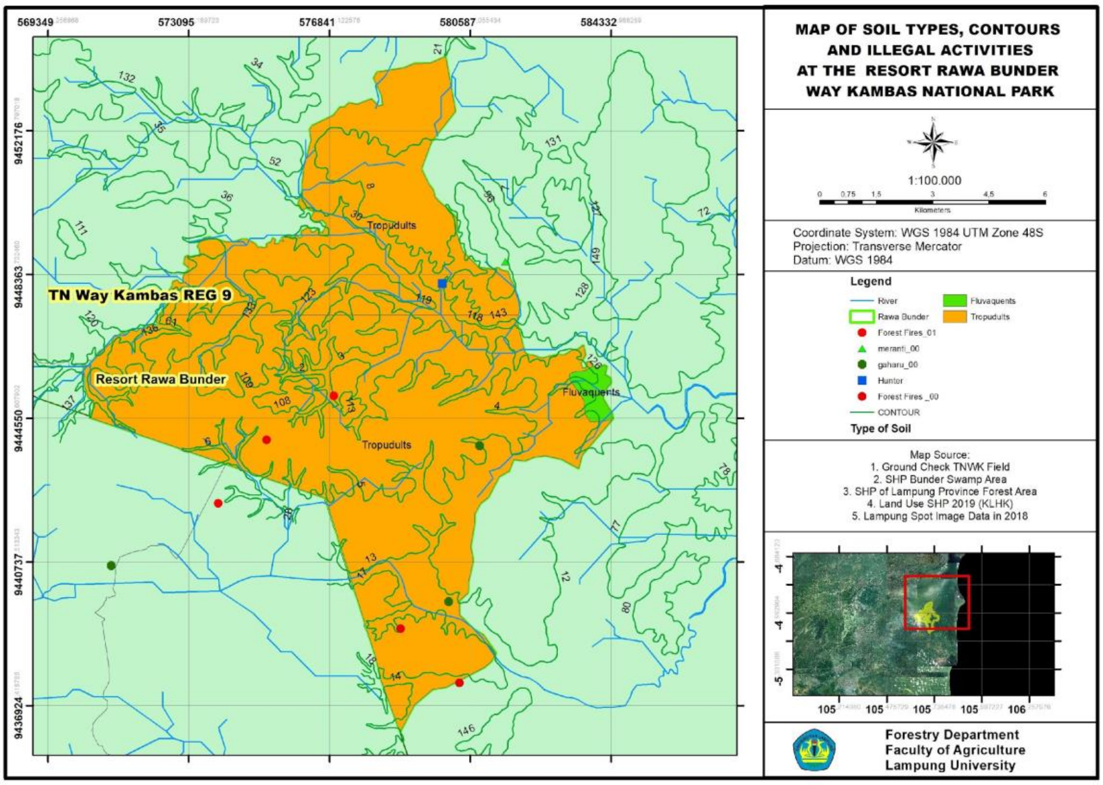

Figure 3 Map of soil types, contours, and illegal activities

Soil Type

The dominant soil type in Rawa Bunder is tropodults (Figure 4) or red-yellow podzolic. This land has experienced a decrease in the quality of soil fertility. Ultisols in Kalimantan generally consist of tropudult, which is difficult to cultivate intensively because of the low nutrient content in the topsoil, as well as Al content and high acidity (RePPProt 1990; MacKinnon et al. 1996). Until 2,000 the land was planted with cassava and then abandoned so that reeds grew densely. Declining soil productivity is a major problem in new planting activities. So if it is not treated, the plants will become stunted and fail to grow. The main cause of the decline in soil productivity is erosion due to the lack of speed of land restoration accompanied by high rainfall. Apart from erosion, the causes of soil damage are other processes such as desertification, acidification, saltization, pollution, compaction, waterlogging, subsidence of organic soil and water level decline (Kurnia et al. 2002).

Figure 4 Elephant feces visible between the reeds and shrubs

Effort to increase soil fertility is by liming the soil. Lime in acid soils is intended to rise soil pH so that the solubility of Al decreases. The need for lime (calcite or dolomite) to neutralize Al is the amount of lime needed so that Al saturation does not exceed the critical limit of the plant concerned. In a lime rotation system, it should be given based on lime requirements for plants that are most sensitive to Al. Giving lime is effective in reducing soil Al saturation to a level that is not toxic to plants. Sukristionubowo et al. (1993) reported that applying 1 ton/ha of lime on acid soils (Ultisols in Kubang Ujo, Jambi) can increase soil pH from 4.0 to 4.7, and it is very effective in reducing soil from 2.25 to 0.25 meq/100g.

If the availability of soil nutrients is low, applying fertilizer to increase the productivity of dry land is necessary. In addition, fertilization efficiency needs attention, especially for N, P, and K fertilizers. Fertilizer application is aimed at increasing the availability of soil nutrients, especially nutrients with low levels, such as N, P, K, and Ca nutrients. Fertilization on Oxisol Pelaihari using corn plants as an indicator shows that N, P, K, Ca, Mg, and S fertilizers can increase the availability of each nutrient in the soil (Nursyamsi 2003). Lime addition is intended to reduce Al saturation, it is also intended to increase soil Ca availability. Increasing the productivity of dry land can also be done by improving soil biological properties because soil biological properties are also a constraint on soil biophysics in dry land. In degraded soils, generally, soil biological parameters such as C-organic content, soil microbial populations (bacteria, fungi, actinomycetes, etc.), and microbial biomass are all low.

Fauna

Bird fauna in the WKNP consists of 406 bird species (Zulham et al. 2021) which 18 species of birds with protected status, including the jungle stuck (*Cairina scutulata*), the blue pheasant (*Lophura ignita)* and four types of storks, namely the tong-tong stork (*Leptoptilos javanicus)*, the bluwok stork (*Mycteria cinerea)*, the clothing stork (*Ciconia episcopus)* and storm stork (*Cicania stormi*). Other protected birds include hornbills (Bucerotidae), white egrets (*Egreta* sp), parrots (*Gracula religiosa*), partridge *(Gallus gallus)*, corporal snake *(Anhinga melanogester)*, and king prawns (*Halcyon* sp.).

Based on the observations of Pujami (2022) in the restoration area, 79 species of birds were observed. Various birds have a role in spreading plant seeds and controlling forest pests in the Bunder Swamp ecosystem. Primates in the Rawa Bunder forest are found in 8 species as follows; gibbons, long-tailed monkeys, surili, gibbons, monkeys, langurs, slow lorises, and tarsiers. Naturally, these primates will disperse the seeds within their home range.

Active herbivores around the Rawa Bunder camp are elephants, deer, deer, and pigs. Herbivorous animal feces (Figure 4) can frequently be seen around the camp and restoration areas. These animals will also spread plant seeds through their feces which support the process of natural succession. According to Campos-Arceiz *and* Blake (2011), forest elephants in Africa can maintain the diversity of several tree species in a wide range of areas through the dispersal of feces along their journey. It was explained that

African elephants spread the seeds of 355 species from 213 genera in 65 families. Meanwhile, Asian elephants spread the seeds of 122 species from 92 genera in 39 families.

Elephants around Rawa Bunder Camp are looking for food and minerals. Minerals are needed for various biological processes, including energy metabolism, organs and immunity, reproductive function, and cell growth (Ishiguro et al. 2018). Elephants have a home range of 32.4–166.9 km², which includes various types of forest ecosystems, namely swamp forest, lowland rainforest, peat forest, and mountain rainforest (Mahanani et al. 2012). The results of Abdullah and Japisa's research (2013) show that Sumatran elephants choose habitat units with criteria (a) a gentle slope (0–20%); (b) close to water sources (0–250m); (c) close to the primary forest (0–500m); (d) rare availability of mineral trees (< 3 trees/plot); (e) low land elevation (0–400m); (f) availability of lots of feed (75%); (g) very rare crown cover (0–25%); (h) the availability of sparse scrubbing trees (< 3 trees); and (i) Secondary Forest type. When viewed from these criteria, this location is suitable habitat for elephants.

According to a local resident who often visits Rawa Bunder, before there was control over cassava planting activities in the area, groups of elephants often came to residents' plantation areas. They eat cassava plants if the residents don't take care of them. Apparently the location is the home range of elephants. So even though there are no cassava plants exist, groups of elephants still continue to visit them. An example of this case also occurs in Eastern Karbi Anglong, India, where Ahmed (2020) reported that elephants often visit agricultural areas even though they are limited by railroad tracks.

Vegetation

Various types of trees found in the lowland tropical rain forest of Rawa Bunder are dominated by meranti group (Family Dypterocapaceae) with a characteristic crown that sticks out like an umbrella. This type of shelters shows the microclimatic conditions underneath become moist, which can support the process of decomposing litter to become nutrients for all types of trees. Karmilasanti and Maharani (2016) reported that the role of Dipterocarpaceae in being a host for growing ectomycorrhizal fungi found in the KHDTK Labanan natural forest in East Kalimantan was in mutualistic symbiosis of 79.22% (22 species), while those in symbiosis with hosts of Non-Dipterocarpaceae species were 20.78% (9 species).

On the other hand, the commercial species target of timber theft is gaharu. Several cases of incidents were recorded against illegal logging to be taken over. If this is not immediately anticipated, the parental population of gaharu can be threatened, and new patches will open in the forest. Invasive Alien Species (IAS) are species that enter a habitat either intentionally or unintentionally originating from areas outside their natural habitat, generally, plants originating at the species, subspecies, or variety level, which includes whole organisms with body parts such as seeds, gametes, seeds or propagules that can live, develop and reproduce in the new habitat they occupy, then become a threat to their original biodiversity (Soekisman and Imam 2016).

Species found in bunder swamps such as mahogany and sonokeling. This type is easy to grow and already large. The spread of this invasive species can grow widely because it is difficult to control. Usually, if it is under the canopy of mahogany, other types of growth cannot grow. All foreign species can certainly threaten the sustainability of the ecosystem, so they need to be controlled. In restoration efforts, care must be taken in selecting species so foreign species would not plant them.

Factors Driving Landscape Change

Factors driving landscape change include natural and human factors. Natural factors are rain, drought, wind, animals, and plants. The human factor is all actions that result in deforestation or reforestation. During the rainy season there are lots of seed germination grow into saplings which will become seedlings and eventually become trees if there is no disturbance. But on the contrary, during the dry season, many seeds have a dormant period. Seed dispersal can be spread by wind or wildlife.

Human can cause forest fires which result in vegetation reduction. On the other hand, humans can also speed up efforts to restore ecosystems by restoring forest areas. Rasyid (2014), the impact of fire that is felt by humans is in the form of economic losses, namely loss the benefits of forest potential, such as forest tree stands that are commonly used by humans to meet their needs for building materials, food, and medicines, as well as animals for meet the need for animal protein and recreation. Another loss is in the form of ecological losses, namely reduced forest area, unavailability of clean air produced by vegetation forests, and the loss of the function of forests as regulators of water management and prevention of erosion.

Restoration Efforts

Efforts to restore forests have been carried out with reforestation and restoration activities. However, some of these reforestation areas have failed, mainly due to forest fires occur every year. Currently, tree planting is being carried out to restore the forest ecosystem, which has turned into reeds. The current field conditions taken from drone can be seen in Figures 5 and 6. It appears that there are scattered Mentru plant crowns. The initial treatment for this restoration was started by slashing the paths for plantation alleys. The distance between the aisles is 3 m. The distance between plants is 2 meters. The width of the lane is made 1 meter for the plant run.

Figure 5 Pre-restoration conditions (Drone photo)

Figure 6 Post-restoration conditions (Drone photo)

Constraints and Restoration Solutions

Wildlife can become an obstacle when they eat young seedlings that grow or they step on them can be caused seedlings to be disabled or even die. Therefore, restoration can be done by avoiding the plant species that become the feed. The difficulty is when elephants (megaherbivores) are considered, there are so many species that will be eaten, it is up to 258 species. So, the solution is to choose the type that elephants dislike. Data on types of food palatability for elephants are presented in Table 1.

Dry weather during the dry season can cause forest fires. Rasyid (2014), in general, forest fires are caused by three main factors, namely fuel conditions, weather, and the social culture of the community. Fuel conditions that are prone to fire hazards are the abundant amount on the forest floor, relatively low water content (dry), and continuous availability of fuel. Planting activities planned during the rainy season can be taken as prevention. Sometimes weather constraints can also be anticipated by making modern irrigation.

Humans are the reason for population decline and even ecosystem loss. The role of security is needed to overcome poaching, which indirectly or directly reduces the richness of flora and fauna species. Fatimah et al. (2021) uncontrolled fires often occur accidentally due to careless human activities and lead to forest degradation as a habitat for wildlife. Njeri et al. (2017) fires cause immediate adverse effects on vegetation, wildlife, and soil chemistry. The solution for restoration efforts to be successful requires several methods, namely silviculture which applies zero Imperata with 3 processes as follows; (a) Site preparation for restoration plants must be zero Imperata, (2) Plant maintenance with organic fertilization, (3) Selection of local species that are pioneers for the initial phase and after 1 year the main plants are planted.

Table 1 Elephant's favorite type of feed and neu index (Supartono 2007)

No.	Scientific name	Family	Local name	Average
1	*Gigantochloa cf. atroviolacea*	Poaceae	*Bambu sri*	79.86
2	*Ficus recurva*	Moraceae	*Beringin*	40.11
3	*Ficus variegata*	Moraceae	*Kayu aro*	37.18
4	*Ficus fistulosa*	Moraceae	*Batang siap*	26.00
5	*Panicum sp.*	Poaceae	*Petai*	20.65
6	*Knema laurina*	Myristicaceae	*Rotan Sabut*	18.53
7	*Alsophila amboinensis*	Parkeriaceae	*Pakis Tiang*	8.94
8	*Nephelium maingaji*	Sapindaceae	*Kupai berbulu*	7.86
9	*Dendrocnide stimulans*	Urticaceae	*Akar toha*	7.26
10	*Caesalpinia sp.*	Fabaceae	*Akar Petaian*	5.68
11	*Calamus cf. javensis*	Arecaceae	*Salak hutan*	5.43
12	*Hymenachne acutigluma*	Poaceae	*Alang-alang*	5.20
13	*Gonocaryum gracile*	Icacinaceae	*Liana manggul*	4.59
14	*Spatholobus sp.3*	Fabaceae	*Mayor*	4.58
15	*Artocarpus elastica*	Moraceae	*Terap*	4.57
16	*Tephrosia sp.*	Fabaceae	*Akar leper*	4.19
17	*Macaranga diepenhorstii*	Euphorbiaceae	*Sekubung*	4.08
18	*Korthalsia echinometra*	Arecaceae	*Rotan dahan2*	3.67
19	*Ficus pumila*	Moraceae	*Akar teratai*	3.58
20	*Centotheca lappacea*	Poaceae	*Kupai daun lebar*	3.25
21	*Macaranga hypoleuca*	Euphorbiaceae	*Kemang*	2.77
22	*Calamus ornatus*	Arecaceae	*Rotan kesur*	2.24
23	*Coscinium fenestratum*	Menispermaceae	*Sepatah*	2.18
24	*Commersonia bartramia*	Sterculiaceae	*Akar waru*	1.91
25	*Spatholobus ferrugineus*	Fabaceae	*Akar jitan*	1.68
26	*Gigantochloa robusta*	Poaceae	*Kayu sebulu*	1.50
27	*Vitex pubescent*	Verbenaceae	*Laban*	1.38
28	*Calamus cf. heteroideus*	Arecaceae	*Rotan semut*	1.34
29	*Phanera kockiana*	Fabaceae	*Akar kupu-kupu*	1.25
30	*Gymnopetalum chinense*	Cucurbitaceae	*Pulai*	1.22
31	*Scindapsus hederaceus*	Araceae	*Sejanet*	1.18
32	*Oplismenus compositus*	Poaceae	*Pandan duri*	1.07
33	*Zizyphus horsfieldii*	Icacinaceae	*Liana berduri*	1.02

To suppress weeds at zero level, an effective method is needed by using systemic herbicides. These herbicides usually use chemicals. Nature Conservation areas need to be avoided, and it is recommended to use organic systemic herbicides. If the growth of reeds can be reduced to zero percent, the risk of fire on the site is also little, even reaching zero percent during the dry season. Besides, the plants will be free from competition for nutrients from the weeds. Restoration efforts will run safely. Furthermore, fertilization should also be done considering the critical soil conditions since cassava was planted and overgrown with reeds. Organic fertilization will support the growth of restoration seedlings and restore soil conditions at the same time.

Determination of local pioneer seeds that grow fast and have broad leaves is very important to suppress other types of weeds which will grow simultaneously. In this case, weeds are the main focus of attention. It will become a competitor with pioneer plants. The spacing of pioneer plants needs to be dense, for instance, 1.5 x 2 meters, so the canopy will quickly cover the soil surface while simultaneously suppressing the growth rate of weeds. This pioneering combination of dense planting with a systemic herbicide will suppress Imperata as much as possible for a relatively long period (6 months) at the first year, which is decisive at that time. Systemic herbicides can be done twice a year.

The fast-growing species that usually resides on the banks of rivers is Sungkai (*Peronema canescens* Jack). This plant can be planted along the banks of the river. Another common fast-growing type is usually the *Mallotus paniculatus* and *Trema orientalis*. Trees from the Euphorbiaceae Tribe, such as Macaranga, Mallotus, and Omalanthus are pioneer species that commonly fill secondary forest elements. In general, these types grow fast in open habitats. The pioneer species often found in Rawa Bunder is puspa (*Schima wallichii*). Even though this restoration area was burnt in 2019, this type is still visible. Case study research results by Gunawan et al. (2011) stated that these plants spread randomly and grow well even though they compete with reeds. Vegetation type Schima wallichii consistently has the highest importance value index on the growth rate of seedlings, saplings, poles, and trees in natural forest ecosystems/vegetation types and mixed puspa forest ecosystems/vegetation types.

According to Mansur (2011), there are four types with a fairly high CO_2 absorption capacity; *Trema orientalis*, *Macaranga triloba*, *Omalanthus populneus* and *Mallotus paniculatus.* For this reason, these four species can be selected as species for reforestation of damaged forests or on marginal lands. In addition, these four types can reduce CO_2 gas emissions in the air, which is considered a trigger for greenhouse gases. The ideal condition expected after restoration is 100% canopy closure. The tree canopy will be layered to form the structure of the growth phase starting at the level of seedlings, saplings, poles and trees. Microclimate will certainly change and support the development of litter decomposition bacteria. The sustainability of flora and fauna is realized with the balance of the ecosystem. If the growth in diameter of a tree trunk is 1 cm, the tree is expected to grow to a diameter of 100 cm will be occurred 100 years in the future. It is such a very long process that will be achieved (Figure 7) if there are no disturbances like forest fires and illegal logging.

Figure 7 Ideal conditions expected after restoration (Photo from drone)

CONCLUSION

The landscape characteristic of Rawa Bunder Resort consists of lowland tropical rainforest and open land filled with reeds or shrubs with almost the same composition. The position of the forest seems to unite in the central to eastern parts of the WKNP. Meanwhile, the thickets of reeds extend in the central to western parts of the WKNP. The pressure of Imperata fires can threaten the forest's existence. If preventive measures are not taken immediately, the forest area will decrease. The driving factor for reducing the forest matrix is the frequent occurrence of forest fires every year. This fire was triggered because humans intentionally or unintentionally caused the fire to appear and were carried by the wind so that it spread widely. This landscape mapping will document the land cover development in quantity and quality by looking at the tree crowns aerially improvement.

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